Course Name-Biology and Diversity of Algae, Bryophyta and Pteridophyta (Paper Code: BOT 501)

Unit –1 : General Characters and Classification

Unit- 2 : Thallus Organization in Algae

Dr. Pooja Juyal
Department of Botany
Uttarakhand Open University,
Haldwani

email.id: pjuyal@uou.ac.in

Contents

INTRODUCTION

During rainy season the slippery green structure we see on the shady and moist places. All these structures which we are study among plants. These organisms are commonly known as ‘algae’- a Latin word which literally means sea weeds.

1- Algae are simplest chlorophyllous forms found on the earth.
Photoautotrophs: Make their food with the help of water and carbondioxide in presence of Sunlight.

2- Algae belongs to thallophyta.

Thallophyta: A division of the plant kingdom containing relatively simple plants, i.e. those with no leaves, stems, or roots. It included the algae, bacteria, fungi, and lichens.

- The name algae was first given by Linnaeus.
- Algae may be define as thalloid, autotrophic, non-vascular plants having unicellular or muticellular, non jacketed sex organs with no embryo formation.
- These have been placed under thallophyta.
- The study of algae is called Phycology (a Greek word *Phycos* means ‘sea weeds’ and *logos* means ‘study’) and references of algae are available in ancient literature of Greek, Roman and Chinese.
- Prof. M.O.P. Iyengar is known as father of Modern Indian Algology.
- Near about 30,000 species of algae are found in the world.
- It is generally autotropic but can also exist in the form of symbiont, parasite etc.
- Algae, commonly known as pond scum, can be seen easily growing on water surface of ponds, ditches, tanks, pools etc.

GENERAL CHARACTERSTICS OF ALGAE

- Algae are chlorophyll bearing thalloid plants with no differentiation into tissue or tissue system; however some algae have advanced complex thalli with slight differentiation of true tissues (*Ulva*, *Sargassum* etc.).
- All the algae except few are aquatic.
- All the cells of the thallus are morphologically and physiologically similar.
- The cell has cell wall.
- Sex organs are unicellular generally, when multicellular, each cell is capable to reproduce.
- Sex organs are never surrounded by sterile jacket layer.
- No embryo is formed after gametic fusion.
- New plants develops after meiotic division in the zygote.
- Sporophytic and gametophytic generations are independent when represented in life cycle.
- Generally the main plant is a gametophyte.
- Reproduction in algae takes place by vegetative, asexual and sexual modes.

Algae

HISTORY OF PHYCOLOGY

❑ The history of algae is quite old and is available in early literature of Chinese, Roman and Greek. Romans called algae as *Fucus*. Chinese named it *Tsao* while Hawanians called them as *Limu*. In ancient literature it was reported that algae were used as manure on the north coast of France.

❑ **In India**, literature provided the evidence of phycology since 18th century where major interests were on macroscopic forms of algae. F. E. Fritsch (1907) published a marvelous work on sub-aerial and fresh water algae from Ceylon. He published the classification of algae in his book 'Structure and Reproduction of the algae'.

❑ Ghose (1919-32) was the pioneer of phycology in India. He conducted research on blue green algae of Burma and Punjab. Prof. M. O. P. Iyengar is regarded as 'Father of modern phycology of India'. He (1920), together with his students Balakrishna, Desikachary, Kanthamma, Ramanathan and Subramanium studied a number of Indian algae. Iyengar discovered *Fritschiella tuberosa* from India. Biswas (1922-26) wrote on algal flora of East India, Assam and Bengal. Prof. Y. Bhardwaj established a school of algology at Banaras Hindu University.

HABITAT

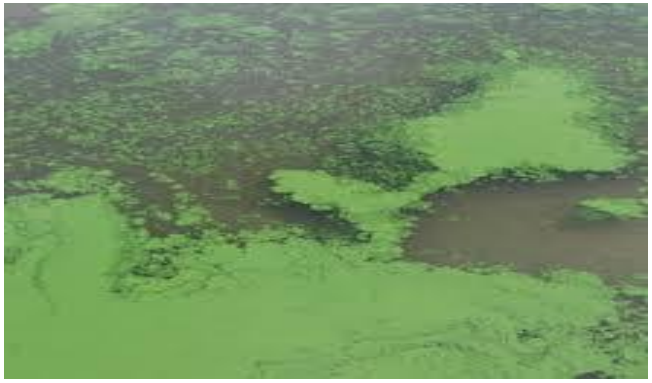
- Algae are of universal occurrence because of their presence in nearly all types of habitats.

- They are found in fresh water, sea water, on soil, on rocks and stones, on sands, in very hot water, on ice and snow, on tree trunks, in the plants (Endophytic); on the plants (Epiphytic), in the animals (Endozoic) or on the animals (Epizoic) etc.

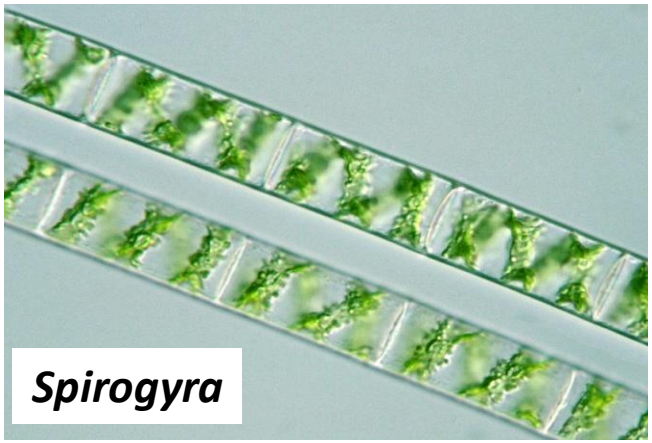
- On the basis of its presence they may be:

1- Aquatic
2- Terrestrial
3- Specialized types

1-Aquatic Algae: Most of the algae are found in fresh water or marine water.



a) Fresh water algae- free floating algae as *Spirogyra*, or even attached to the substratum e.g.- *Ulothrix*



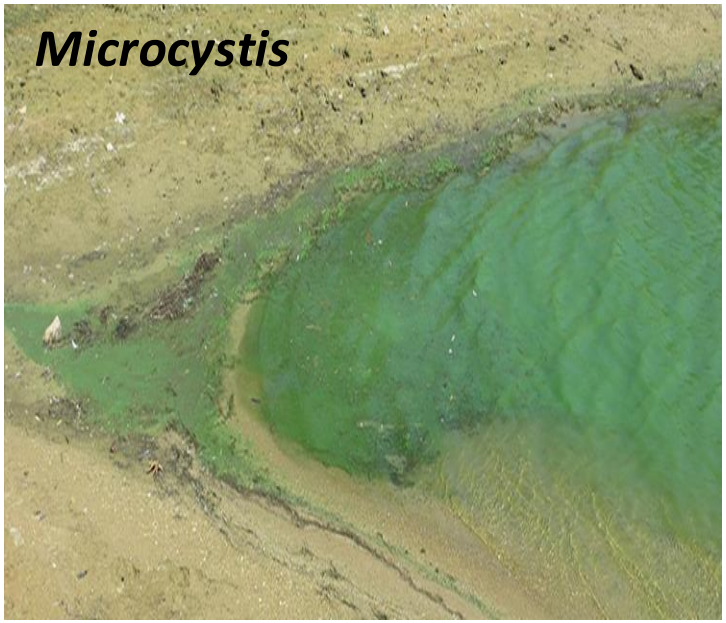
b) Marine Algae- are common in salty water of sea and oceans. Generally the members of phaeophyceae, Rhodophyceae and some Chlorophhyceae e.g., *Enteromorpha*, *Caulerpa*. *Ulva*, *Codium*, *Enteromorpha* etc. are found in marine water.

(i) Benthophytes- They are generally the attached forms. They cannot float freely in water. Fresh water benthophytes are *Chara*, *Nitella* etc and the marine water forms are *Lamillaria*, *Fucus* etc.

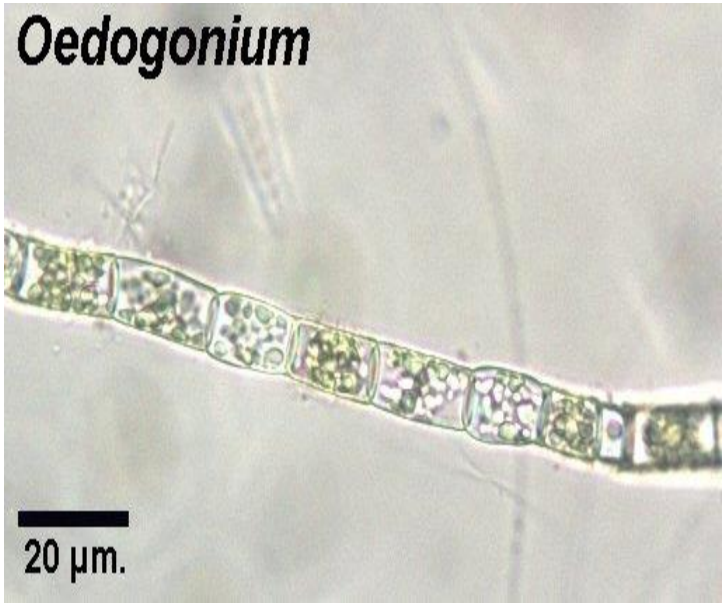
Chara

Fucus

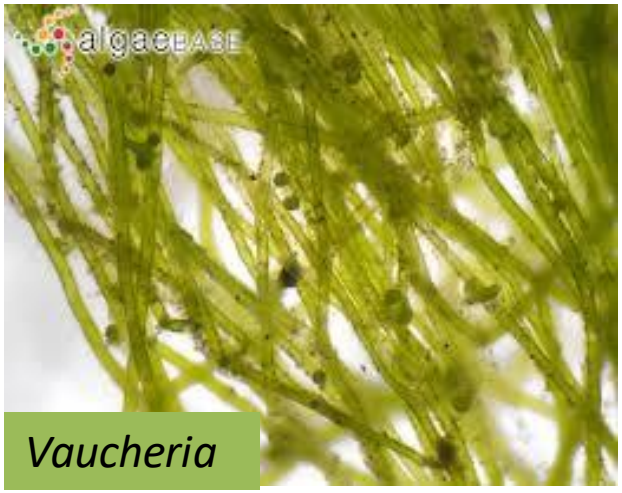
(ii) Euplanktophytes- The plants are never attached to the substratum. They remain free floating type throughout their life.
e.g.- *Microcystis*



(iii) Tychoplanktophytes-
The plants start their life as attached form but later on become free floating type. e.g.- *Oedogonium*, *Nostoc* etc.



2-Terrestrial Algae- Those algae which are found in soil are termed as terrestrial algae. The algae makes a green film on the surface of soil. These are of two types-



Vaucheria

(a) Saphrophytes – The algae is found in the surface of soil. e.g.- *Botrydium*, *Vaucheria*.

(b) Cryptophytes- The algae is found in the subterranean region. They are found in the soil.
e.g. *Oscillatoria*, *Anabaena*, *Nostoc* etc.


Anabaena

3-Specialized Algae- Such algae are found in places other than water and soil. They are found in specialized habitats. These are:

(i) Thermal algae- The algae are found in hot water springs above 70° C temperature. They can survive well in such a high temperature. e.g. are-

Thermophytes

- Hot springs, tolerate temperature upto 85c.

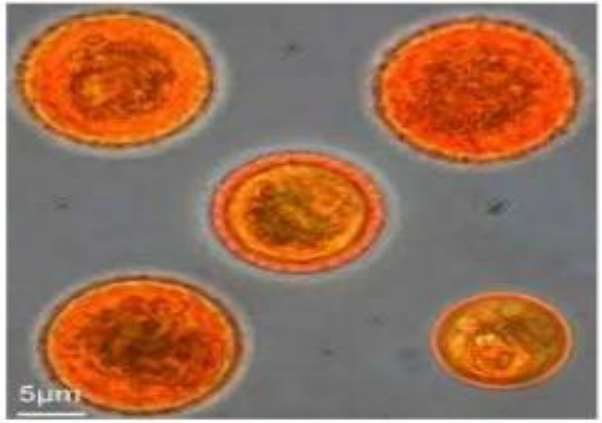
Example: Haplosiphon lignosus

(ii) Cryophytic algae- The algae are found on snow clad (बर्फ से ढका हुआ) mountains. examples are-

(iii) **Halophytic algae-** Found in high salt condition. e.g.-

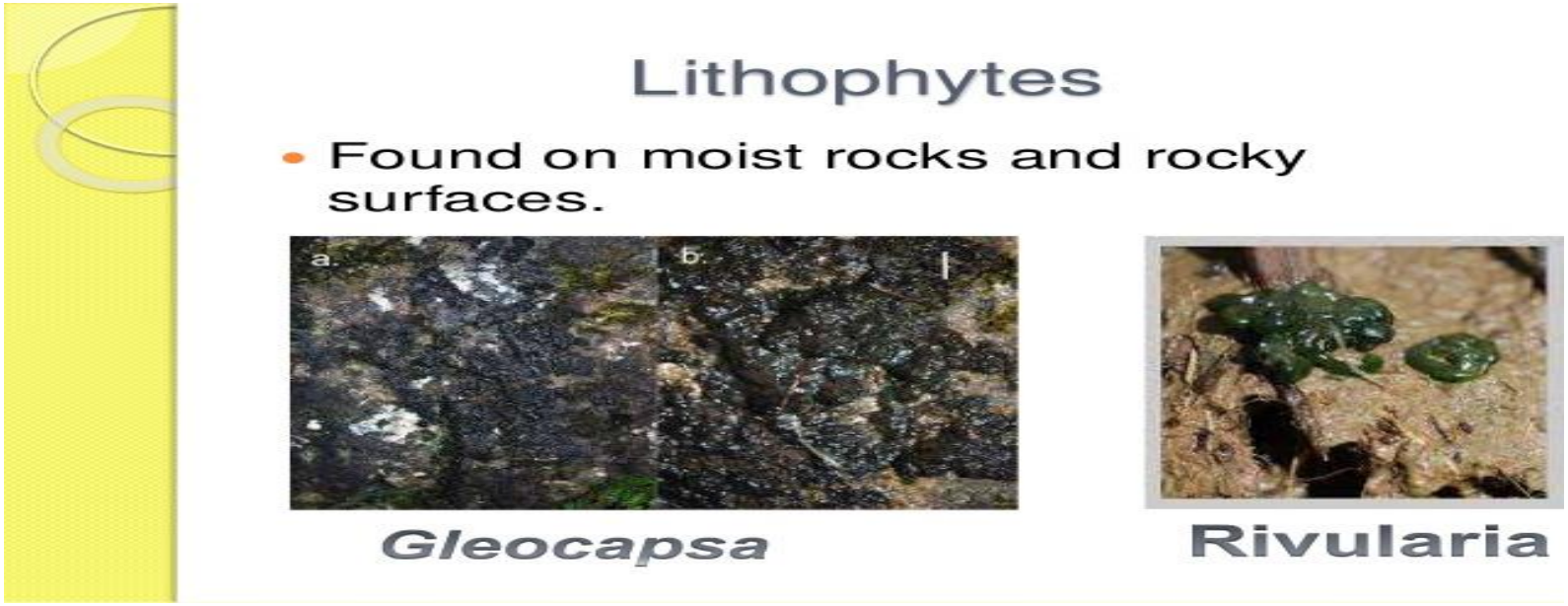
Halophytic Algae

- They are present in water containing high percentage of salt.



Haplosiphon salina

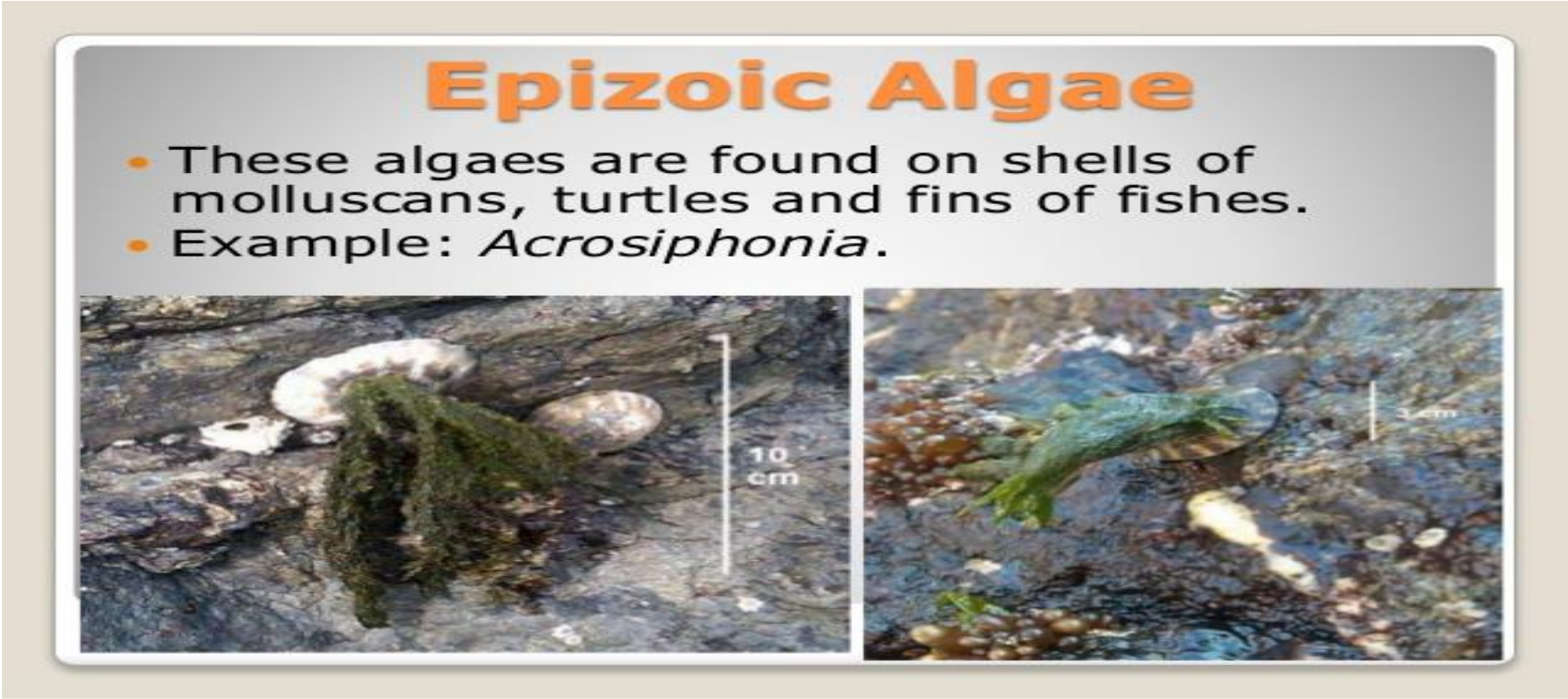
(iv) **Lithophytic algae-** Common in wet rocks and walls. e.g.- *Vaucheria*, *Nostoc* etc.



(v) **Epiphytic algae** (परोपजीवी) – These algae grow on other aquatic plants. On trees, barks, leaves etc. of higher plants. e.g. – *Trentopohlia*, *Rubus*, etc.

(vi) **Endophytic algae** (अंत:पादपीय)- These algae are found inside the higher plants. Nostoc is found in the thallus of *Anthoceros* and *Anabaena* grows inside the coralloid roots of *Cycas* etc.

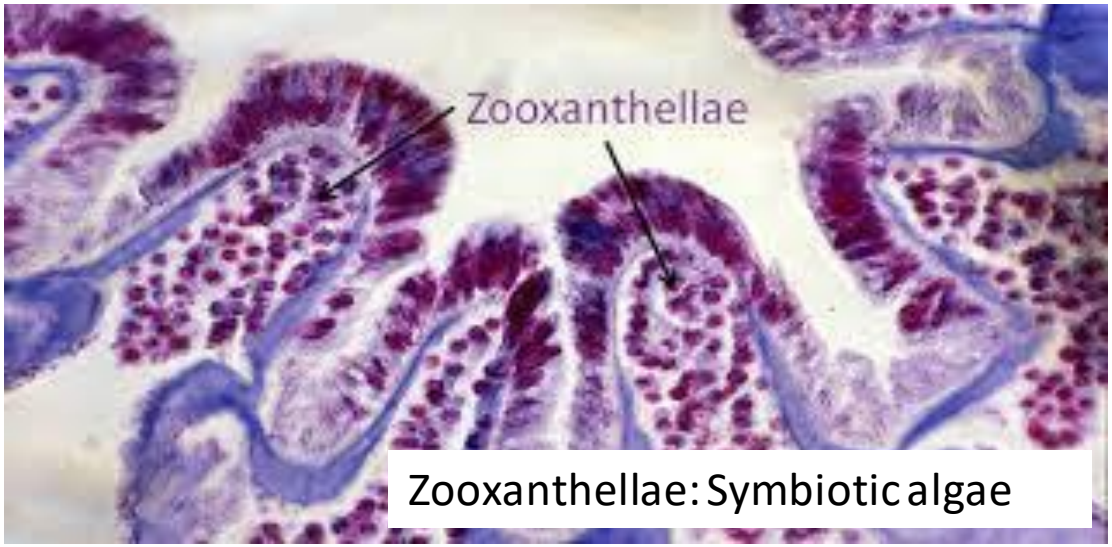
(vii) **Epizoic algae** **(अधिजातव)** - Found on the surface or shell of the animals. e.g.- *Cladophora* sp. found on the shell of snail.



(viii) **Endozoic algae (अंत:जंतुक)-** Found inside the body of aquatic animals. e.g.-*Zooxanthella* is found in the fresh water sponges.

(ix) Parasitic(परजीवी)algae- Some algae are heterotrophic (परपोषी) parasitic type, Red rust of tea(*Thea sinensis*) is caused by *Cephaleuros virescens.*

(x) Symbiotic(सहजीवी) Algae- Several algal species live in symbiotic(सहजीवी) forms with other plants. e.g.- Lichen where algae (Cynophyceae) and Fungi (*Ascomycetes or Basidiomycetes)* live in symbiotic form. *Nostoc*, *Anabaena* easily live in symbiotic form in various higher plants.



Zooxanthellae: Symbiotic algae

(xi) Water blooms- Some unicellular and filamentous forms of algae grow extensively on the surface of water and make the place lathery (झागदार) called water blooms. e.g.- *Nostoc*, *Anabaena*

Size of Algae

- Their sizes varies from 0.5microns to 700 feet(giant kelps) in length.

CLASSIFICATION OF ALGAE

In 1753, Linnaeus placed algae in the class cryptogamia together with mosses, vascular cryptogames and fungi in his *Species Planatarum*. He did not classified algae further. Since then classification of algae has been continually modified. Vaucher (1803) was perhaps the first to propose a system of classification of algae. He recognized three groups, *Conferves*, *Ulves* and *Tremelles.*

Algae along with fungi were grouped under Thallophyta, a division created by Eichler (1836). Engler and Prantle (1912) proposed a system of classification which is summarized as follows-

1. Schizophyta
2-Phytosarcodina
3. Flagellata
4-Dinoflagellata
5- Bacillariophyta
6- Conjugatae
7- Chlorophyceae
8- Charophyta
9- Phaeophyceae
10-Rhodophyceae
11- Eumycetes

A brief account of characteristics of the 11 classes of algae as proposed by Fritsch (1945):

1-Chlorophyceae: Members of this class are green in colour because of chlorophyll a and b, associated with some amount of yellow pigment. Pyrenoids are also present in all the members (except member of the order Siphonales) of this class. Starch is the chief food reserve. Majority of these algae are fresh water, also includes terrestrial and marine forms. These green algae reproduce by vegetative, asexual and sexual means.

2- Xanthophyceae: Algae of this class are yellow- green in colour because of the presence of xanthophylls pigment. They lack pyrenoids. Reserve food material in the form of oil drops. These are fresh water algae but few are marine. Reproduce sexually by means of microscopic gametes with unequal cilia. (Cilia are active organelles that are used by most eukaryotic organisms to move fluids).

3-Chrysophyceae: These are unicellular forms which possess orange colour due to the presence of phycochrysin pigment. Reserved food is in the form of oil and leucosin. These are fresh water and marine forms.

4-Bacillariophyceae (Diatoms): These algae are yellow, golden-brown, or olive green in colour. The chief pigment is Diatomin. These are unicellular forms which sometimes form small colonies. Pyrenoids are present and hence the reserve food material is starch. They inhabit fresh and marine water.

5-Crytophyceae: The members of this class greatly vary in the colour of their plant body. These are usually brown, red or even blue green in colour. The real nature of the pigment or pigments which render such a variety of colours is not definitely known. These are fresh-water and marine forms characterized by the presence of two large parietal chloroplasts.

6-Dinophyceae: The members of this class are brown or dark yellow in colour. The chief pigment is Pyrrophyll which is a combination of yellowish green pigment chlorophyll, dark-red peridinin and red phycopyrrin. These forms are characterized by the presence of several discoid chloroplasts and large, prominent nucleus. Reserved foods in the form of fat and starch.

7-Chloromonadineae: These are bright green which consist excess of xanthophylls pigment. These are characterized by the presence of many discoid chloroplasts. Reserved food is in the form of fat.

8-Euglinineae: These are naked flagellates which according to Fritsch " show a more definite trend in the direction of animal organization". Majority of them lack chromatophores.

9-Phaeophyceae: The members are generally known as brown algae. Structurally these are the most complex algae. Pigments include chlorophyll a and c, β- carotene and xanthophylls. The brown colour is due to excess fucoxanthin. Commonly algae are called sea weeds. They are marine forms. Reserve food material is in the form of laminarin and mannitol. Algin and fucoidin is present in cellulosic cell wall. Reproduction is by vegetative and sexual both. Sexual reproduction ranges from isogamy to oogamy. Motile cells are biflagellate with unequal length. Flagella are unequal and are attached laterally.

10-Rhodophyceae: Majority of the forms are marine and only few are fresh water forms. Members are called red algae. Major pigments include chlorophyll a and d, β- carotene, xanthophylls and phycobilins- r-phycoerythrin, r-phycocyanin and allophycocyanin. The colour of algae is red due to the presence of excess r-phycoerythrin. Reserve food material is floridean starch.

Thallus is organized and possess complexity. Plasmodesmata is present in the cells except in the members of Protoflorideae. Sexual reproduction is specialized and oogamous. Motile cells are altogether absent.

11-Cyanophyceae or Myxophyceae- The members are called blue green algae. Members are prokaryotic. Thallus is simple unicellular, colonial or multicellualr bodies. Pigments are not in organized bodies as in other cases. Principle pigments are chlorophyll a, α-carotene, β- carotene, xanthophylls and phycobilins- c-phycocyanin and c-phycoerythrin. The colour of algae is due to the presence of excess c-phycocyanin. Reserve food material is cyanophycean starch. The cell wall is made up of mucopeptide. Most of the members are embedded in mucilaginous sheath. False branching and special cells heterocysts are characteristics of several members. Motile cells are altogether absent in life cycle as in the case of Rhodophyceae.

The criteria and modern concept to classify algae are-

- Nuclear organization
- Cell wall components
- Pigments
- Flagellation
- Chemical nature of reserve food material
- Type of life cycle and reproduction

1. **Nuclear organization**: On the basis of nuclear organization, algae can be prokaryotic or eukaryotic. Cyanophyceae or cyanobacteria (blue green) are prokaryotic in nature while all other algae are eukaryotic. In cyanophyceae, nuclear membrane is absent and genetic material (chromatin threads) is not bounded with histone proteins. Moreover, membrane bound organelles like mitochondria, plastids, golgi bodies, endoplasmic reticulum, vacuoles etc are not found. Eukaryotic algae have well organized nucleus, mitochondria, golgi bodies, chloroplasts, endoplasmic reticulum etc. in their cell structure.

2-Chemical composition of cell wall: The cell wall of algae is made up of cellulose (polysaccharide). In general, the inner wall is insoluble cellulosic layer and outer wall is made up of pectic substances which are soluble in water. In addition to this certain classes of algae possess certain chemical components in their cell wall which make them distinct from other classes. For example, members of Phaeophyceae possess alginic acid and fucinic acid in their cell wall while silica is impregnated in the cell wall of bacillariophyceae. Xylan and galactan is found in cell wall of Rhodophyceae. Cell wall of cyanophyceaea is made up of mucopeptide.

3-Pigments- It is one of the most important criteria of classification of algae. In the beginning, algae were classified as red algae, brown algae, green algae and blue green algae on the basis of their colour. Pigments are present in plastids of eukaryotic algae while in thylakoids of prokaryotic algae.

Plastids contain three types of pigments in algae. These are chlorophyll, carotenoids and phycobilins.

a) **Chlorophyll-** Five types of chlorophyll namely-chlorophyll a, b, c, d and e are found in algae.

Chlorophyll a is present in all classes of algae.
Chlorophyll b is present in Chlorophyceae and Euglenineae.
Chlorophyll c is present in Phaeophyceae and Cryptophyceae.
Chlorophyll d is found in Rhodophyceae only.
Chlorophyll e is present in Xanthophyceae only.

b) Carotenoids- Carotenoids are yellow or orange coloured pigments. They are capable of absorbing destructive oxygen molecules from light and provide a protective sheath. The various colours in algae is due to these pigments.

Carotenoids are of fat soluble and divided into carotene, xanthophylls and carotenoid acids.

Carotene- There are six types of carotenes- α, β, γ, ε, flavicine and lycopene etc. Carotene is a linear chain of unsaturated hydrocarbons and fat soluble. β-carotene is found in all classes of algae. α-carotene is found in Rhodophyceae and Cryptophyceae. γ-carotene and lycopene is found in Charophyceae. ε-carotene is present in Cryptophyceae and Bacillariophyceae. In Cyanophyceae, flavicin is found.

Xanthophyll- Xanthophylls are oxygen derivatives of carotenes. There are about 20 types of xanthophylls are found in algae. e.g., Zeathanthin, Flavoxanthin, Diatoxanthin, Myxoxanthin, Myxoxanthophylls, Fucaxanthin, Zeaxanthin, Ocillaxanthin, Terraxanthin etc.
Myxoxanthin and Myxoxanthophyll are present only in Cyanophyceae, Terraxanthin only in Rhodophyceae, Antheroxanthin only in Euglenineae.

Carotenoid acids- Carotenoid acid resembles with carotene and xanthophylls and are hydrocarbons consisting a chain of carbon atoms.

c) Phycobilins or biliprotiens- Phycobilins are soluble in water. They are attached to a protein moiety. There are three types of phycobilins- phycocyanin, phycoerythrin and allophycocyanin. r-phycocyanin and r-phycoerythrin are confined to Rhodophyceae while c-phycocyanin and c-phycoerythrin are found in cyanophyceae. Allophycocyanin is found in Rhodophyceae.

4-Nature of reserve food material: The main reserve food material in algae is starch which is a product of photosynthesis. Due to accumulation of food over long period the nature of reserve food material may be different. In Chlorophyceae starch remains the reserve food material. In Cyanophyceae it is myxophycean starch. Floridean starch is found in Rhodophyceae. In Pheaophyceae, mannitol, laminarin are main reserve food material while in Xanthophyceae, leucosine and oil are reserve food.

5-Flagellation: Flagella are the important basis of criteria to classify the algae. The type, number and position of flagella is different for different classes of algae. Flagella are entirely absent in Cyanophyceae and Rhodophyceae.

There are two main types of flagella- **whiplash** or **acronematic** and **tinsel** or **pleuronematic**.

(A)Whiplash or **acronematic-** It has smooth surface.

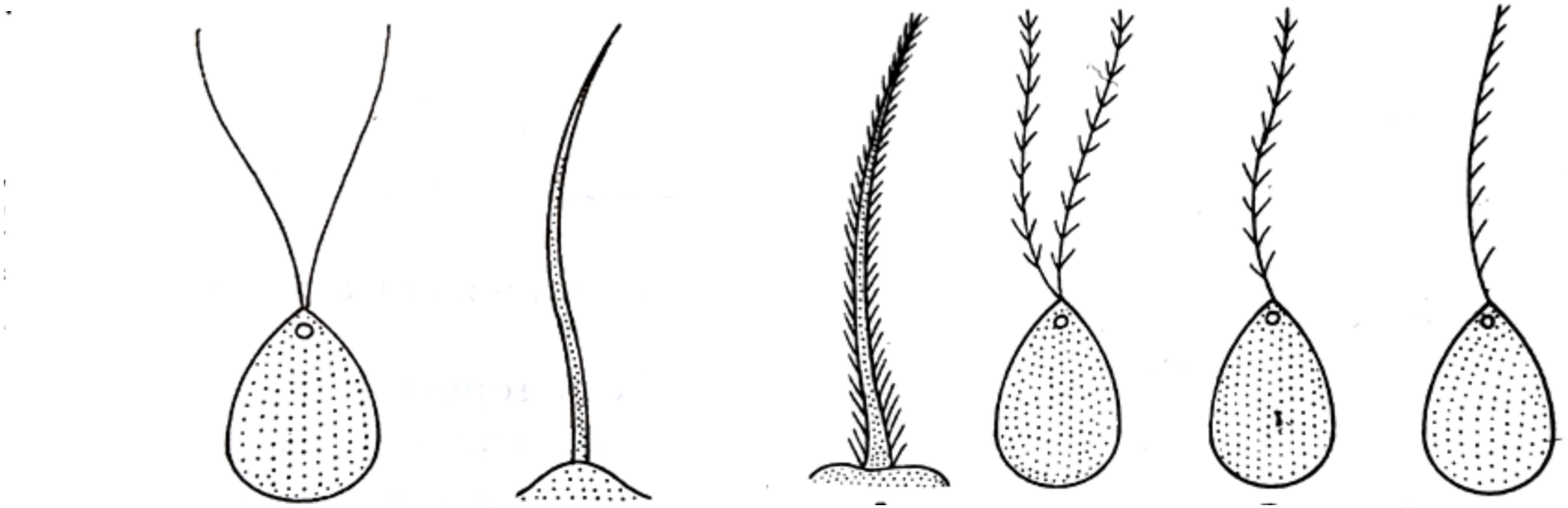
(B) Tinsel or **pleuronematic** tinsel flagellum bears longitudinal rows of fine, minute flimmers or mastigonemes. Tinsel flagella may be *pantonematic*, *pantoacronematic* or *stichonematic*.

(a)Pantonematic-Mastigonemes are arranged in two opposite rows in the flagellum.

(b)Pantoacronematic- It is a pantonematic flagellum with terminal fibril.

(c) Stichonematic- Mastigonemes are present only on one side of flagellum.

In Chlorophyceae flagella are 2, 4 or indefinite in number, apical or sub-apical in position and acronematicn type (isokontic- all flagella are of same type). In Xanthophyceae flagella are two, unequal, apical in position (heterokontic-one whiplash and one tinsel). In phaeophyceae flagella are two, lateral and unequal (one whiplash and one tinsel).



A B C D E F

Fig.- Flagellation in algae (A- F). (A, B) Acronematic flagella; (C) Pleuronematic flagellum with mastigonemes (D) Cell with two equal pantonematic flagella, (E) Pantoacronematic flagellum, (F) Stichonematic flagellum

6- Type of lifecycle and reproduction- The presence or absence of sexual reproduction, complexity of reproductive organs, and method of reproduction is also considered as criteria to classify the algae. Haplontic, diplontic and triphasic life cycle are characteristics of different groups. Sexual reproduction is completely absent in Cyanophyceae. In Rhodophyceae and Phaeophyceae, reproduction is oogamous and life cycles are usually complex. In chlorophyceae reproduction may be isogamous, anisogamous and oogamous, the life cycle may be simple or complex.

THALLUS ORGANIZATION IN ALGAE

As we all know that algae are thalloid plants that lack differentiation into roots, stem and leaves. The thallus of algae ranges from simple single cell to the highly organized one having differentiation of tissues yet lack vascular tissues. There exists motile unicellular solitary or colonial, unicellular non motile may be solitary or colonial, filamentous forms either unbranched or branched, heterotrichous filament etc.

In this section you will able to know the varied forms of thallus in algae which are as follows:-

(A) Unicellular motile form- Unicellular motile algae can move with the help of flagella attached at the anterior end of the body e.g., *Chlamydomonas*. The number of the flagella may vary in different algal forms.

(B) Unicellular non-motile forms- These unicellular forms have no locomotory organ (flagella are absent) e.g., *Chlorella*, *Gloeocapsa*, *Cosmarium*, *Closterium* etc.

(C) Multicellular colonial forms- Many cells come together and forms colony and each cell of colony is capable of doing life processes. The colonial forms are of following types-

a) **Motile coenobial colony-** Definite numbers of motile cells are embedded in gelatinous matrix with flagella protruded out and all cells are connected with cytoplasmic connections in a motile colony. The cells are compactly or loosely arranged. A colony formed of definite number of cells arranged in a specific manner is known as **coenobium**. E.g., *Volvox* , *Pandorina*, *Eudorina* etc.

b) **Non-motile coenobial colony or coccoid form-** In this type of colony definite number of cells are closely attached together in specific manner and does not have flagella as locomotory organ. E.g., *Hydrodictyon*, *Pediastrum* etc.

c) **Palmelloid form-** In this type of colony, cells are aggregated together in a gelatinous matrix of indefinite shape but the number of cells are not fixed as in the case of coenobium. In palmelloid form cells are embedded in mucilaginous substance. It can be a temporary stage as in the case of asexual reproduction of *Chlamydomonas* or may be permanent as in *Tetraspora*.

(d) Dendroid form- This is also a non motile colony of unfixed number of cells but differs from palmelloid form in having attachment of cells to the substratum. E.g., *Prasinocladus*, *Mischococcus* etc.

(D) Filamentous form- Filamentous thallus may be of indefinite length. The cells are attached end to end in a linear fashion and form a filament. The filamentous form may be branched, unbranched or falsely branched.

a) **Unbranched filament-** Simple unbranched filaments are found in many algalll forms. They are either free living e.g., *Spirogyra* or attached e.g., *Oedogonium*, *Ulothrix* or may be found in colonial forms e.g., *Nostoc*.

b) **Branched filament-** In this type of algal forms, filaments are branched e.g., *Cladophora*.

c) **False branching-** In falsely branched filamentous forms, filament appear to be branched but it is not actually branched. Two filaments generally come so close to each other that they appear to be branched e.g., *Scytonema*.

(E). Siphonaceous form- The thallus is non-septate, multinucleate siphon like structure. It may be simply branched or elaborately developed with clear division of labour being differentiated into aerial and subterranean and in some cases into subaerial branches. E. g., *Vaucheria* , *Botrydium*, *Caulerpa*, *Codium*, *Halimeda* etc.

(F). Heterotrichous form- This is a highly advanced type of thallus which is characterized by the differentiation of plant body into prostrate and erect system. This type of thallus shows a good amount of labour division. This algal form is chararcteristic feature of Chaetophorales order of class Chlorophyceae, in many Phaeophyceae, Rhodophyceae, in some Chrysophyceae and Dinophyceae. The prostrate system is attached to the substratum with the help of some rhizoidal filaments. The erect system is developed from the prostrate system. E.g., *Fritschiella*, *Ectocarpus* *Dinoclonium*, *Stigeoclonium*, *Trentepholia*, *Coleochaete*, *Drapanaldiopsis* etc.

(G). Pseudoparenchymatous form- As the name implies it is a type of thallus which looks like parenchymatous but not a true parenchymatous form. Parenchyma is a type of tissue in which a single parent cell divides and redevides to form a tissue whereas in pseudoparenchymatous algal forms the thallus is constructed by the close association of cells or of filaments rather than a parent cell. The filament may form uniaxial axis as in *Batrachospermum* or multiaxial as in the case of *Polysiphonia*. Other examples include *Chara* and *Nitella*.

(H). Parenchymatous Form- Parenchymatous thallus organization is a modification of the filamentous habit; in which cell division occur in various directions to form parenchymatous structure. Such thallus may appear flat, leaf like or cylindrical or well branched. Common examples of flat and leaf like parenchymatous thalli are *Ulva*, *Punctaria* and *Porphyra*. Tubular parenchymatous thallus is found in *Enteromorpha*. *Sargassum* shows specialized differentiation of cells. The other examples are *Laminaria*, *Fucus*, *Dictyota* etc.

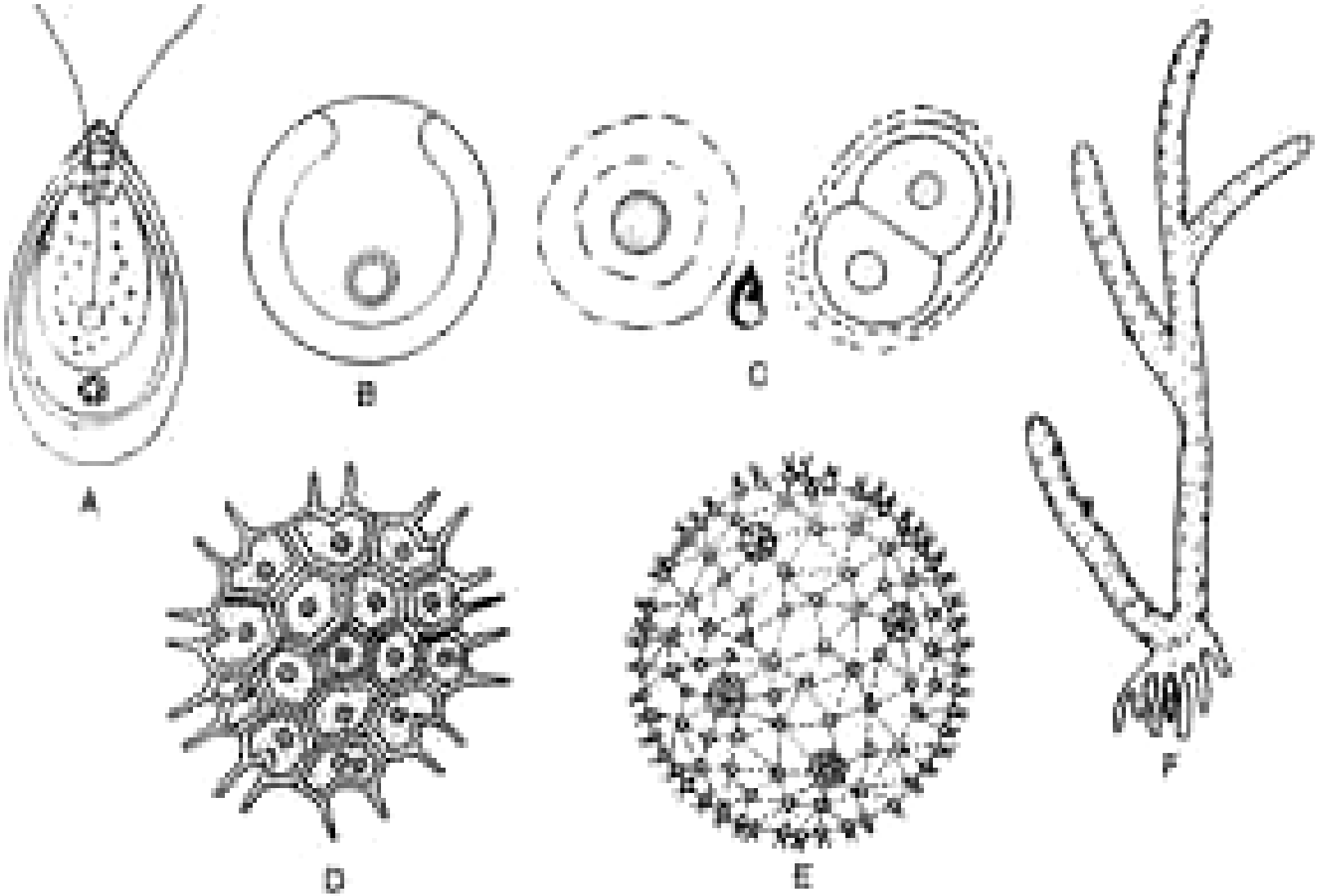


Fig. Range of thallus organization in algae. (A) Chlamydomonas, (B) Chorella, (C) Gloeocapsa, (D) Pediastrum, (E) Volvox, (F) Vaucheria

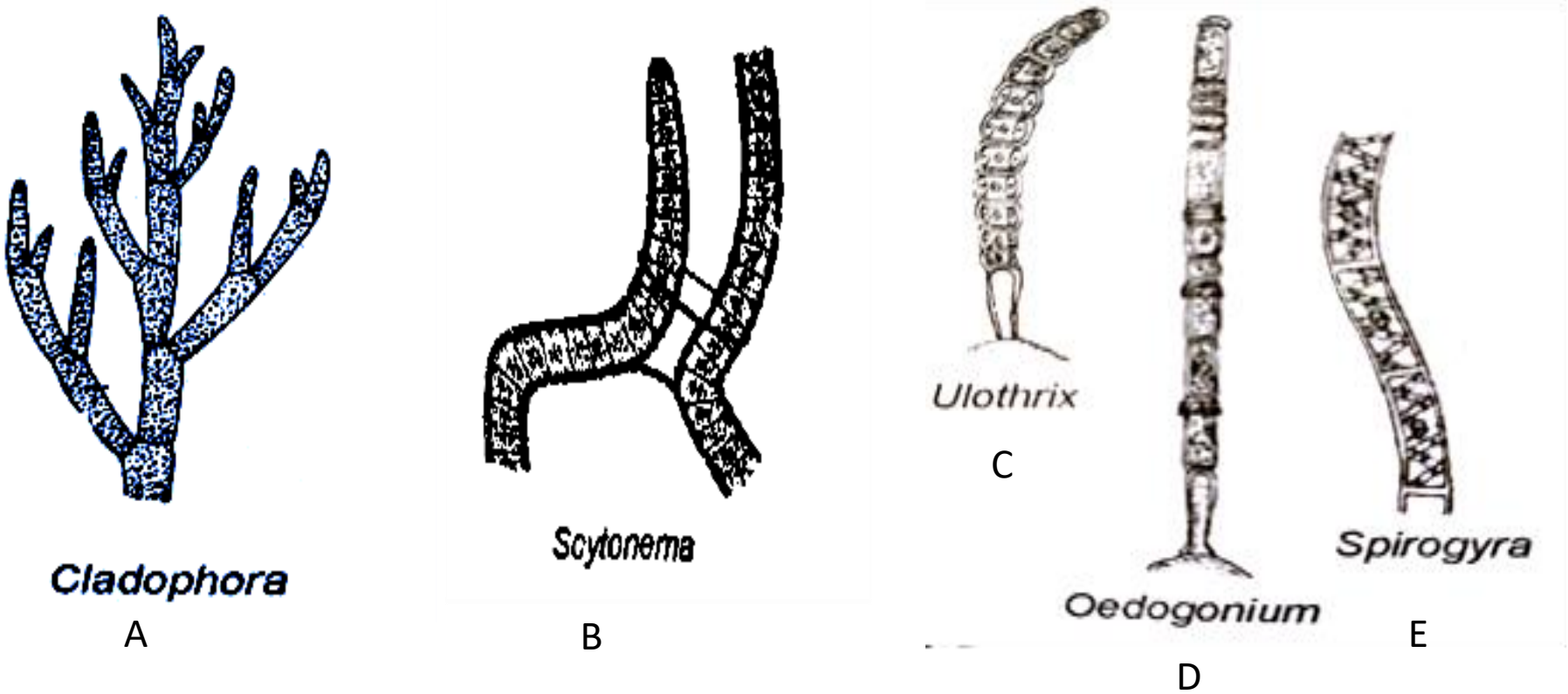


Fig. Filamentous thallus (A) Branched filament, (B) False branching, (C, D, E) Unbranched filaments

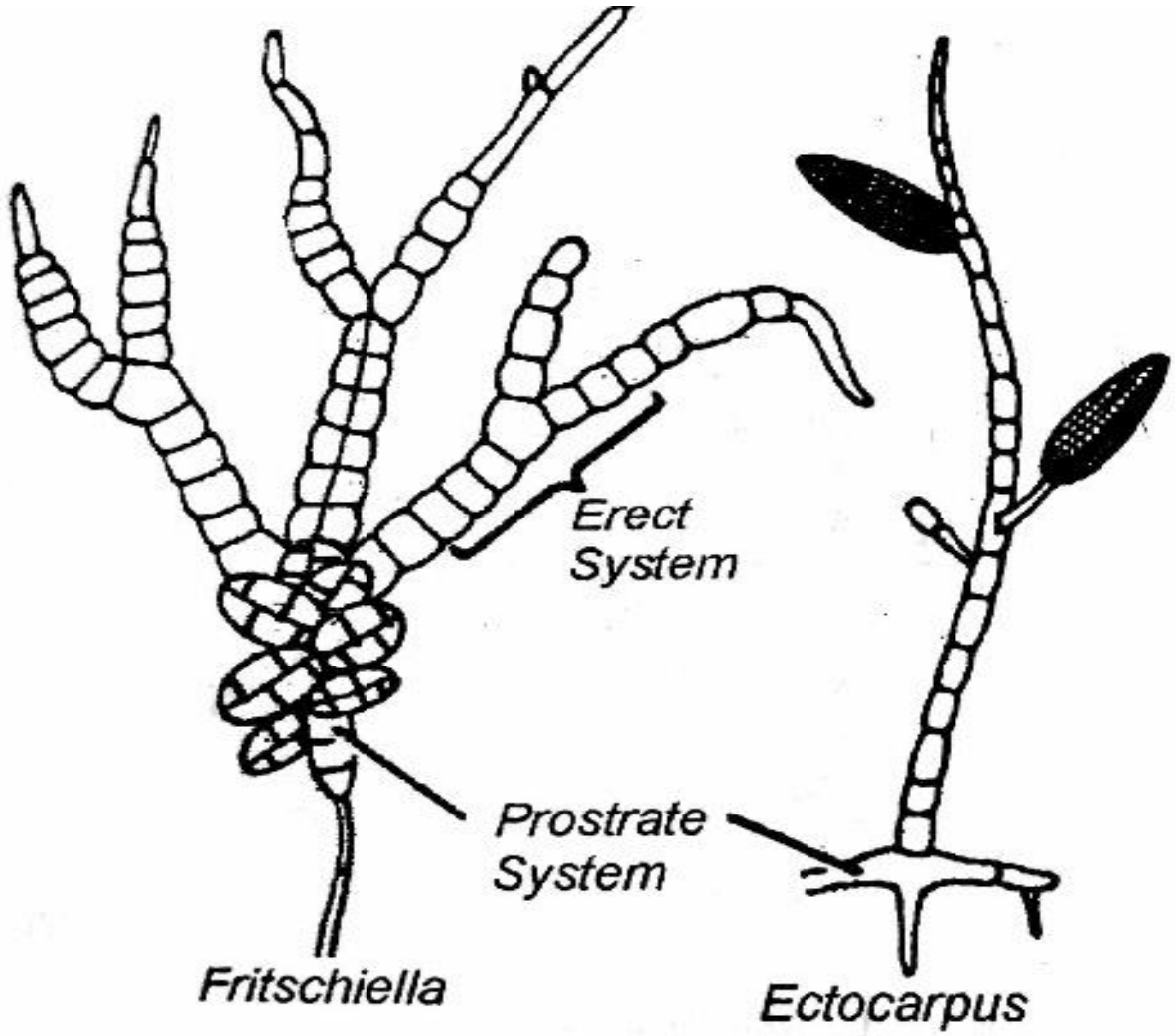
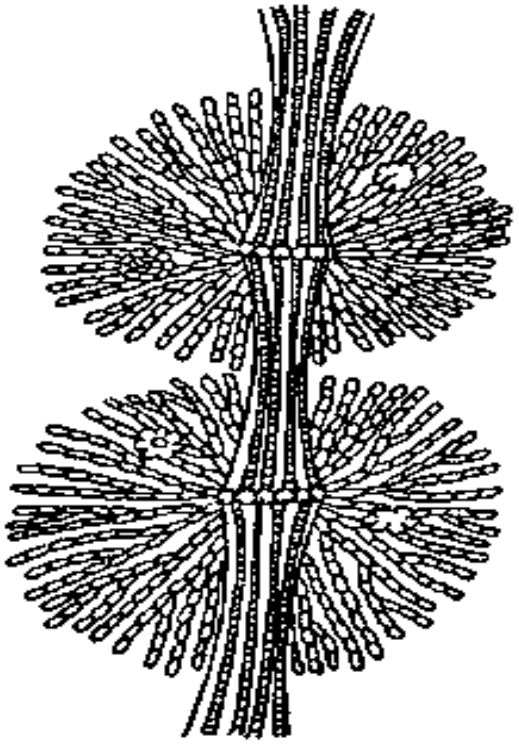
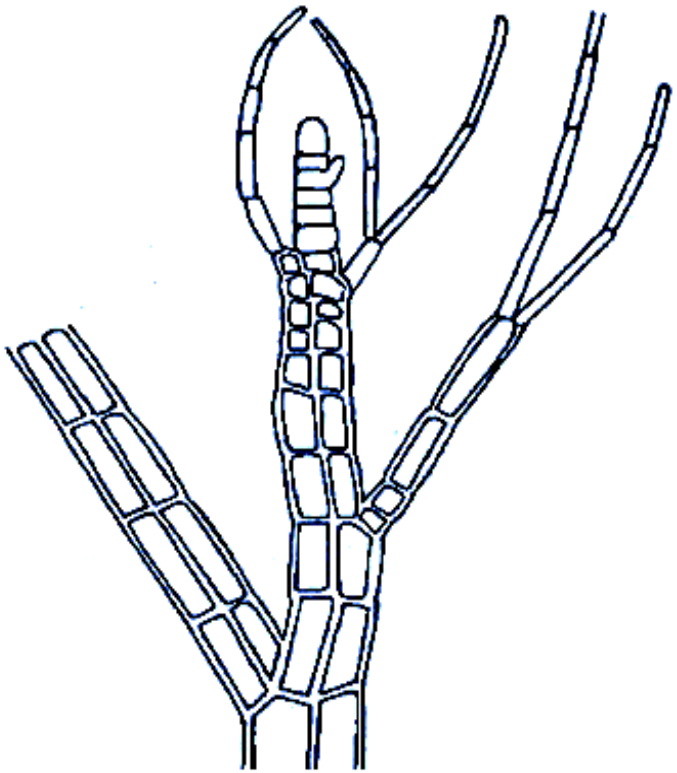


Fig. Heterotrichous thallus



A



B

Fig. Pseudoparaenchymatous thalli (A) Batrachospermum, (B) Polysiphonia

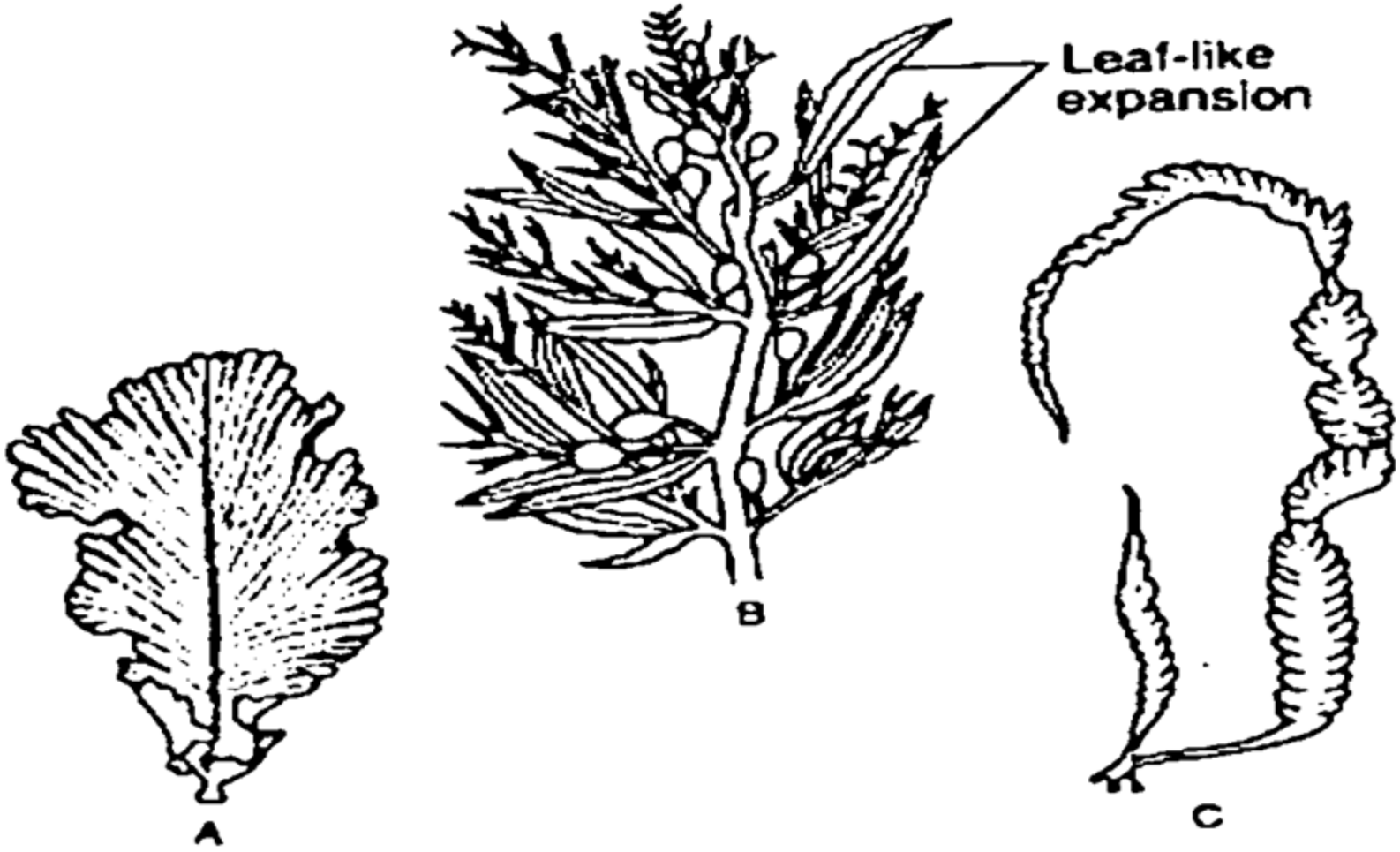


Fig. Parenchymatous thallus (A) Ulva, (B) Sargassum (C) Laminaria