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PLANT DIVERSITY – I
UNIT – II

ECONOMICAL IMPORTANCE AND DIVERSITY OF ALGAE

Economic importance of algae

1. **Algae is used as fertilizers:**

The value of seaweeds in fertilizing the soil was discovered early in the history of agriculture in coastal Asia, and by the ancient colonizers of the coasts and islands of north-western Europe. In some areas of Britain, and along the coast of north-west France, the cutting of rockweeds for manure has been so intensively practiced that it became necessary to regulate it by laws that have now been in effect for nearly 100 years.

In the United states, long before the recognition of their potash content, seaweeds were employed for fertilizers by the thrifty farmers. Not only the chemical fertilization, but also the water-holding capacity of fragments of the algae in the soil proved effective. These provided valuable small reservoirs of water in close contact with the roots of the cultivated plants.

Furthermore, the bulky organic substances decay slowly in the soil and form humus. Again yield of paddy is increased substancially when paddy field is inoculated with nitrogen fixing blue-green algae. Some of them are: tolypothrix tenius, aulosira fertilissima, anabaena oryzae, anabaenopsis arnoldii, calothrix confervicola, nostoc commune, and cylindrospermum bengalense.

2. Industrial utilization of algae:

(I) Kelp Industry:

Industrial utilization of seaweeds in Europe had its principal early development in the production of 'kelp', a name that originally referred to the ash, rich in soda and potash, derived from burning marine plants. Kelp production was begun sometimes in the seventeenth century by French peasants and spread to other parts of north-west Europe.

Drift-weeds were first used, but cutting was later resorted to laminaria and saccorhiza in north Britain as of major importance.

But fucus and ascophyllum were also widely used, and in some areas himanthalia and chorda. The kelp ash from these plants was widely bought by early industrialists for use in manufacture of soap, glass and alum. During the eighteenth and early nineteenth centuries the demands became considerable, and enormous quantities of seaweeds were handled in areas of rich algal growth.

Kelp extract contains a number of chemical elements, notably potassium and iodine. About 25 per cent, of the dry weight of kelp is potassium chloride. Many species of kelp are used as food for man, especially in the orient. In northern Europe they also serve as food for domestic animals, such as sheep and cattle.

(Ii) Algin Industry:

Algin is the general term designating the hydrophilic, or water-loving derivatives of alginic acid. The most commonly known algin is sodium alginate, but other commercially important compounds are the potassium, ammonium, calcium, and propylene glycol alginates, as well as alginic acid itself.

With the exception of alginic acid and calcium, alginate, the algin products offered commercially arc soluble in water to form vis-sous solutions.

Algin occurs generally throughout the brown algae (laminaria, macrocystis, sargassum and fucus) as a cell wall constituent. It has remarkable water-absorbing qualities that make it useful in numerous industries in which a thickening, suspending, stabilizing, emulsifying, gel-forming, or film-forming colloid is required.

Thus, algin provides ice cream with a smooth texture by preventing the formation of ice crystals. In automobile polishes it suspends the abrasive; in paints, the pigments; also in pharmaceuticals, the drugs and antibiotics. As a stabilizing agent it serves in the processing of rubber latex .and in the printing of textiles. As an emulsifier it is widely used in such products as water-based paints, French dressings, and cosmetics.

The algin industry has become so important to such a wide variety of industries that extensive survey of kelp-bed ecology is an effort to guard against loss of this important resource. Harvesting methods are now carefully regulated, and a huge amount of money is being spent on kelp-bed research throughout the world.

Experimental studies are continuing on the relation of pollution to kelp survival and on kelp-bed grazing organisms.

(iii) Agar Industry:

The outstanding use of the red algae, however, is in the production of agar. This is a dried and bleached gelatinous extract obtained from red algae—gelidium nudifrons, g. Pusillum, g. Robustum, and gracilaria verrucosa. Agar is used extensively in medicine, chiefly as laxative, since it is not digested and increases greatly in bulk with the absorption of water.

More important than this medicinal utilization is its use as an essential ingredient in the preparation of medium for the growth of bacteria and fungi. As such it is indispensable in bacteriological laboratories, because no adequate substitute for agar is known.

Since the introduction of agar into bacteriology in 1881, the agarophytes have become increasingly industrialized and the technical uses of agar enormously expanded. Modern industry has developed such a multitude of applications that only a fraction of them can be noted here. Large quantities of agar are used as a food adjunct.

Agar serves widely as a substitute for gelatin, as an anti-drying agent in breads and pastry, in improving the slicing quality of cheese, in the preparation of rapid-setting jellies and desserts, and in the manufacture of frozen dairy products. The use of agar in meat and fish canning has greatly expanded, and hundreds of tons are utilized annually.

Agar has proved effective as a temporary preventive for meat and fish in tropical regions, due to the inability of most purifying bacteria to attack it.

Early industrial uses of agar in the orient included sizing fabric, water-proofing paper and cloth, and making rice paper more durable. Modern industry has refined and expanded these uses to meet new needs in the manufacturing of such items as photographic film, shoe polish, dental impression molds, shaving soaps, and hand lotions.

In the tanning industry agar imparts a gloss and stiffness to finished leather. In the manufacture of electric lamps, a lubricant of graphite and agar is used in drawing the hot tungsten wire.

The increasing applications have called for wide expansion of the collection of agarophytes, and since japan supplied most of the world's markets before world war ii, when those supplies were cut off, a great amount of hurried research was conducted in an attempt to develop domestic agar supplies not only in the united states, but in south Africa, Australia, new Zealand and Russia.

3. Algae is used as food:

Large number of algae have entered into the diets of human beings from ancient times. The earliest records are those of the chinese, who mentioned such food plants as laminaria and gracilaria in their 'materia medica' several thousand years ago.

The ancient inhabitants of japan ate porphyra as a healthful supplement to their rice diet. Its use became widespread, not only in japan, but in china in course of time. Kombu, a Japanese food is prepared from stipes of species of laminaria.

The most diversified dietary use of seaweeds was developed by the polynesians and reached its peak in Hawaii, where during the nineteenth century at least 75 species were separately named and used regularly as food in that island world.

The Hawaiians called them ‘limu’ and considered them a necessary staple of their daily diet.

Perhaps the best known and most widely used food alga in western Europe in recent centuries was Irish moss, or carragheen (chondrus chrispus), which was cooked with milk, seasoned with vanilla or fruit, and made into a highly palatable dish known, as blancmanges. The jellying qualities of Irish moss gave the alga an early food use.

Man, thus obtains carbohydrates, vitamins (algae are especially rich in vitamins a and e, and they contain some c and d), and inorganic substances, e.g., iodine (goiter is unknown among the people who eat seaweeds), not to mention the benefits of the mild laxative action of the ingested algae. Witsch (1959) stated that vitamin B value of young cultures of chlorella equals that of lemon juice.

In japan, powdered chlorella ellipsoidea has been used successfully mixing with green tea.

In Germany and in the United states considerable work is being carried out on the suitability of mass cultures of chlorella as an alternative source of animal feed and of human vegetable food.

4. Algae is used as fodder:

The orientals developed wide human uses for marine algae, but Europeans profited by extensive use of these plants for stock feed. In Iceland and Scandinavia, in the British isles, and along the coast of France, stock has long been driven or allowed to wander to the seashore at low tide to feed on seaweeds.

Some kinds of algae, such as rhodymenia palmata and alaria esculenta, are favourable food of goats, cows, and sheep, and in Scotland and Ireland the stock actively hunt the shores at low tide for particular algae, especially the former.

The milk does not have any taste of algae, nor is the meat inferior because of the seaweed diet. Such animals, that have for several generations been nourished on algae, show better ability to digest it than those not so habituated.

The shortage of grain in many parts of Europe during world war I led to considerable experimentation with the use of seaweeds as food for cows and horses. Stock- feed factories were established in France, Norway, Denmark and Germany, and various methods of treating and reducing seaweeds to meal or powder were developed.

The favourable results in animal husbandry in Europe led to the industrial processing of the great pacific-coast kelp (macrocystis) for animal rations. Seaweed-meal factories have been operating in the united states for several decades, providing supplementary feeds for poultry , cattle and hogs.

The high mineral and vitamin g content of kelp meal has made possible its use in various poultry and other animal rations.

5**. Algae as the origin of petroleum and gas:**

The origin of oil and gas has been a matter of controversy, but it is now generally believed that, like coal, these fuels owe their energy to photosynthesis in ancient plants. Unlike coal, however, which was laid down in inland swamps, oil and gas were formed from organic matter in marine environments.

The plankton of the seas was probably of the greatest importance as a source of this organic matter. Minute marine algae captured the energy of sunlight, which was in turn transferred to the animals that fed upon them.

Organic compounds derived from the plankton, both plant and animal, accumulated in mud deposits in shallow waters of the ocean floor. In the source, materials were buried by sedimentary action and, in an oxygen-free environment, gradually converted into oil and gas.

Natural gas is largely methane (CH_4), which can be produced by certain kinds of anaerobic bacteria. Gas is generally associated with oil and can result from the action of methane-producing bacteria upon organic compounds.

6. Diatomaceous earth industry:

The diatoms are equally important in comparison with other algae that have industrial utilization. Most species of diatoms are marine, and when these minute plants die, they fall to the sea bottom and, because of their siliceous nature, the cell walls are preserved indefinitely. Great deposits of this material, known as diatomaceous earth, are found in many parts of the world.

The largest beds in the United states, some 1400 feet thick, are in California. The beds are sedimentary deposits originally laid down on the floor of the ocean and later raised above the level of the sea.

Because diatomaceous earth is inert chemically and has unusual physical properties, it has become an important and valuable material in industry. It makes an excellent filtering agent, which is widely used to remove colouring matters from products as diverse as petrol and sugar.

As a poor conductor of heat it is used in soundproofing. It is used in the manufacture of paints and varnishes, of phonograph records, and as a filler for battery boxes. Because of its hardness, it is used as an abrasive in scouring and polishing powders.

7. Algae is used as medicine:

Medicinal applications of plants are almost as old as their food uses. From earliest times the Chinese used sargassum and various lamina-riales for treatment of goiter and other glandular troubles. Gelidium very early became employed for stomach disorders arid for heat-induced illness.

The gentle swelling of dried laminaria stipes upon exposure to moisture make them surgical tool in the opening of wounds. Similarly, the orientals have employed the same technique in child-birth for expansion of the cervix.

Perhaps the algae used most widely and for the longest time for medicinal purposes and from which agar is extracted are the agarphytes, including gelidium, pterocladia, gracilaria, and ahnfeltia. The name ‘agar-agar’ is of malay origin and. Means ‘jelly’. This jelly was obtained by boiling up seaweeds and cooling the resulting liquid.

Agar early became useful for stomach disorders and as a laxative, and was once employed as a dietetic. It was originally produced and marketed in china, bat the Japanese took over production in about 1662 and maintained a world monopoly till 1940.

The most significant date in the utilization of agarphytes was 1881, when Robert Koch proved the value of agar in the cultivation of bacteria. Since that time is has become essential to the work of hospitals and medical research laboratories throughout the world. Besides these, chlorella is used for the preparation of antibiotic chlorellin.

FOSSIL ALGAE:

Algae are very important producers in the marine environment's food chain. Through photosynthesis, by using energy from sunlight, algae can convert carbon dioxide and important nutrient elements such as carbon, magnesium, hydrogen, oxygen, potassium, iodine, nitrogen, calcium and iron into carbohydrates and proteins that sustain all animal life. Some very important examples of fossilized algae have been found in the Pennsylvanian and Permian strata of southeastern nebraska and southwestern Iowa.

Algae are very important fossils in helping geologists and paleontologists to understand the ancient environments of depositions and ecosystems that existed in the geologic past. The kind of algae present in a rock can give the geologist some idea as to the depth of water in which the rock was deposited. Some wavelengths of light penetrate the water column deeper than other wavelengths. Different species of algae photosynthesize at different wavelengths of light. For example, red wavelengths of light penetrate deeper than blue wavelengths so a species of algae that used only red wavelengths would suggest it lived in deeper water.

All algae live in the photic zone---the range of water depths that sunlight penetrates and photosynthesis takes place. By using carbon dioxide, the algae produces the carbonate (co_3) ion which is one of the building blocks of calcite ($caco_3$), the mineral component of limestone.

SALIENT FEATURES OF CYANOPHYCEAE:

A. Nucleus is of prokaryotic nature i.e., devoid of nuclear membrane and nucleolus,

B. Absence of well-organised cell organelles, and

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

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

Important characteristics of cyanophyceae:

1. The individual cells are prokaryotic in nature. The nucleus is incipient type and they lack membrane bound organelles.

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

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

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

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

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

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

8. Many filamentous members possess specialized cells of disputed function (supposed to be the centre of n_2 fixation) known as heterocysts.
9. Reproduction takes place by vegetative and asexual methods. Vegetative reproduction takes place by cell division, fragmentation etc. Asexual reproduction takes place by endospores, exospores, akinetes, nannospores etc.

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

Occurrence of cyanophyceae:

Members of cyanophyceae are available in different habitats. Most of the species are fresh water (e.g., oscillatoria, rivularia), a few are marine (e.g., trichodesmium, darmocarpa), and some species of oscillatoria and nostoc are grown on terrestrial habitat.

Species of some members like anabaena grow as endophytes in thallus of anthoceros (bryophyta) and in leaves of azolla (pteridophyta) and nostoc in the root of cycas (gymnosperm).

Species of nostoc, scytonema, gloeocapsa, and chroococcus grow symbiotically with different fungi and form lichen. Some members like nostoc, anabaena etc. Can fix atmospheric nitrogen and increase soil fertility.

Thallus organisation in cyanophyceae:

Plants of this group show much variation in their thallus organisation.

The thallus may be of unicellular or colonial forms:

1. Unicellular form:

In unicellular form, the cells may be oval or spherical. Common members are gloeocapsa (fig. 3.23a), chroococcus and synechococcus.

2. Colonial form:

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

The colonies may be of two types:

A. Non- filamentous, and

B. Filamentous.

A. Non-filamentous type:

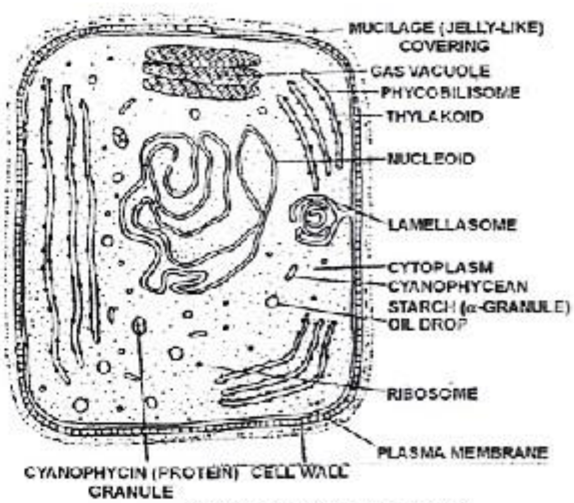
The cells of this type divide either alternately or in three planes, thereby they form spherical (gomphosphaera, coelosphaerum), cubical (eucapsis alpine, squarish (merismopedia) or irregular microcystis, colony.

B. Filamentous type:

By the repeated cell division in one plane, single row of cells are formed, known as trichome. E.g., oscillatoria, spirulina, arthosporia etc. The trichome when covered by mucilaginous sheath is called a filament. The filament may contain single trichome (oscillatoria, lyngbya) or several trichomes (hydrocoleus, microcoleus,).

The trichomes may be unbranched (oscillatoria, lyngbya), branched (mastigocladus limilosus, fig. 3.23j) and falsely branched (scytonema, fig. 3.23k and tolypothrix).

Cell structure of cyanophyceae:



Structure of cyanobacterial cell

Reproduction in cyanophyceae:

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

The vegetative reproduction performs through fission (synechococcus), fragmentation (oscillatoria, cylindrospermum muscicola), hormogonia formation (oscillatoria, nostoc), hormospores (westiella lanosa), planococci and palmelloid stage.

During asexual reproduction various types of asexual spores are formed. These are akinetes (anabaena sphaerica, gloeotrichia natans, calothrix fusca), endospores (dermocarpa), exospores (chamaesiphon) and nannocyte (microcystis)

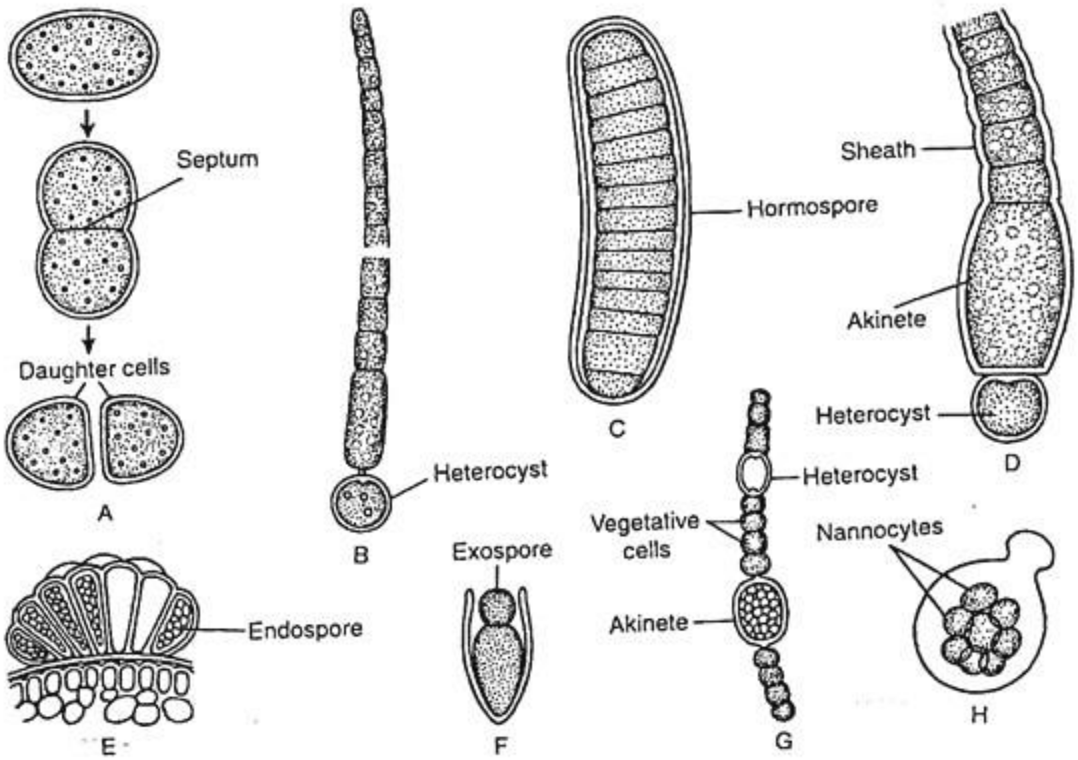


Fig. 3.27 : Vegetative and asexual reproduction in Cyanophyceae : A. Cell division (*Synechococcus* sp.), B. Fragmentation of filament (*Cylindrospermum muscicola*), C. Hormospore (*Westiella lanosa*), D. Akinete (*Gloeotrichia natans*). E Endospore (*Dermocarpa prasina*), F. Exospore (*Chamaesiphon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

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

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

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

Similarities of cyanophyceae with rhodophyceae (red algae):

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

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

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

Reproduction in cyanophyta:

The cyanophyta are characterized by the complete absence of sexual reproduction; no sexual organs and no motile reproductive bodies have been observed. Propagation takes place by simple division, by spores (akinetes, endospores, and exospores) or else by fragmentation (fission). The multiplication of unicelluar and colonial forms is brought about mainly by simple cell division.

In all the filamentous forms multiplication is largely effected by the formation of hormogonia.

The hormogonia are the fragments of the filament delimited by the occasional death of cells at intervals along the length of the filament. In certain forms, the hormogonia are enveloped by thick sheath and thus are modified as organs of perennation, known as hormocysts or hormospores (fig. 10c), which on germination grow out into new filaments.

Many of the filamentous forms produce heterocysts (fig. 23d, e), which break up the filament into hormogonia. At times the heterocysts may behave as spores to germinate into new filaments. In some cyanophyta, the akinetes germinate immediately after formation, while in others they remain dormant for long time behaving as resting spores.

On germination the protoplast divides producing germling. In a number of genera, particularly in certain unicellular members, small spores, known as endospores are formed endogenously within a cell (fig. 10d). They arise by successive division of the protoplast along three planes. The endospores forming cell behaves as a sporangium.

The endospores are generally naked, but a thin wall is secreted after their liberation from the sporangium.

In some epiphytic forms the delicate cell wall ruptures apically exposing the protoplast from which spherical spores are abstricted successively from its tip, these are called exospores'. The abstricted spores are surrounded by a delicate membrane.

The protoplast is continuously active. The exospores may germinate when already attached to the parent .protoplast giving rise to new individuals.

True sexuality does not exist in the blue-green algae, but a kind of parasexual phenomenon designated as genetic recombination has been demonstrated in anacystis nidulans by gene transfer and gene recombination through blue-green algal virus. Genetic recombination differs from true sexuality in that it is not through syngamy or meiosis, and yet the function of true sexuality is achieved.

Genetic recombination has also been reported in cylindrospermum majus and anabaena doliolum. It is likely that genetic recombination is brought about by conjugation between donor and recipient cells, as in bacteria. It is also possible that gene recombination may be caused by transduction, a process in which the virus acts, as a vector of certain genes transferring them from donor to recipient cells.

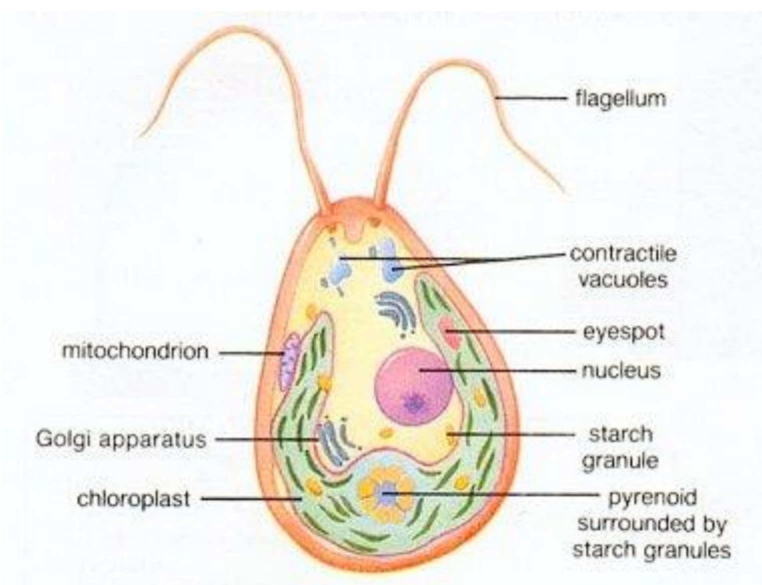
Large number of blue-green algal viruses have already been discovered to play the above role, of which mention may be made of the blue-green algal virus, cyanophage lpp-1 having host range (lyngbya, plectonema and phormidium).

Chlorophyceae:

Salient features of chlorophyceae

- Plant body may be unicellular, colonial, filamentous or multicellular.
- They are usually green due to the presence of chlorophyll a, chlorophyll b and beta-carotene.
- The chloroplast may be discoid, cup-shaped (e.g. *chlamydomonas*), spiral or ribbon shaped (e.g. *spirogyra*)
- Most chlorophytes have one or more storage bodies called pyrenoids (central proteinaceous body covered with a starch sheath) that are localised around the chloroplast.
- The inner cell wall is made of cellulose and the outer layer is pectose.
- asexual reproduction is by zoospores. They are flagellates produced from the parent cells by mitosis. Also by aplanospores, hepnospores, akinetes, palmella stage, etc.
- sexual reproduction of plants is isogamous, anisogamous or oogamous.

Cell structure of chlamydomonas

- 

Reproduction of chlorophyceae

Vegetative reproduction usually takes place by fragmentation. Asexual reproduction is by flagellated zoospores. And haplospore, perrination (akinate and palmellastage). Asexual reproduction by mytospore absent in spyrogyra. Sexual reproduction shows considerable variation in the type and formation of sex cells and it may be isogamous e.g. *Chlamydomonas*, *ulothrix*, *spirogyra*, anisogamous e.g. *Chlamydomonas*, *eudorina* or oogamous e.g. *Chlamydomonas*, *volvox*] *chlamydomonas* has all three types of sexual reproduction.

They share many similarities with the higher plants, including the presence of asymmetrical flagellated cells, the breakdown of the nuclear envelope at mitosis, and the presence of phytochromes, flavonoids, and the chemical precursors to the cuticle. The sole method of reproduction is asexual and azosporic. The content of the cell divide into 2,4 (b), 8(c) sometimes daughter protoplasts. Each daughter protoplast rounds off to form a non-motile spore. These autospores (spores having the same distinctive shape as the parent cell) are liberated by the rupture of the parent cell wall (d). On release each autospore grows to become a new individual. The presence of sulphur in the culture medium is considered essential for cell division. It takes place even in the dark with sulphur alone as the source material but under light conditions nitrogen also required in addition. Pearsal and loose (1937) reported the occurrence of motile cells in *chlorella*. Bendix (1964) also observed that *chlorella* produces motile cells which might be gametes. These observations have an important bearing on the concept of the life cycle of *chlorella,* which at present is considered to be strictly asexual in character.

Asexual reproduction in *chlorella ellipsoides* has been studied in detail and the following four phases have been observed during the asexual reproduction.

(i) Growth phase- during this phase the cells grow in size by utilizing the photosynthetic products.

(ii) Ripening phase- in this phase the cells mature and prepare themselves for division.

(iii) Post ripening phase- during this phase, each mature cell divides twice either in dark or in light. The cells formed in dark are known as dark to light phase, cells again grow in size.

(iv) Division phase- during this phase the parent cell wall ruptures and unicells are released.

Salient features of phaeophyceae:

1. Phaeophyceae commonly called as brown algae.

2. Majority are marine habitats. Pleurocladia is a fresh water form.

3. Thallus may be filamentous, frond – like or giant kelps.

4. Thallus is differentiated into photosynthetic part-frond, stalk – like structure – stipe and a holdfast for attachment.

5. Chlorophyll ‘a’ and ‘c’ , carotenoids and xanthophylls are photosynthetic pigments.

6. A golden brown fucoxanthin pigment gives olive green to brown colour.

7. Mannitol and laminarin starch is the storage material.

8. Motile spores with unequal flagella (one whiplash and one tinsel) are present.

9. Oogamous is the major type of sexual reproduction. Isogamy is also seen.

10. Alternation of generation is seen. Example: sargassum, fucus, laminaria and dictyota.read

Reproduction in phaeophyceae:

Many brown algae reproduce by vegetative method by the process of fragmentation of the young or adult thallus. Fragments of the thallus, thus produced, may become detached from the parent plant and float away to form new individuals, or they remain united with one another forming an aggregation of individuals, being attached to the substratum by the common holdfast. In some cases, special reproductive branches (propagula) are formed and these are separated from the parent plant, ultimately developing into new individuals.

All brown algae, excepting the fucus and a few allied genera, reproduce asexually by the production of zoospores or aplanospores. The zoospores are produced within both unilocular (or unicellular) and plurilocular (or multicellular) sporangia and are always borne on the diploid thallus (sporophyte). The unilocular sporangium is a true sporangium, because reduction division of the uninucleate protoplast takes place prior to the formation of the haploid zoospores.

The nucleus of the protoplast first divides reductionally into two nuclei, which subsequently divide and re-divide mitotically into 32, 64 or 128 nuclei. This is followed by the cleavage of the protoplast forming uninucleate masses, each of which is finally metamorphozed into a biflagellate zoospore. Each of these zoospores, after liberation, produces a haploid thallus (gametophyte).

On the other hand, the zoospores produced by the plurilocular sporangium are diploid, each of which on germination gives rise to a diploid thallus, similar to the thallus from which it is derived. These zoospores are, therefore, termed neutral zoospores and the sporangium, neutral sporangium.

During the formation of neutral zoospores, the uninucleate protoplast of each cell of the plurilocular sporangium (neutral sporangium), without undergoing reduction division, is directly metamorphozed into a neutral zoospores with two flagella. Thus, by the neutral zoospores the same generation is reduplicated. Sometimes the unilocular sporangium, instead of producing the zoospores, may produce 4-8 large, non-flagellate aplanospores.

Sexual reproduction in the brown algae may be a case of:

(i) Isogamy, i.e. By the union of two motile morphologically identical gametes,

(ii) Anisogamy, i.e. By the union of two motile gametes of unequal size, and

(iii) Oogamy, i.e. By the union of a motile, flagellate antherozoid with a non-motile, non-flagellate, passive egg.

The iso- and aniso-gametes are produced within multicellular gametangia, which are similar in appearance with the neutral sporangia but these are always produced on the gametophyte, which is either homothallic or heterothallic.

The zygotes, thus produced, develop into new sporophytes. Several members of the phaeophyceae are oogamous and heterothallic. The male sex organ, the antheridium, may be unicellular or multicellular, and the entire protoplast of each cell is directly metamorphozed into a single antherozoid with two flagella.

The female sex organ, the oogonium, is always unicellular containing within it 1-8 oospheres or eggs. In some cases, the egg is extruded from the oogonium or even discharged from it, so that fertilization takes place outside the body of the oogonium.

When sexual union fails, the gametes either degenerate or the unsuccessful gametes may develop into parthenospores.

The salient features of rhodophyceae:

1. Rhodophyceae commonly called as red algae.

2. Mostly marine habitats.

3. The thallus is multicellular, macroscopic, and may be filamentous, ribbon – like etc.

4. Chlorophyll ‘a’ , r-phycoerythrin and rphycocyanin are photosynthetic pigments.

5. Asexual reproduction is by means of monospores, neutral spores and tetraspores.

6. Floridean starch is the storage material

7. Sexual reproduction in oogamous.

8. Male sex organ is spermatangium producing spermatium.

9. Female sex organ is carpogonium.

10. Spermatium is carried by water and fuses with egg forming zygote.

11. Zygote undergoes meiosis forming carpospores.

12. Alternation of generation is seen. Example: Ceramium,G and Gigartina.

Reproduction in rhodophyceae:

Red algae seldom reproduce vegetative. Vegetative reproduction may take place by the fragmentation of the thallus. Asexual reproduction takes place by one or more types of non-flagellate asexual spores.

In the sexual reproduction, the male sex organ (spermatangium), and the female sex organ (procarp or carpogonium) are produced, either on the same plant or on different plants. The male gamete (spermatium) is produced from the spermatangium, and its nucleus zygote nucleus.