ALGAE

UNIT-I & II

The algae are chlorophyll-containing primitive plants, both prokaryotic and eukaryotic, with wide range of thaifi starting from unicellular to multicellular organisations. Autophytic (which can manufacture their own food) and thalloid plant bodies are also found in Bryophytes.

Fritsch, F. (1935) defined algae as the holophytic organisms (as well as their numerous colourless derivatives) that fail to reach the higher level of differentiation characteristic of the archegoniate plants.

Characteristics of Algae:

1. Algae are chlorophyll-bearing autotrophic thalloid plant body.
2. Almost all the algae are aquatic.
3. The plant body may be unicellular to large robust multicellular structure.
4. The multicellular complex thalli lack vascular tissue and also show little differentiation of tissues.
5. The sex organs are generally unicellular but, when multicellular, all cells are fertile and in most cases the entire structure does not have any protection jacket.
6. The zygote undergoes further development either by mitosis or meiosis, but not through embryo formation.
7. Plants having distinct alternation of generations. Both gametophyte and sporophyte generations — when present in the life cycle are independent.

Occurrence of Algae:

The algae are ubiquitous (present everywhere) in distribution, i.e., they are found in fresh water as well as marine water, on soil, on rock, as epiphytes or parasites on plants and animals, in hot springs, in desert, on permanent snow-fields etc. But they mainly dwell in aquatic environments.

Based on habitat the algae may be categorized as:

1. Aquatic algae.

2. Terrestrial algae, and

3. Algae of remarkable habitats.

1. Aquatic Algae:

Aquatic algae may be fresh water (when salinity is as low-as 10 ppm) or marine (when salinity is 33-40%). Again, certain algae grow in brackish water which is unpalatable for drinking, but less salty than sea water. The fresh water algae usually grow in ponds, lakes, tanks, ditches etc.

The very common fresh water algae are Chlamydomonas, Volvox, Ulothrix, Chara, Oedogonium, Spirogyra, Nostoc, Oscillatoria etc. Some of the very common marine algae are Sargassum, Laminaria, Ectocarpus, Polysiphonia, Caulerpa, Bangia, Padina etc.

Fresh water algae may be termed as planktonic when they grow and remain suspended on the upper part of water (e.g., Volvox, diatom), while the benthic algae are bottom-dwellers. The algae that grow at air-water interface are called neustonic. The benthic algae may be epilithic, that grow on stones; epipelic attached to sand or mud; epiphytic — growing on plants; and epizoic — growing on animal body surface.

The marine algae may be supralittoral or sub- aerial, as they grow above the water level and in the spray zone. The intertidal algae grow in such a depth so that they are exposed periodically due to tides. Other marine algae are sublittoral, meaning hat they are constantly submerged at depths as great as 30-60 metres (100-200 ft).

Again, the supralittoral algae may be edaphic— that grow in and on the soil, epilithic— growing on stones, epiphytic — growing on plants, epizoic— growing on animal body surface, and corticolous — growing on tree barks and parasitic on plants and animals. Some algae (e.g., Chlorella) live endozoically in various protozoa, coelenterates, molasses etc.

2. Terrestrial Algae:

Some algae are found to grow in terrestrial habitats like soils,’ rocks, logs etc. The algae that grow on the surface of the soil are known as saprophytes. Many blue-greens, on the other hand, grow under the surface of the soil, and are called cryptophytes.

The algae growing in the desert soil may be typified as endedaphic (living in soil), epidaphic (living on the soil surface), hypolithic (growing on the lower surface of the stones on soil), chasmolithic (living in rock fissures) and endolithic algae (which are rock penetrating).

The common terrestrial members are Oscillatoria sancta, Vaucheria geminata, Chlorella lichina, Euglena sp., Fritschiella sp. and Phormidium sp.

3. Algae of Remarkable Habitats:

In addition to above mentioned habitats, some algae also occur in uncommon habitats and termed as:

1. Halophytic Algae (or Eurhaline):

They grow in the highly concentrated salt lakes, and include Chlamydomonas ehrenbergli, Dunaliella and Stephanoptera sp.

2. Symbiotic Algae:

They grow in association with fungi, bryophytes, gymnosperms or angiosperms. The best examples of symbiotic algae found in association with fungi are Nostoc, Gloeocapsa, Rivularia; the members of Cyanophyceae and Chlorella, Cytococcus, Pleurococcus; the members of Chlorophyceae.

This symbiotic association consisting of algae and fungi is called lichen. Nostoc may also associate with Anthoceros and Anabaena associates with the roots of Cycas to form coralloid roots.

3. Cryophytic Algae:

This group of algae growing on ice or snow provides attractive colours to snow-covered mountains. The alpine and arctic mountains become red due to the growth of the Haemotococcous nivalis; green snow in Europe is due to the growth of Chlamydomonas yellowstonensis. Scotiella nivalis and Raphidonema brevirostri cause black colouration of snow, whereas Ancyclonema nordenskioldii is responsible for brownish purple colouration.

4. Thermophytes or Thermal Algae:

This group of algae occurs in hot water springs (50- 70°C) where normal life is not possible. Many blue-greens (e.g., Oscillatoria brevis, Synechococcus elongates, Heterohormogonium sp.) are grown in such hot springs.

5. Lithophytes:

They grow on the moist surface of stones and rocks, e.g., Nostoc,. Gloeocapsa, Enteromofpha, Batrachospermum etc.

6. Epiphytic Algae:

They grow on other plants including other algal members.

These are:

a. Algae on Algae:

i. Ptilota plumosa and Rhodymenia pseudopalmatta on Laminaria hyperborean, ii. Diatoms on Oedogonium, Spirogyra etc.

b. Algae on Bryophytes:

Blue-green algae like Nostoc, Oscillatoria, diatoms like Achnanthes etc. grow on different bryophytes.

c. Algae on Angiosperms:

Algae like Cocconis, Achnanthes etc. grow epiphytically on Lemna, an aquatic angiosperm. Alga like Trentepohlia grows on the barks of different angiospermic plants, and is very common in Darjeeling (India).

7. Epizoic Algae:

The algae growing on animals like fish, snail etc. are called as epizoic, e.g., Stigeoclonium are found in the gills of fishes.

8. Endozoic Algae:

They grow in the tissues of animals, e.g., Zoochlorella sp. is found in Hydra viridis.

9. Parasitic Algae:

Some algae grow parasitically on different plants and animals.

These are:

a. Cephaleuros (Chlorophyceae) is parasitic and grows on the leaves of various angiosperms, such as tea (Camellia sinensis), coffee (Coffea arabica), Rhododendron, Magnolia and pepper (Piper nigrum). The most important one is Cephaleuros virescens, which causes Red rust of tea.

b. Rhodochytrium (Chlorophyceae) grows on ragweed (Ambrosia) leaves.

c. Phyllosiphon (Chlorophyceae) grows on the leaves of Arisarum vulgare.

d. Ceratocolax (Rhodophyceae) grows in Phyllophora thallus.

10. Psammon:

The algae which grow in sandy beaches are called psammon, e.g., Vaucheria, Phormidium etc.

Classification of Algae by Smith

G.M.Smith's Classification (1955):

Smith proposed the classification of algae taking into consideration the evolutionary principles proposed by Fascher (1914). He did not use the term algae. He classified spore producing plants into various divisions.

(1) Division: Chlorophyta

Class 1: Chlorophyceae(Grass green algae)

Class 2: Charophyceae(stoneworts)

(2) Div: Euglenophyta

Class 1: Euglenophyceae(Euglenoids)
(3) Div: Pyrrophyta
Class 1: Desinophyceae(Dinophysids)
Class 2: Dinophyceae(Dinoflagellates)
(4) Div: Chrysophyta
Class 1: Chrysophyceae (Golden brown algae)
Class 2: Xanthophyceae(Yellow green algae)
Class 3: Bacillariophyceae(Diatoms)
(5) Div: Phaeophyta (Brown algae)
Class 1: Isogenerateae
Class 2: Heterogenerateae
Class 3: Cycyclosporeae
(6) Div: Cyanophyta
Class 1: Myxophyceae
(7) Div: Rhodophyta(Red algae)
Class 1: Rhodophyceae
(8) Div: Algae of uncertain systemic position
Chloromopnadales
Cryptophyceae.

Ultrastructure of Eukaryotic Algal Cell:

Ultrastructure can be divided into following parts :

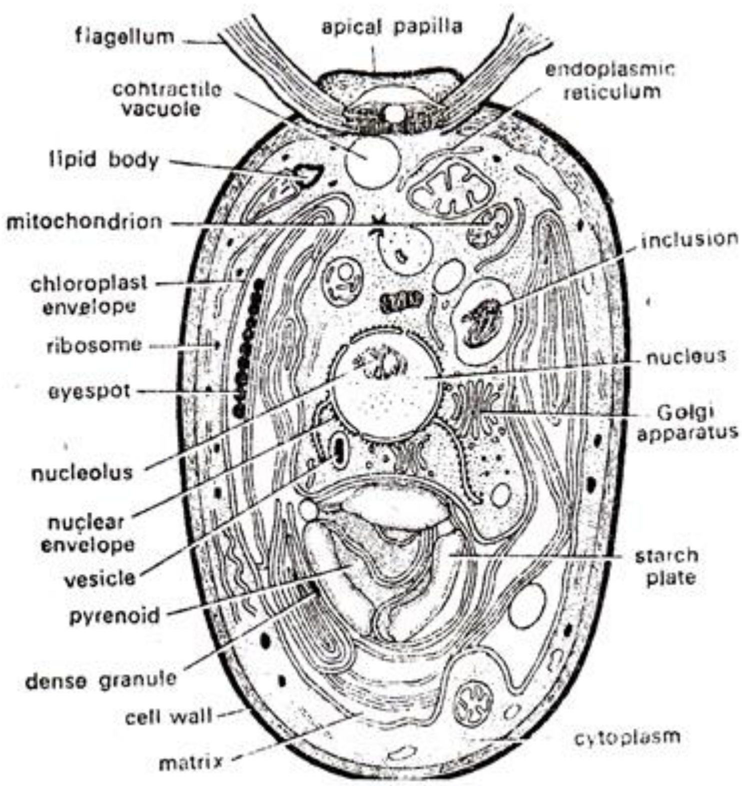


Fig. 1. *Chlamydomonas.* Ultrastructure of eukaryotic cell.

Cell Wall of Eukaryotic Algal Cell:

The cell is bounded by a thin, cellulose cell wall. Cellulose layer is finely striated with parallel cellulose fibrils (Fig. 1). In many species there is a pectose layer external to it which dissolves in water and forms a mucilaginous pectin layer. According to Roberts et. al. (1972), Hills (1973) the cell wall in C. Reinhardt consists of seven layers.

Plasma Lemma of Eukaryotic Algal Cell:

It is present just below the cell wall and consists of two opaque layers which remain separated by less opaque zone.

Protoplast of Eukaryotic Algal Cell:

It is bounded by plasma lemma. It is differentiated into cytoplasm, nucleus, chloroplast with one or more pyrenoids, mitochondria, Golgi bodies, two contractile vacuoles, a red eye spot and two flagella.

Chloroplast of Eukaryotic Algal Cell:

In majority of the species of Chlamydomonas, cytoplasm contains of a single, massive cup shaped chloroplast which almost fills the oral or pear shaped body of the cell. It is surrounded by a double-layered unit membrane. It bears number of photosynthetic lamellae (disc or thylakoids).

The lamellae are lippo-proteinaceous in nature and remain dispersed in a homogeneous granular matrix (stroma). About 3-7 thylakoids bodies fuse to form grana like bodies. Matrix also contains ribosomes, plastoglobuli, microtubules and many crystals like bodies.

Flagella of Eukaryotic Algal Cell:

The anterior part of thallus bears two flagella. Both the flagella are whiplash or acronematic type, equal in size. Each flagellum originates from a basal granule or blepharoplast and comes out through a fine canal in cell wall. It shows a typical 9+ 2 arrangement. Fibrils remain surrounded by a peripheral fibril. According to Ringo (1907), 2 central ones are singlet fibrils and 9 peripheral ones are doublet fibrils (Fig. 2).

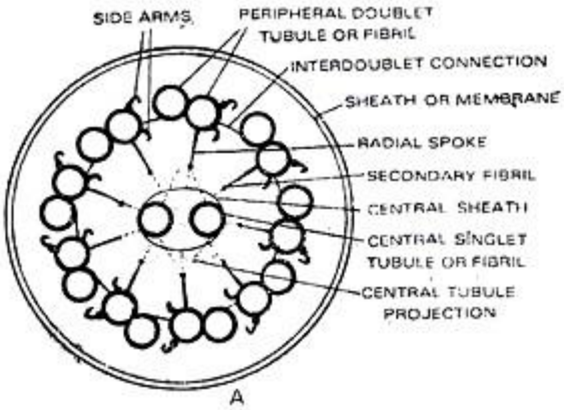


Fig. 2. Ultrastructure of flagellum of *Chlamydomonas.*

Stigma or Eyespot of Eukaryotic Algal Cell:

The anterior side of the chloroplast contains a tiny spot of orange or reddish colour called stigma or eyespot. It is photoreceptive organ concerned with the direction of the movement of flagella. The eye spot is made of curved pigmented plate. The plate contains 2-3 parallel rows of droplets or granules containing carotenoids .

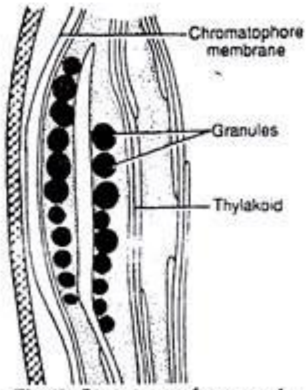


Fig. 3. Structure of eyespot.

The other structures such as mitochondria, Golgi bodies, endoplasmic reticulum and nucleus are also bounded by double-layered unit membrane.

Ultrastructure of Prokaryotic Cell:

The cell exhibits a typical prokaryotic structure. It can be differentiated into two parts:

1. Outer cellular covering

2. Cytoplasm

1. Outer Cellular Covering of Cyanobacterial Cell:

It can be differentiated into following parts:

A. Slime layer or Mucilaginous sheath:

Presence of mucilaginous sheath is the characteristic feature of cyanobacteria. It consists of fibrils reticulately arranged within the matrix to give a homogeneous appearance (Fig. 4 A). Fibrils are made up of peptic acids and mucopolysaccharides. It retains the absorbed water and protects the cell against dessication.

B. Cell Wall:

It is present between the slime layer and plasma membrane. It is a rigid and complex structure and resembles the cell wall of bacteria. It is made of four layers. Carr and Whitton (1973) named all these four layers as L I, L II, L III and L IV). L I is a transparent space and occurs between the L II and plasmembrane. L II and L III are mucopolymer, made up of alanine, glucosamine, peptidoglycan, muramic acid, glutamic acid and α-diaminopimelic acid. The L IV is undulating, wavy and made of liposaccharides and proteins.

C. Plasma Membrane:

It is present below the cell wall. It is made up of protein-lipid-protein layers. The cytoplasmic membrane and its invaginations are the sites of biochemical functions, normally associated with the membrane bounded structures like mitochondria, endoplasmic reticulum and Golgi bodies of the eukaryotic cells.

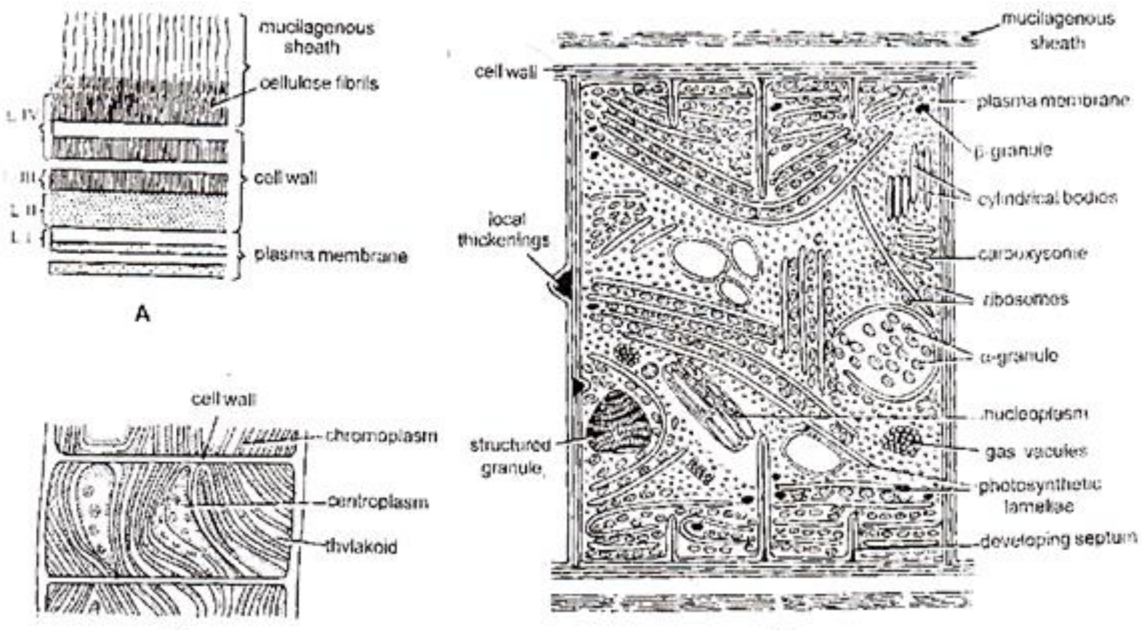


Fig. 4. (A–C). Cyanobacteria. Cell structure. A. Cell structure as seen under light microscope, B. Cell wall as seen under electron microscope, C. Ultrastructure of a cell.

2. Cytoplasm of Cyanobacterial Cell:

It is differentiated into two regions

(1) Chromoplasm

(2) Centroplasm

(1) Chromoplasm:

It is the outer or peripheral pigmented region. This region consists of flattened vesicle like structures called thylakoids or photosynthetic lamellae. These lamellae contain chlorophyll V, carotenoids and three phycobilins—C-phycocyanin, allophycocyanin and C-phycoerythrin.

Photosynthetic lamellae are arranged in parallel rows close to the periphery of the cell or they are distributed irregularly throughout the cell. In between the lamellae, occur certain granules of 400 A° diameter. These granules contain phycobilin pigment and are called cyanosomes y or phycobilisomes.

(2) Centroplasm:

It is the inner or central colourless region. It is often called nucleoid or incipient nucleus. It consists of DNA fibrils. DNA is not surrounded with protein materials (histones). Like bacteria, small circular DNA segments occur in addition to nucleoid. These are known as plasmids or transposons. 70S ribosomes are also present in this region).

Cytoplasmic Inclusions:

The membrane bound organelles such as the plastids, endoplasmic reticulum, vacuoles, mitochondria and the dictyosomes are absent. However, the chromoplasm contains a large number of inclusions.

These are ribosomes, a granules, (3 granules, structural granules, polyhedral bodies, gas vacuoles and vacuoles like inclusions (Fig. 4 C). α granules are also called mitochondrion granules and are said to be the region of storage. β granules are thought to be equivalent to cyanophycin (cyanophycean) granules.

Structural granules are considered as modified β or cyanophycean granules. Polyhedral bodies are also found in the central region. They are associated with the genetic material but their function is unknown. In some cyanobacteria e.g., Oscillatoria, gas filled vacuoles (pseudo vacuoles) are present in the peripheral part of the cell. A gas vacuole is made up of a large number of units called vesicles. Gas vacuoles provide a buoyancy regulating mechanism.

OSCILLATORIA

Scientific classification

Domain: Bacteria

Phylum: Cvanobacteria

Order: Oscillatoriales

Genus: Oscillatoria

Occurence:

Oscillatoria princeps grows in sea water and sub-aerial habitats. O. brevis can separation bear a temperature of -16°C while O. terebriformis occurs in hot water springs (thermal algae). Some of saprophytic species are found in the digestive and respiratory tracts of the animals.

Thallus Structure of Oscillatoria:

It is an un-branched filamentous alga. Filaments may be either attached or free floating and rarely occur singly. In majority of the species they form compact tangle mass or spongy sheets. The filaments may be interwoven or arranged in parallel rows. The filaments are uniseriate each containing a single trichome the trichomes are usually naked and have a thin, poorly developed sheath.

They are usually smooth but sometimes constricted at the cross walls. Each trichome is an un-branched, long, flat thread like structure made up of numerous cells. The cells are broader than in their length and show prokaryotic organization.

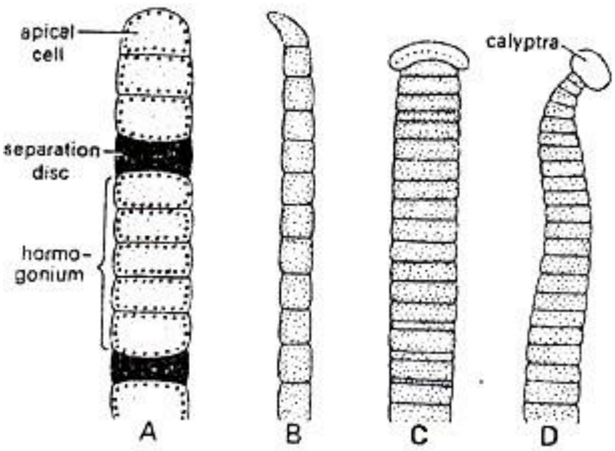


Fig. 1 (A–D) : *Oscillaloria* : Trichomes.

Cell Structure of Oscillatoria:

All cells in the trichome are similar in structure. It can be differentiated into two parts: Cell wall and protoplasm. Cell wall is made of mucopeptide. Ultra structurally it consists mainly a 2000 A structural layer external to plasma membrane. Outside the structural layer is 160° A° thick another layer and there is a third 90° A layer loosely wrapped around the two.

The structural layer has s series of 700 A° wide pores which terminate at the 160 A° layer. Under an ordinary microscope the protoplasm is distinguishable into a peripheral chromoplasm and a central colourless centroplasin or central body.

Ultrastructure of cell shows that the chromoplasm contains photosynthetic lamellae or single thylakoid which often run parallel to one another. The thylakoids contain photosynthetic pigments like chlorophyll a, carotenes, xanthophyll’s and phycobilins (C-phycocyanin, allophycocyanin, c-phycoerythrin).

Phycobilins occur in minute vesicles called phycobilisomes. The centroplasm represents the incipient nucleus called gonophore. It is represented by DNA fibrils. The cell contains many ribosomes but mitochondria, plastids, ER and Golgi bodies are absent.

Reserve food material is in the form of cyanophycean starch, lipid, globules and cyanophycin. The protoplasm also contains two types of granules α and β α granules contain proteins and polysaccharides while (3 granules have lipid. Planktonic species of Oscillatoria possess gas vacuoles or pseudovaculoles which are devoid of any membrane. It is made of a number of ‘hexagonal’ structures called ‘gas vesicles’

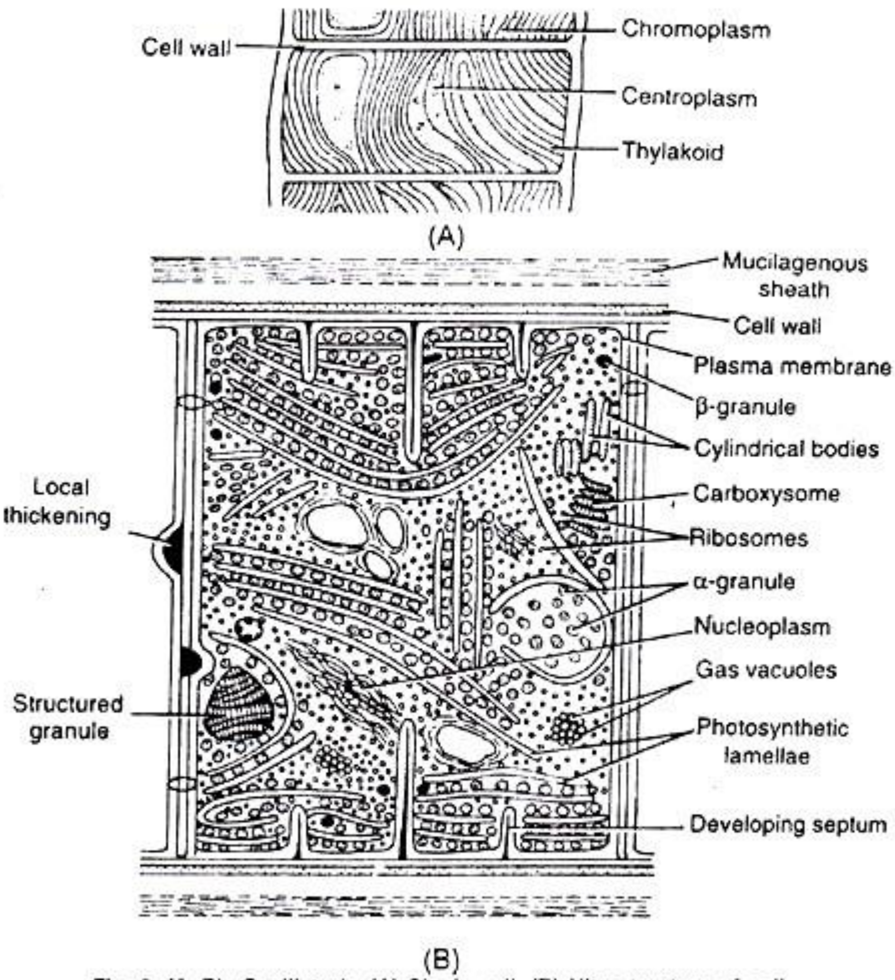


Fig. 2. (A–B). ***Oscillatoria*****. (A) Single cell, (B) Ultrastructure of cell.**

The trichome shows polarity. It possesses characteristic apical cell. It may be cap like (capitate) or covered by a thick membrane called calyptra. The apical cell may also be conical, dome shaped, acuminate, oval, flattened convex or coiled and accordingly to the shape of the cap cell, the species are identified

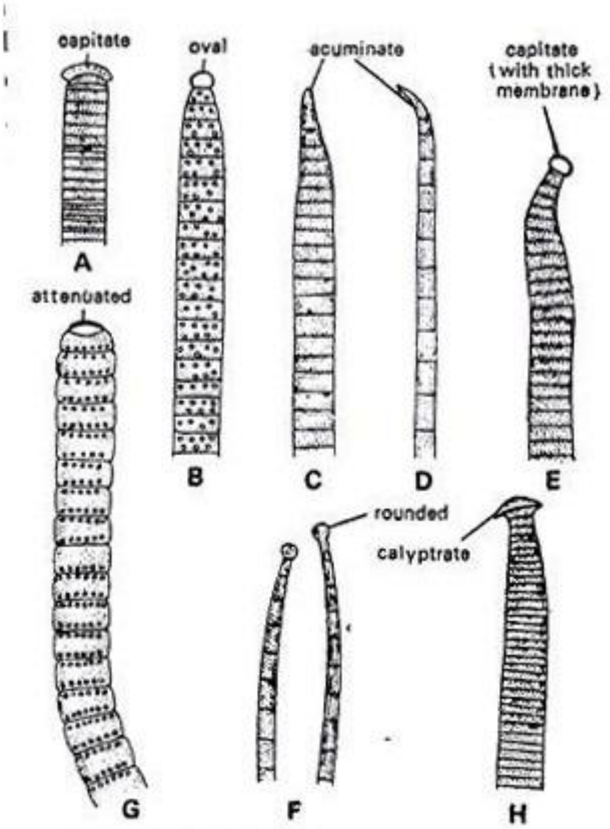


Fig. 3. (A—H). ***Oscillatoria.*** **Apex of trichomes showing different shapes of the terminal cells.**

<u>Reproduction in Oscillatoria:</u>

Oscillatoria reproduces only be vegetative methods.

These are:

1. By fragmentation:

It occurs due to accidental breakage of the filament, biting of some .insects or animals. Filament divides into small pieces or fragments. Each of these fragments is capable of developing into new individual.

2. By hormorgonia:

Hormogones are formed due to formation of separation discs. These discs are mucilaginous, pad like and biconcave in shape. These are formed by death of one or more cells of the filament. These mucilage filled dead cells are also called necridia.

Movement in Oscillatoria:

The name Oscillatoria (oscillare, to swing) is given to this alga due to the peculiar movement shown by the. trichome. It is called 'oscillatory movement'. These are the jerky, pendulum-likemovements of the apical region of the trichome.

Some other movements shown by the trichomes of Oscillatoria are:

Gliding or creeping movement:

The trichome moves forward and backward along its long axis.

Bending movement:

The tip of the trichome shows bending.

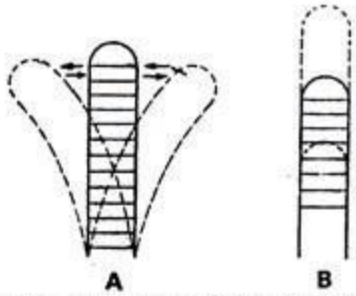
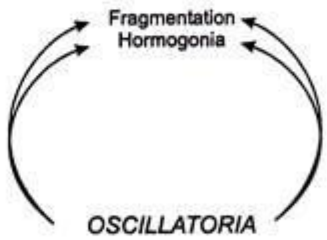


Fig. 3 (A, B). *Oscillatoria*. (A). Oscillatory movement; (B) Gliding movement.

LIFE CYCLE



CHLAMYDOMONAS

Kingdom: Plantae

Division: Chlorophyta

Class: Chlorophyceae

, Order: Volvocales

Family: Chlamydomonadaceae

Genus: Chlamydomonas algae ك

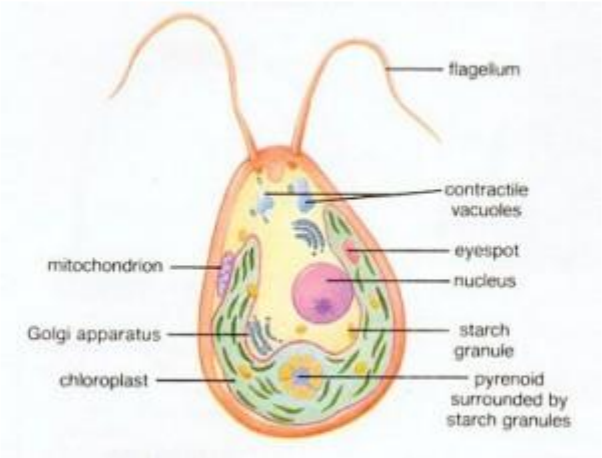
Occurrence

Chlamydomonas has 150 species. It is the commonest unicellular Volvocales. It is one of the simplest unicellular widely distributed algae. It is found in standing water of ponds, pools, ditches and on moist soil. It often grows in abundance in water rich in ammonium compounds. The turbid green colour of the water of .he stagnant ponds is due to the presence of thousands of these rants. Some of the species occur in very unusual places. inlamydomonas ehrenbergi occurs in saline water. Some of its species are found in sea. A bright red pigment is often abundant in certain species, especially in The resting stages. Such plants make the pools red.

Structure of Chlamydomonas

Its vegetative stage has very simple structure. Its size is about 0.02 mm. Each cell is spherical, ellipsoidal, sub-cylindrical or pyriform. Their anterior end is more or less pointed. It has following structure: 1. Cell wall: There is a thin cell wall on the outside. It occasionally possesses an outer thin mucilage sheath. This sheath projects into a beak-like process at the anterior end.

Fig: cell structure of ChlamYdomonas



Flagella:

The two flagella situated anteriorly near the pointed. They either project through one aperture in the wall or through two separate canals. These flagella arise form two basal granules called blepharoplast.

Contractile vacuoles:

Each cell typically possesses two contractile vacuoles at the base of flagella. They have respiratory and excretory functions.

Eye spot:

An orange-red pigment spot or eye-spot (stigma) is present near the origin of flagella. This eye spot is covered by a minute lens in the thickness of the cell wall. It supposed to function as an extremely primitive eye. This is sensitive to light. Therefore, it directs the movement of the individual. In C. pluristigtna, there are two or three eye-spots. Eye spots are very sensitive to intensity of light.

Chloroplast: There is a large cup-shaped chloroplast towards the broader end. The chloroplast varies in shape. In C reticulate, g is reticulate. In C. aplina, it is small discoid. The plants are autotrophic. They prepare their own food by photosynthesis. by taking carbon dioxide from the water.

Pyrenoid:

Pyrenoid is embedded in the chloroplast. Pyrenoid consists of a central protein body surrounded by numerous minute starch grains. The number of pyrenoids is variable in different species. There may be two to any or no pyrenoid at all.

Nucleus: All species are uninucleate. A single nucleus lies in the cytoplasm, filling the cup of the chloroplast.

Reproduction

Both asexual and sexual reproductions occur in Chlamydomonas. Asexual reproduction

Asexual reproduction takes place by the following methods:

Zoospore formation:

Zoospores are formed when the conditions are favourable. During the formation of zoospores the cell becomes quiescent (nonmotile). Its flagella are retracted or discarded. The contractile vacuoles disappear. Its protoplast divides longitudinally into two. It is followed by a simultaneous division of each daughter protoplast and sometimes by a third series of division. Each division of the protoplast is preceded by the division of the nucleus into many parts. Thus each cell produces 2-16 pieces. Each piece secretes a wall around it and forms two flagella. Contractile vacuole and pigment spots also soon appear. In this way 2-16 swarmspores or zoospores are formed within the parent cell. The zoospores or swarmspores are liberated by gelatinization or by the rupturing of the patent cell wall. Each of them develops into a new Chlamyclomonas plant. This process of division is repeated every 24 hours. Thus by the end of week, from one parent plant about 2,000,000 individuals are formed.

Aplanospore formation:

Aplanospores are formed under conditions of drought. The zoospores instead of being liberated found up and develop into aplanospores. Aplanospores germinate directly or divide to produce zoospores on the approach of favourable conditions.

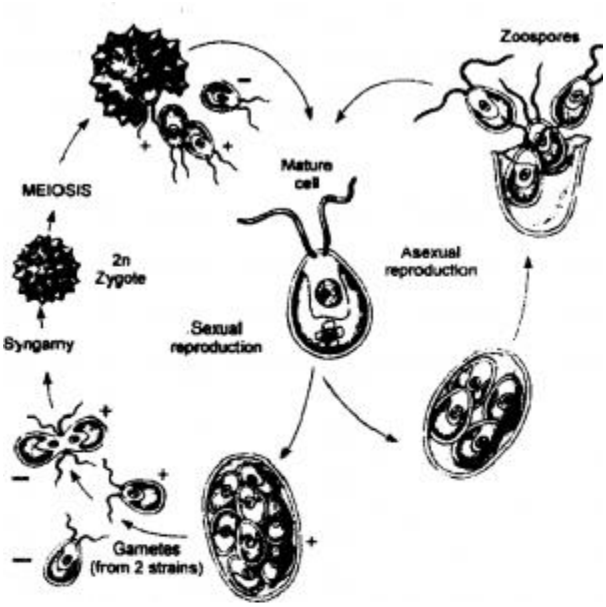
Palmella stage:

This stage is formed under less favourable, but not very dry conditions. In this condition, the ponds are gradually drying up. So the plants are growing on damp soil. The daughter cells are produced by the division of the parent cells. These cells do not develop flagella. They are embedded in the mucilage formed by the gelatinization of the parent cell wall. The daughtei'cells divide further into four. Their cell walls also become mucilaginous. Thus a large number of small non-motile structures are formed. They are embedded in jelly-like substance. In this way, an amorphous colony is formed. It has hundreds or thousands of cells. All its cells are embedded in a common gelatinous matrix. This stage is known as the palmella stage. It ;s named so because the older phycologists thought it to be a species of an alga named Palmella. This is however, a temporary phase. Soon all small daughter cells develop flagella and become motile.

Sometimes, cells of the Palmella stage develop into thick-walled hypnospores. These are red coloured due to the presence of a red pigment called the haematochrome.

Sexual reproduction

The sexual reproduction may be isogamy to anisogamy and oogamy. At the time of sexual reproduction, the protoplast of a cell divides into 16,32 or even 64 biflagellate gametes. The gametes may be naked called gymnogametes. Or they may be enclosed in a cell wall called calyptogametes. The walls of calyptogametes may be left behind as the gametes fuse in pair or they may be retained.



I. Isogamy: In this case, the fusing pairs of gametes are naked and equal in size. It occurs in Creinhardi and C.Iongistigma.

Anisogamy: In this case, fusing pairs are similar in shape but different in size. The female cell produces four larger macrogametes. The male cell produces eight smaller microgametes. It occurs in C.monocia, C. Braunii etc. It produces a large macrogamete or egg. The male cell functions as antherozoid. It produces 8, 16 or 32 small spherical biflagellate microgametes or sperms. The egg is not completely non-motile. It is surrounded by a number of motile male gametes or sperms.FertilizationThe flagella disappear during fertilization. In some species, flagella may persist. Therefore, quadriflagellate zygote may remain motile for more than fifteen days. Then it secretes a wall. Sexual process is chemically regulated. Fusion occurs between the gametes of different cell types.Germination of zygospore

The resting zygospore or zygote secretes thick wall. It becomes red as the chlorophyll is masked by haematoohrome. Its starch is converted into fats.

Before germination the protoplast of the zygote becomes green. Its nucleus divides twice followed by the division of the protoplast into four parts.Each uninucleate piece of protoplast is metamorphosed into a biflagellate zoospore. Thus four zoospores are formed.They are liberated in water by the rupturing of the zygote wall. Meiosis takes place during the formation of zoospores from the zygote. They zygote is diploid. But the normal vegetative cells are haploid.

OEDOGONIUM

Occurrence of Oedogonium:

Oedogonium (Gr. oedos, swelling; gonos, reproductive bodies) is an exclusively fresh water alga. Out of about 400 species more than 200 have been reported from India. They are very common in pools, ponds, lakes etc.

The filamentous plant body may get attached with the stone, wood, leaves of aquatic plants, small branches of dead plant remain in water etc. by their basal cell the holdfast. Some species like O. terrestris are terrestrial.

Plant Body of Oedogonium:

The thalloid plant body is green, multicellular and filamentous. The filaments are unbranched and cells of each filament are attached end to end and form uniseriate row (Fig. 3.72A). The filament is differentiated into 3 types of cells: 1. Basal cell, 2. Apical cell and 3. Middle cells.

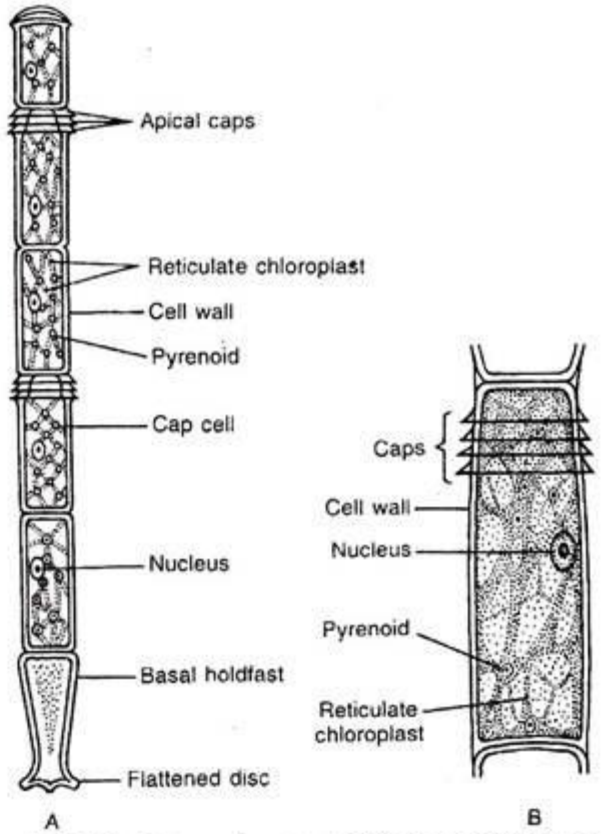


Fig. 3.72 : *Oedogonium* sp. : A. Single vegetative filament with holdfast and apical cell, B. Single vegetative cell

1. Basal Cell:

It is the lowermost cell of the filament. The cell is long, gradually narrowed and towards the basal end it expands to form simple, disc-like, multilobed or finger-shaped structure. The cell is generally colourless, which performs the function of fixation to the substratum and called holdfast.

2. Apical Cell:

It is the topmost cell of the filament. The cell is usually rounded towards apical side and green in colour.

3. Middle Cells:

All the cells in between basal and apical cells are alike. The cells are longer than their breadth i.e., rectangular in shape. Towards the upper end of some cells a ring-like structure is present known as cap or apical cap (Fig. 3.72A). The cell with cap is called cap cell. The number of caps on a cell indicates the number of cell divisions in that cell.

Important Features of Oedogonium:

1. This is a common fresh water alga growing on substratum like sand particles, rocks etc.

2. The plant body is unbranched, filamentous and differentiated into apex and base.

3. Cells have reticulate chloroplasts.

4. Presence of caps on the young dividing cells.

5. Vegetative cell division is very elaborate.

6. Asexual reproduction takes place by multi- flagellate zoospore, where flagella are arranged around the beak-like apical region.

7. Sexual reproduction is advanced oogamous type.

8. The female gamete i.e., ovum, is produced singly in each oogonium.

9. The male gametes i.e., antherozoids, are very much similar to zoospores but smaller in size. Two antherozoids are produced in each antheridium.

10. Based on the size of male filament the plants are divided into two groups: Macrandrous and Nannandrous type.

11. In macrandrous type the antheridia develop into the filament of normal size. But in nan- nandrous type the antheridia develop on small and thin male filament, the dwarf male or nannandrium (remain attached with the oogonium wall or its lower cell, the supporting cell), develop on germination of andro- spore. The androspore forms singly in andro- sporangium, develop in the normal filament.

12. The androspores are smaller than zoospores (produced asexually), but larger than antherozoids.

13. The zygote undergoes meiotic division and produces four zoospores. In dioecious species two produce male and other two produce female plants.

<u>Cell Structure of Oedogonium:</u>

The intercalary cells are longer than their breadth and are cylindrical in outline.

The cells are surrounded by thick and rigid cell wall. The cell wall is differentiated into three layers an outer chitin, middle pectin and innermost cellulosic. Just interior to the wall, cell membrane is present, which encloses the protoplast.

The protoplast consists of cytoplasm, chloroplast and nucleus. The cells contain many small or single large vacuoles situated in the centre and remain filled with cell sap. The cytoplasm lies between the cell membrane and vacuole.

The Chloroplast is single, large and reticulate, which remains embedded in the cyto- plasm. It extends from one end of the cell to the other end. Cells are uninucleate and nucleus is generally present in the centre of the cell within the cytoplasm or it may be excentric.

Cell Division:

Growth of the filament takes place through cell division (Fig. 3.73). All cells except apical and basal ones are capable of dividing through cell division though division remains restricted in some of the cells of the filament.

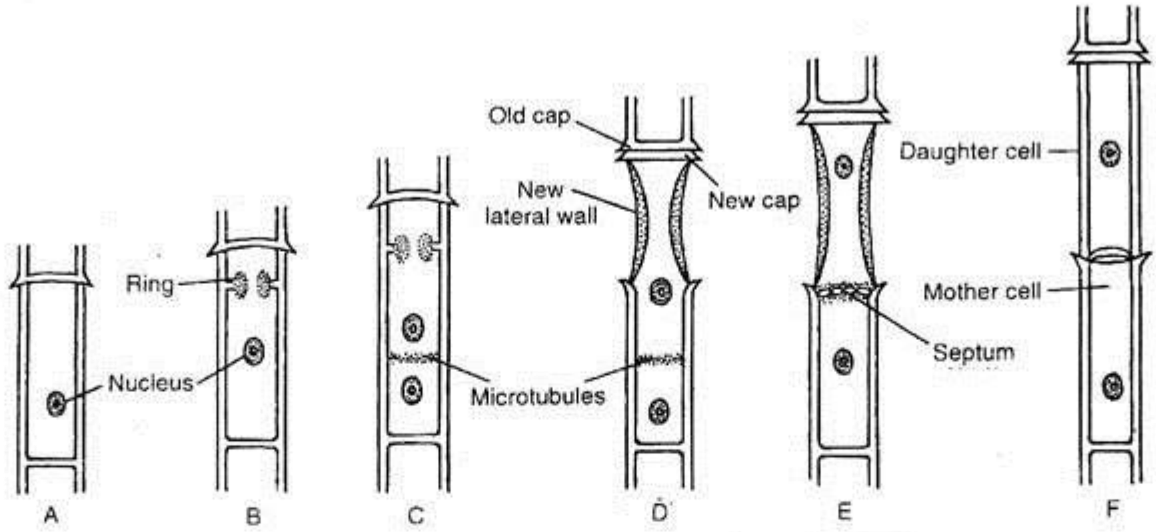


Fig. 3.73 : *Oedogonium* sp. : A-F. Successive stages of cell division

The steps of cell division are:

1. Initially the nucleus becomes shifted from peripheral position towards the centre and then moves slightly towards the upper half of the cell..

2. Ring-like thickening develops towards the upper part of the cell wall which gradually increases in thickness.

3. The nucleus undergoes mitotic division and form two nuclei.

4. At the end of cell division (telophase), a row of microtubules develop and accumulate as a layer between the daughter nuclei. This layer remains in floating condition which will develop the future septum.

5. The ring-like thickening gradually elongates and splits the mother wall towards the apical region. The ring expands much more and forms a concave cylindrical structure (Fig. 3.73D). The ring material ultimately forms the cuticle of the upper daughter cell.

6. The upper part of the ruptured mother wall remains attached to the anterior end of the new daughter cell as a cap i.e., the apical cap. The other part remain towards the basal region of the daughter cell.

7. The floating septum gradually goes up to the base of the future daughter cell i.e., at the top of the mother cell at the ruptured end and it becomes fixed. Later on it develops into mature cross wall.

8. New side wall develops between the cuticle and the plasmalemma of the upper cell. Thus the two cells are formed. It is evident that the cell with cap is the younger one which develops between the two old cells.

Reproduction in Oedogonium:

Oedogonium reproduces by all the three means: vegetative, asexual and sexual.

Vegetative Reproduction:

It takes place by fragmentation and akinete formation:

1. Fragmentation:

It takes place by accidental breakage of the filament, dying off of intercalary cells or by the formation of intercalary sporangia. The fragments are capable of developing into new filaments.

2. Akinete:

During unfavourable condition the entire protoplast of a cell becomes a thick-walled, reddish-brown, round or oval structure, the akinete. The akinete germinates during favourable condition and develops a new filament. They generally form in chain.

Asexual Reproduction:

Asexual reproduction takes place by means of zoospores (Fig. 3.74A-C). Zoospores are formed singly within a cell. Comparatively younger cell i.e., the cell with cap behaves as sporangium mother cell.

The zoospores are multiflagellate and ovoid, pyriform or spherical in shape. They are uninucleate with single chloroplast and occasionally with an eye-spot.

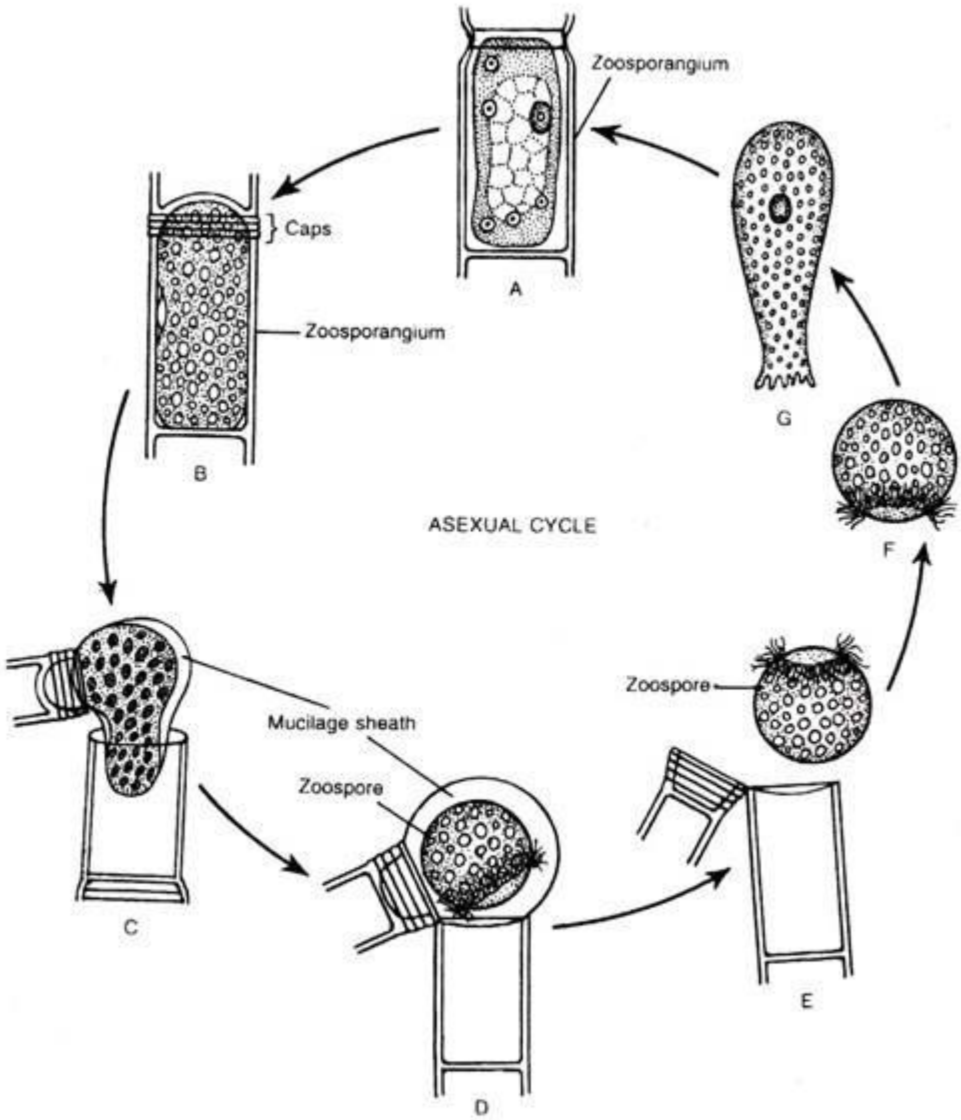


Fig. 3.74 : *Oedogonium* sp. Asexual reproduction : A-E. Successive stages of zoospore formation, F. Single zoospore, and G. Germination of Zoospore

During favourable condition, the zoospore formation begins in a cap cell of the filament. The entire protoplast of zoosporangium contracts from the wall and behave as a unit. The protoplast becomes round or oval in shape and its nucleus moves at one end.

Near the nucleus a semicircular hyaline area develops. Just below the hyaline area a ring of blepharoplast granules develops, connected with each other by fibrous strands. Later on, from each blepharoplast granule, single flagellum develops. Thus a crown of flagella is present around the colourless semicircular area.

The fully developed zoospores are liberated by breaking the zoosporangium wall. The wall of the zoosporangium breaks near the cap region and the neighbouring cell bend on one side to make way for the liberation of zoospore. During liberation, the zoospore remains as a delicate mucilaginous vesicle for 3-10 minutes. After dissolution of vesicle the zoospore gets free and starts swimming in the surrounding water.

Germination:

The zoospore can swim for about one hour or more. Coming in contact with substratum by the anterior end, it loses flagella and starts to elongate. The lower hyaline part becomes separated by cell wall, which forms the hold fast. Through the subsequent division and re-division in a single plane, new filament is formed.

Sexual Reproduction:

The sexual reproduction in Oedogonium is an advanced oogamous type. The male gametes or antherozoides are produced in antheridium and the female gamete or egg is produced in oogonium. Male and female gametes differ both morphologically and physiologically.

Only one egg is produced in each oogonium and two antherozoides in each antheridium. Another motile structure, the androspore, is produced singly in each androsporangium. Deficiency of nitrogen and alkaline pH are the important factors for promoting sexual reproduction.

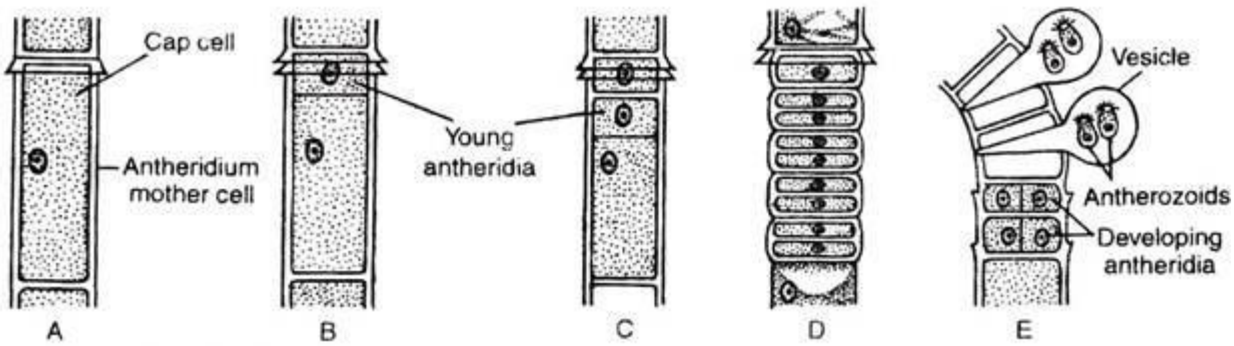


Fig. 3.75 : *Oedogonium* sp. : A-E. Successive stages of development of antherozoids

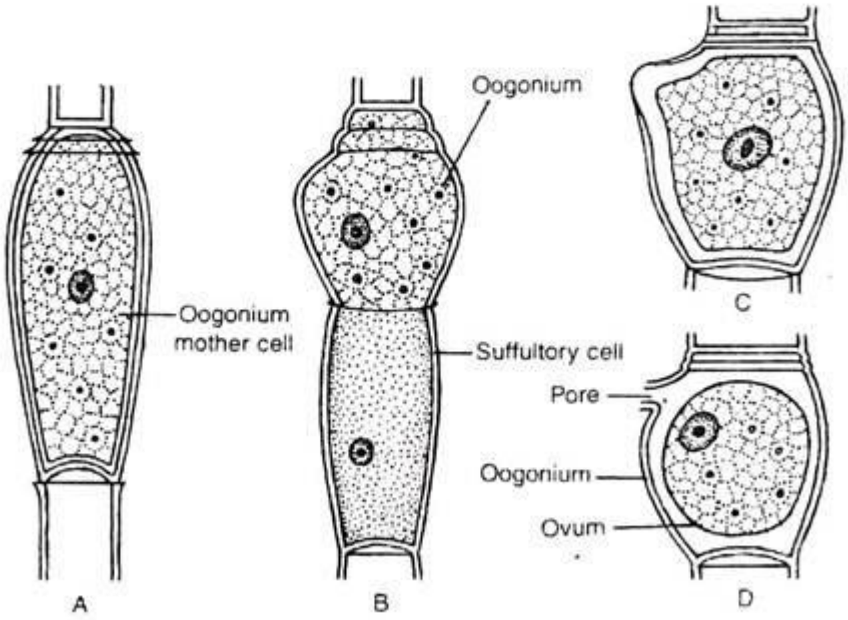


Fig. 3.76 : *Oedogonium* sp. : A-D. Successive stages of development of ovum

Distribution of Sex Organ in Oedogonium:

Based on the size of the male (antheridial) filament the species of Oedogonium are divided into two groups macrandrous and nannandrous type:

1. Macrandrous Type:

In macrandrous type the antheridium develops in the filament of normal size.

It is of two Types:

i. Monoecious type (homothallic or bisexual). In this type (e.g., O. fragile, O. nodulosum and O. hirnii) antheridia and oogonia are borne on the same filament (Fig. 3.79).

ii. Dioecious type (heterothallic or unisexual). In this type (e.g., O. gracilius, O. cardiacum and O. aquaticum) the antheridia and oogonia are borne on the different filaments (Fig. 3.80).

2. Nannandrous Type:

The nannandrous species are always dioecious (heterothallic) i.e., antheridia and oogonia are borne on different filaments. In this type the antheridia develop on a very small filament termed as dwarf male or nannandrium. In nannandrous type initially androsporangia are developed in series on normal sized filament. The androspore form singly within androsporangium.

Liberating from androsporangium, the androspores swim freely in water. The androspore germinates on the oogonial wall (O. ciliatum) or on supporting cell (O.

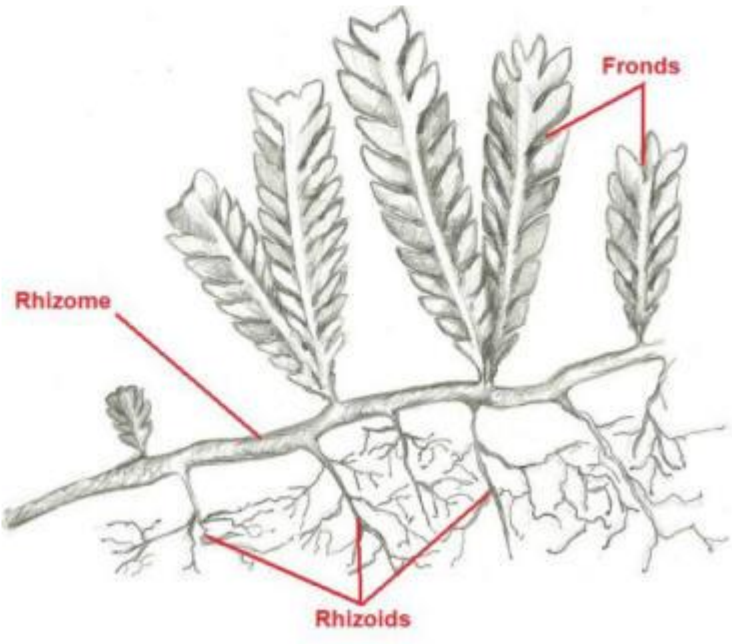
concatenatum) and forms dwarf male filament. Towards the apical region, the dwarf male filament cuts off small cells as the antheridial mother cells.

Each antheridium produces two antherozoides. The androspores, antherozoids and zoospores are morphologically alike but differ in their sizes (Table 3.1). The androspores are smaller than zoospores (produced asexually) but larger than antherozoides.

CAULERPA

Caulerpa are fast-growing green algae with fronds ("leaves") that come in a variety of shapes. The fronds from to between 15-30 cm (6-12 inches) in length and are attached to long runners ("stems") called rhizomes. Besides simply spreading outwards, Caulerpa can also propagate themselves vegetatively through sections of rhizome that break off the parent plant and become established elsewhere.

Caulerpa rhizomes are attached to the substrate by fine hair-like extensions known as rhizoids. As is the case with all algae, the similarities between rhizoids and the roots of true (vascular) plants such as seagrasses are misleading; rhizoids only anchor the algae in the sediment, and play no role in absorbing mineral nutrients. Caulerpa, like all algae, absorb the minerals they need from the water via their leaves.



Caulerpa are found in a variety of shallow water marine habitats. Substrate types vary from solid rock through to sand and mud, and Caulerpa can be found in both calm and rough water areas. Because of their adaptability and the ease with which they can propagate themselves vegetatively, Caulerpa can be a highly invasive species.

SARGASSUM

Occurrence of Sargassum:

The genus Sargassum (Spanish sargazo, seaweed) is represented by about 150 species, out of which 1 6 species are found in India. It is found in temperate, subtropical and tropical regions of both northern and southern hemispheres. It is very common in Africa, South America, Australia etc.

Plant Body of Sargassum:

The plant body is diploid (2n), erect and branched thallus. The thallus is differentiated into a basal holdfast and an expanded, leafy, cylindrical main axis.

The holdfast is discoid and serves the function of anchorage with the substratum. The main axis is generally of 10 to 50 cm in length. It is erect, flattened or cylindrical structure. The main axis bears many primary laterals arranged spirally in a phyllotaxy of 2/5. Due to its unlimited growth, the primary laterals are also called long shoots. The main axis and primary laterals (long shoots) bear flat' expanded structures, called secondary laterals or leaves.

The leaves are flat, simple structures with distinct midrib and dentate, serrate or entire margins, with an acute apex. Sometimes, the leaves growing towards sunlight show many dots on both the surfaces. These dots are the ostioles i.e., openings of the sterile conceptactes. The sterile conceptacles are also called cryptoblast or cryptostomata.

On the main axis as well as on the primary laterals, the secondary laterals i.e., the leaves are replaced by many spherical, hollow bodies, called air bladders. The air bladders help to float them in water.

The axils of leaves develop long much branched flattened or cylindrical structures called receptacles. The receptacle bears many fertile flask-shaped structures, the conceptacles. The conceptacles bear sex organs.

Internal Structure of Sargassum:

Axis:

It is generally of circular in outline and differentiated into three regions: outer meristoderm, middle cortex and innermost medullAa.

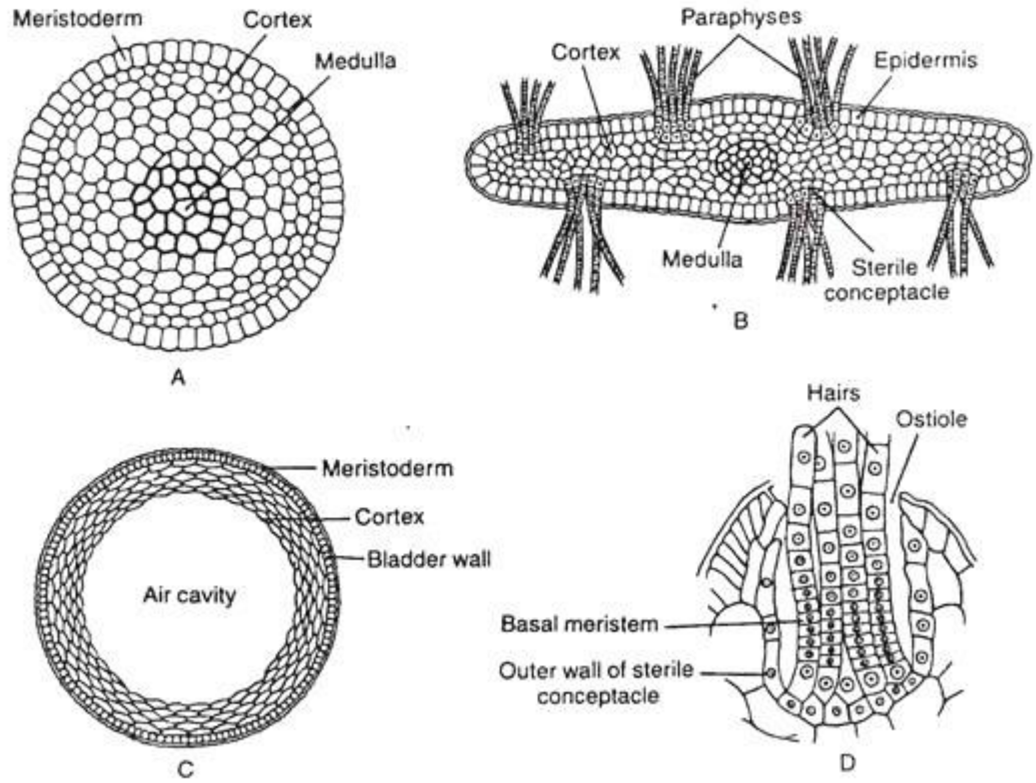


Fig. 3.117 : *Sargassum* sp. Internal structures : A. T.S. of main axis, B. T.S. of leaf, C. T.S. through air-bladder, and D. V.S. through a sterile conceptacle

The meristoderm is made up of single layer of closely packed cells. The cells are meristema- tic in nature. The cells contain chromatophores and perform photosynthesis. This layer can store food material.

The cortex is situated next to meristoderm and occupies major part of the axis. It consists of compactly arranged parenchyma cells of polygonal shape, rarely with intercellular spaces. The cells are smaller in size than meristoderm. Like the outer layer this layer also stores food material.

The medulla i.e., the inner layer consists of narrow, thick walled elongated cells. This layer possibly helps in conduction.

Leaf:

It is flat and differentiated into outer meristoderm, middle cortex and inner medulla like the axis (Fig. 3.117B). The medulla is round and present in the middle region. On both surfaces of the leaf there are many sterile conceptacles, the cryptostomata or cryptoblasts.

These are flask-shaped with many sterile unbranched filaments, the paraphyses developed from the base. The paraphyses protrude out through the opening present on the outer side, the ostiole. The cells of the wall have many chromatophores.

Air Bladder:

Internally it is almost alike with the axis but without medulla (Fig. 3.117C). The central region is occupied by a large hollow cavity filled with air and gases. Outer to the cavity, cortex is present; which consists of a few layers and thinner cells than axis and finally it ends with a single layered outer meristoderm.

Thus the thallus shows division of labour along with differentiation of tissues. It serves the function of anchorage, photosynthesis, storage, conduction and support.

Reproduction in Sargassum:

It reproduces by both vegetative and sexual means. Asexual reproduction is absent.

1. Vegetative Reproduction:

It takes place by fragmentation. Due to death and decay of the older part, the younger region gets separated. The separated region grows and finally develops into a new individual like the mother. The free floating members like S. hystrix and 5. natans, multiply only by this method.

2. Sexual Reproduction:

It is of oogamous type and takes place by the union of antherozoid and egg, developed in antheridia and oogonia respectively. The sex organs develop in separate flask-shaped bodies the conceptacles, developed on branched receptacles. The conceptales with antheridia or oogonia are called male or female conceptacles.

Development of conceptacle. The fertile and sterile conceptacle are almost similar. The difference lies in the activity of basal cells of the linear wall of conceptacle. In sterile conceptacle it only develops sterile hairs, the paraphyses, but in fertile conceptacle it develops either antheridia or oogonia and also paraphyses in some regions.

GRACILARIA

The genus of Gracilaria is cosmopolitan in distribution, and has been reported from the arctic, temperate and tropical regions. Greville set up the genus Gracilaria in 1830, which comprised then only four species. Agardh reexamined the genus in 1852, and increased it to 23 species. In 1876 and 1901 he re-identified them again and reported 61 species altogether. Since then, the number of Gracilaria species reported from many places over the world.

External appearance

Erect thallus arise from a small discoid holdfast. The thalli are generally cylindrical, depressed or blade-shaped, with lateral, alternate or subdichotomous branches. Sometimes several different branches may be found in one plant. The external appearance of thalli may be used to identify species. The style of the apex and the base of branches are different with species.

The thalli of most species are cylindrical. Several commercially important species will be discussed. Some species (such as G. eucheumaides) are compressed, their thalli growing horizontally along the substratum and form secondary holdfasts from the margin of branches. A few species (such as G. textorii) are blade-shaped.

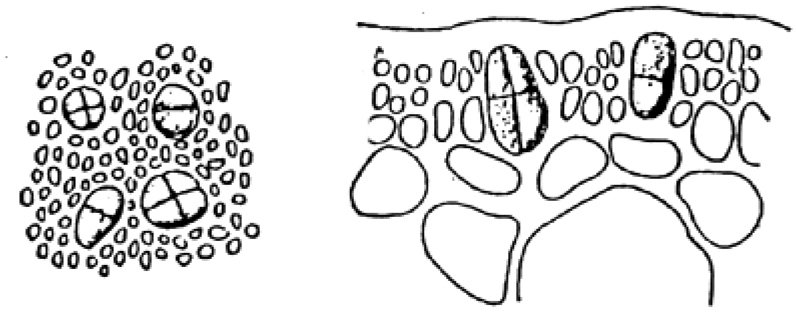
Anatomy of main axis

The vegetative thalli of Gracilaria consist of cortex and medulla. Cortical cells are smaller. The outermost 1–2 layers are pigment cells. Medulla comprise large parenchymatous cells (Fig.1). The layers of cortex, the size and number of medullary cells and the change of cells from cortex to medulla are used for identification of species.

Transection and longitudinal Gection of main axis of Gracilaria

Tetrasporangia

The tetrasporangia are densely scattered on the cortex surface. Each tetrasporangia is composed of four tetraspores arranged in a cruciate manner .



Surface view and transection of tetrasporangia of Gracilaria

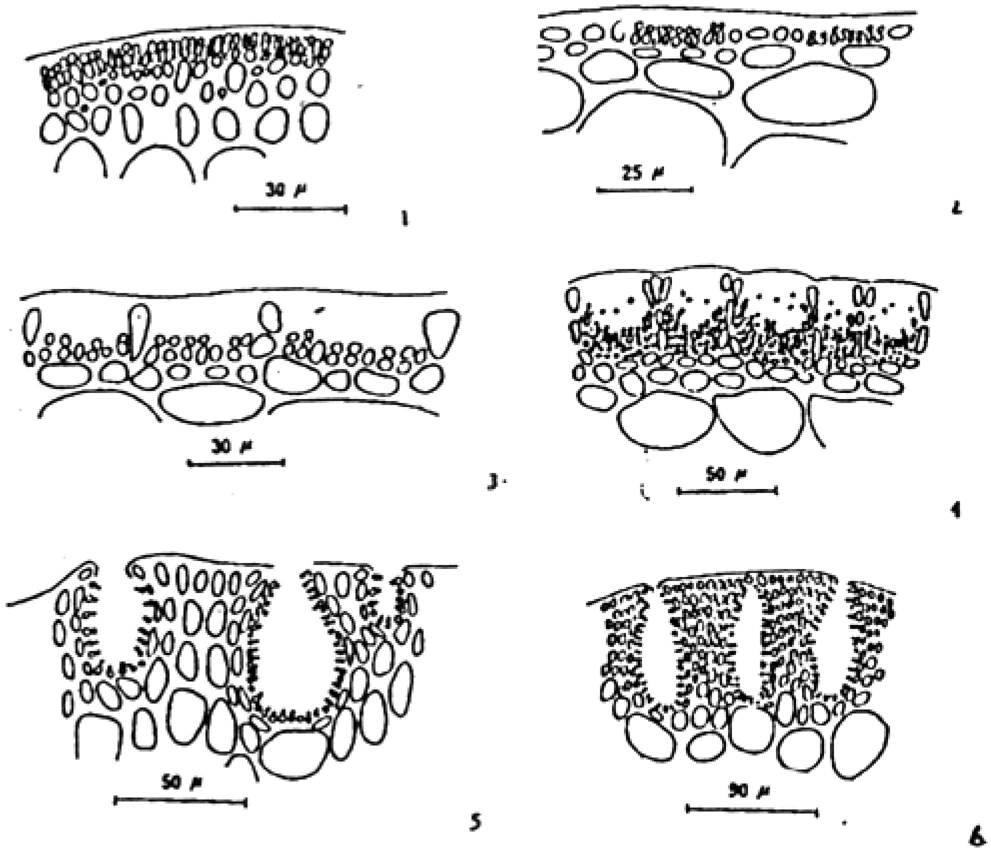
Spermatangia

The spermatangia are globular or oval, scattered over the surface of thalli. The location and type of spermatangial conceptacle are three important considerations for identification of species.

Spermatangia scattered on the surface layer of thalli continuous or interrupted by cortical cells.

Spermatangia in shallow depressed spermatangial conceptacles.

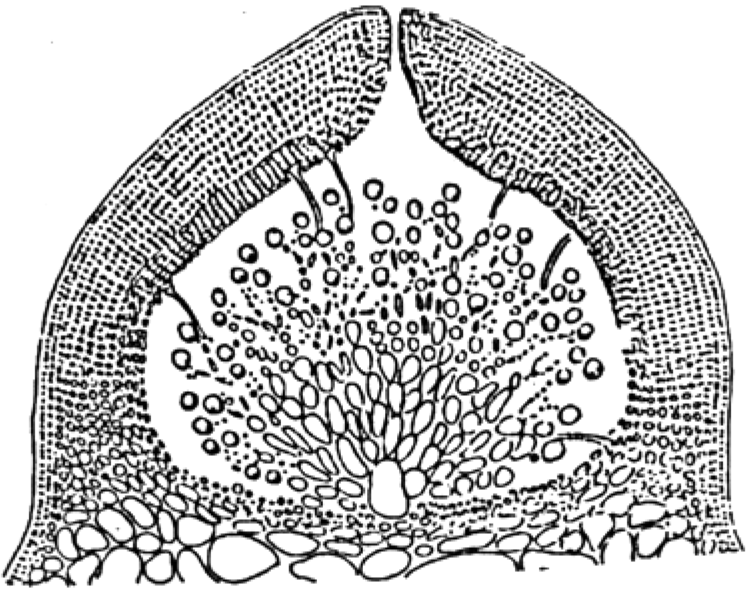
Spermatangia in deeper conceptacles ovoid to long elliptical in sectional view.

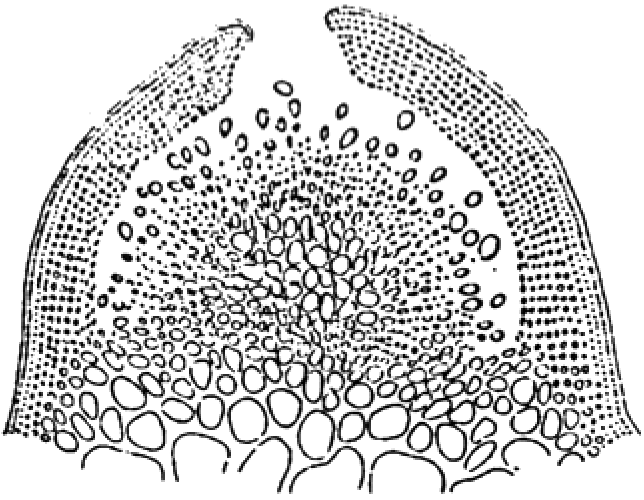


. Transections of spermatangis of Gracilaria

Cystocarp

Cystocarp is prominent, protruding, globose or hemispherical, scattered over the surface of the fronds. It may be divided into 4 portions (Fig. 4).





Transections of cystocarps of Gracilaria

A. Pericarp

Consisting of several layers of cells, outmost layer is composed of pigmented cells.

B. Gonimoblast

In the center of cystocarps, consists of parenchymatous cells.

C. Carposporangia

Formed at the top of the gonimoblast, round or ovoid in shape.

D. Absorbing filaments

Extended from the gonimoblast tissue to the pericarpic-layer. Some species possess absorbing filaments.

UNIT –V . LICHENS

Study of lichen called lichenology.

Lichens are composite thalloid structure containing algae and fungi.

Lichens are distinct group of plant having two components i.e. algal components called Phycobiont and fungal component called Mycobiont.

Algal component of lichen synthesize carbohydrates by photosynthesis and provides nutrition of fungi and themselves while fungal component helps in water absorption and water retention. Hence lichen is an example symbiosis.

The term "Lichen" was first given by Theopharastus for superficial growth on bark of Olea europea (olive) tree.

Erik Acharius – father of Lichenology.

De Bary – gave this association the name Symbiosis.

Crombie – gave the master-slave hypothesis for this association (also called husband-wife relation ship). It is also called helotism (Most accepted association now a days).

In this association, the fungal component shows predominance over algal component and the later is a subordinate partner. Such type of association is known as helotism.

HABIT & HABITAT

The lichen are mostly perennial, aerial, slow growing and long lived plant.

Lichens are cosmopolitan. Lichens are even in areas which appear unsuitable for normal plant like bare hard rock and cold arctic region.

Lichens are most sensitive to air pollution specially SO2-pollution.

In India lichen are most common in eastern Himalaya as compare to western Himalaya Lichens are absent in planes.

On the basis of habitat, lichen are of following type :

Saxicolous – Lichens growing on rocks. eg. – Dermatocarpon, Pornia

Corticolous – Lichens growing on tree bark eg. – Parmelia, Usnea

Terricolous – Lichens growing on soil eg. Cladonia, Collema.

Lignicolous – Lichens growing on wood eg. – Cyphelium.

The lichen may also occur in fresh water eg. – "Hymenelia lacustris" Few marine species eg. "Caloplaca marina"

(2) Classification of Lichen

Major part of lichens thalli are composed of fungal component.

I. On the basis of their fungal component:

A. Ascolichen : - Fungal partner is the member of ascomycetes.

Algal partner is mostly member of green algae and rarely blue green algae. Most of the lichens are Ascolichen

B. Basidiolichen : Fungal partner belongs to basidiomycetes.

In basidiolichen, algal partner is always a member of Myxophyceae (B.G.A.).

Example – Cora pavonia

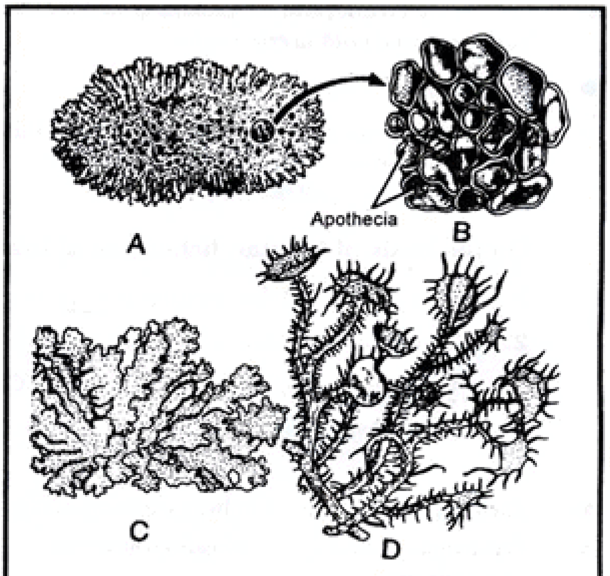
II. classification of the basis of types of thallus :

Lichens are of three types -

1. Crustose lichen:

Thallus are flat. The thallus is closely adhered to the substratum and provides a crust like appearance. These lichens are partially or completely embedded in to substratum. These can't be separated from the substratum without them. Fruiting bodies are visible above the surface of the substratum.

e.g – Rhizocarpon, Graphis, Lecanora, Verrucaria, Haemotomma.



DIFFERENT FORMS OF LICHENS
A = **Crustose lichen** B = A part magnified to show **apothecia** C = **Foliose lichen** D = **Fruticose lichen**

2. Foliose lichen:

Thallus are flat leaf-like and lobed. They are attached to the substratum with the help of rhizoid like rhizines. These hariy structures are developed from lower side of thallus e.g. Parmelia, Peltiger, physcia and collema.

3. Fruiticose lichen

Thallus is well developed, shrub like, cylindrical and branched thallus. They grow erect (Ex. Cladonia) or hang from substratum (Ex. Usnea).

Internal Structure

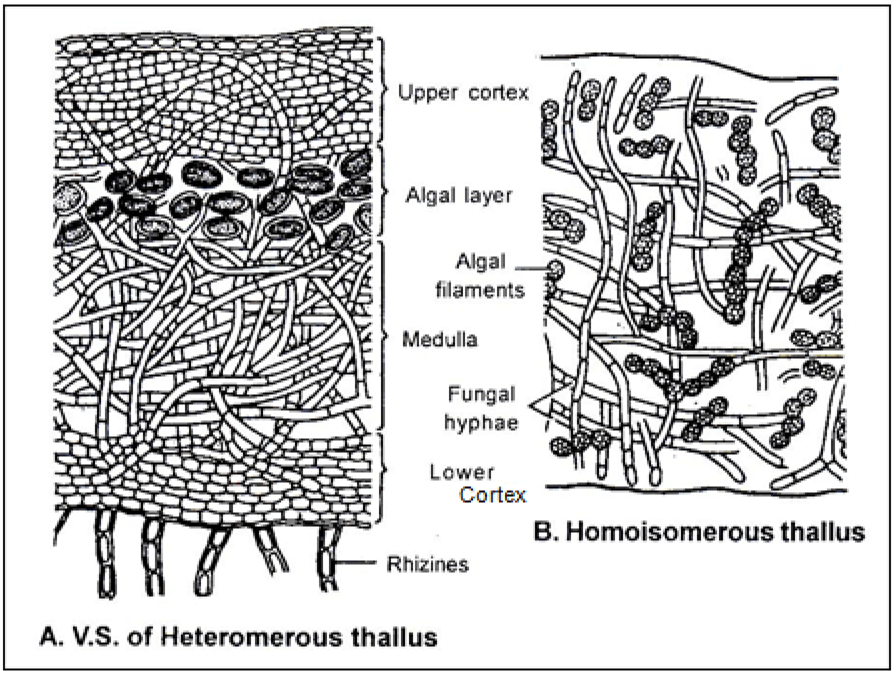
V.S. of foliose lichen -

a. Upper cortex – It is made up of compactly interwoven fungal hyphae. Intercellular spaces are absent. If present then filled with gelatinous substance. In some lichens (Parmelia) breathing pores are present on upper cortex.

b. Algal layer – It occurs just below the upper cortex. This layer forms photosynthetic zone of thallus. In this layer algal cells are present and some fungal hyphae are randomly oriented. This layer also called "gonidial layer".

c. Medulla – Beneath the algal zone there occurs medulla. It is made up of loosely interwoven fungal hyphae with large spaces between them which are randomly oriented.

d. Lower cortex – It is made up of compactly interwoven fungal hyphae some of these hyphae become specialized and extend downward from the lower surface of the cortex and helps in the attachment of thallus to the substratum. These specialized hyphae are known as rhizines.



Internal structure of curstose lichens is also more or less similar to foliose lichens.

The lower cortex does not occur in fruiticose lichens due to their cylindrical structure and medulla forms the central part of the axis.

Important Points :

(i) Breathing pores – The upper surface of some lichen have loosely arranged areas called breathing pores. They help in gaseous exchange. eg. Parmelia

(ii) Cyphellae – These are small, almost circular depression on the lower side of thallus (In foliose lichen). They are meant for exchange of gases. Cyphellae [cyphella-singular] are analogous to stomata of higher plants.

(4) Reproduction

These are of following type -

(i) Vegetative Reproduction

(a) Fragmentation : The main thallus breaks into small pieces and each piece grows to form new lichen thallus.

(b) Soredium : Some small bud-like outgrowths, known as soredia, develop on the surface the thallus. A soredium contains one or few algal cells closely enveloped by a weft of fungal hyphae. They are detached from the thallus by the impact of wind or rain. The soredia germinate on suitable substratum and form new thalli.

(c) Isidium : Isidia are small, stalked, greyish-black coral-like outgrowths which develop on the upper surface of the thallus. The isidium has an outer cortical layer enclosing the algal and fungal components. It is usually constricted at the base and is easily detachable from the parent thallus. It germinates under favourable conditions and forms new thallus.

In addition to propagation, isidia also help in increasing the photosynthetic surface of the thallus. They vary in shape may be rod like (e.g. Parmelia), coral-like (e.g. Peltigera), scale-like (e.g. Collema) or cigar like (e.g. Usnea).

(D) Cephalodium : These are small wart-like structures formed on the surface or inside of the thallus. One of the characteristic feature of cephalodium is that its algal and fungal components differ from that of the thallus. It is due to the fact that cephalodia develop on the younger parts of the thallus from soredia of some other species. Hence, the cephlodium may be regarded as sterile thallus of some other lichen. They retain moisture. In some species, the cephalodium contains the same fungal hyphae as in thallus but the algal component is always different.

ii) Asexual Reproduction

(a) Oidia : The fungal hyphae form small thin walled bodies called oidia. On coming in contact with suitable algal component they form new lichen thallus.

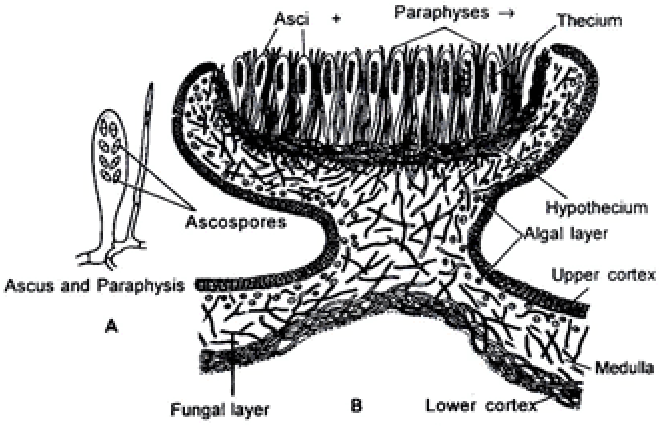
(b) Conidia : In several lichens, the fungal component form conidia. Conidia produced on conidiophores.

(c) Pycnidiospores : These spores are formed in flask shaped structures, called Pycnidium. Pycnidiospores form new fungal mycelium and Mycelium form new lichen in contact with suitable algal component.

(iii) Sexual Reproduction

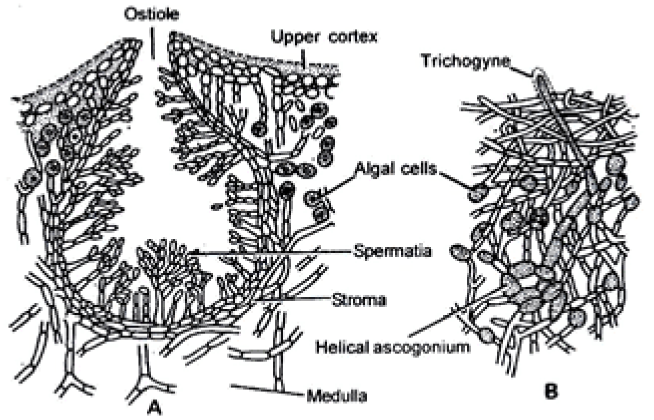
- Sexual reproduction is the function of fungal component.
- The fungal component of most of the lichens belongs to the class ascomycetes.
- Female sex organ is called "Carpogonium".
- Carpogonium differentiated into two parts – lower coiled part is called "ascogonium" and upper straight part is called "trichogyne".

- The ascogonium remains embedded with in the algal layer of the thallus, whereas the trichogyne projects over the surface of the thallus.
- Male sex organ is called "Spermogonium"
- It is flask shaped. It open out side by ostiole.
- Inside spermogonium non motile sperms or spermatia are formed.
- The spermatia are ooze out through ostiole in the form of slimy mass and attach with the trichogyne and wall of both soon dissolves.
- Nucleus of spermatia reaches in ascogonium.
- Many "Ascogenous hyphae" arises from the fertilized ascogonium.
- These cells are uni or binucleated and the terminal or penultimate (sub-terminal) binucleate cell of the ascogenous hyphe develops into an ascus. In ascus both nuclei fuse to form a diploid nucleus.
- In ascus one meiosis and one mitotic division take place and 8-ascospores are formed in each ascus by paraphysis.
- Asci (Ascogenous hyphae, ascus mother cells, ascospores) and some sterile hyphae form fruiting body called "apothecium" eg. Parmelia or Perithecium eg. Dermatocarpon, Verrucaria.
- Ascospores are liberated from ascus and on coming in contact with suitable algae form new lichen thallus.



Lichen - V.S. of fruiting body

A. Showing ascus and paraphyses
B. V.S. of apothecium



***Lichen** A. spermogonium, B. Carpogonium*