ALGAE (SEA WEED):

Introduction

- The term 'Algae' coined by Linnaeus.
- Study of Algae is called Phycology or Algology. F. E. Fristch is known as 'Father of phycology'.
- Father of Indian phycology - M.O.P. Iyenger.
- It involves those organisms that have thallus like plant body, chlorophyll, accessory spores for asexual multiplication no jacketed Gametangial, absence of embryo stage.

Nature-

- Algae are found in both fresh and marine water. Algae are found in many forms like filamentous, colonial.
- Algae are surrounded by mucilagenous sheath and below the sheath cell wall is present which is made up of cellulose and pectin but mainly made up of cellulose, galactans, mannans and mineral like calcium carbonate.
- On the basis of structure, algae are thalloid i.e. plant body is not differentiated into root, stem and leaves. Tissue system is also absent in algae.
- On the basis of nutrition, algae are photoautotrophic. They have plastid in which photosynthetic pigments are present. Classification of algae is mainly based on pigments. Chl-a and β carotene are universal pigment of algae.
- Stored food - starch.
- Pyrenoids - Proteinaceous body surrounded by starch mostly found in chloroplast.
- Main function - starch synthesis.

Habitat of Some Important Algae

- **Terrestrial**: The algae found in moist soil & wall.
  Eg. Terrentofolia
- **Epiphytes :** Algae which are present on plants
  Eg. Protococcus
- **Endophytes :** Algae which are present inside plants
  Eg. Coleochaete nitelum (in Nitella plant)
- **Epizoic** : Algae which are present on animals
  Eg. Cladophora (present on Mollusca shell), on sloth bear (Symbiotically)
- **Endozoic** : Algae which are present inside the body of animals
  Eg. Zoo chlorella and Zooxanthellae (inside the Hydra)
- **Parasites** : Algae that live as parasite and causes diseases
  Eg. Cephaleruos (algae remain in the leves of tea plant)
  Cephaleruos causes red rust disease of tea.
- **Thermophilic** : Algae found in hot water
  Eg. Chlorella
- **Cryophytes** - Algae which are present in Polar Regions & Low temperature.
  Eg. Chlamydomonas (some species)
  Haematococcus nivalis (It develops red snow in polar region)
- **Cryptophytes :** Algae which found under the soil
  Eg. Nostoc
- **Sapophytes** : Algae found on surface of soil
  Eg. Vaucheria
- **Epiphloephytes** – Algae arise on bark of trees.

Reproduction

(1) Vegetative **(2)** Asexual **(3)** Sexual

Vegetative reproduction:-

By Fragmentation - Filaments break down into small pieces & form new filaments.

Asexual reproduction:-
Zoospores are formed in favorable conditions and Aplanospores, Hypnos pore and akinete etc. are formed in unfavorable condition.

Sexual reproduction:-

- Male sex organ is called antheridium and female is called oogonium. The sex organs of algae are unicellular & jacketless. But exceptionally sex organs of green algae Chari (Chari green algae - known as stone wort) are multicellular and jacketed. The male sex organ of Chara is known as globule and female is known as nucule.
- Plant body of algae is haploid so sexual reproduction take place through zygotic meiosis.
- So their life cycle is haplontic. But exceptionally brown algae are diploid. [Ex. In Fucus life Cycle in diplomatic]
- Algae reproduce by zygotic meiosis i.e. first division in zygote is meiosis so embryo is not Formed.

Sexual reproduction is of three types

- Isogamous - Chlamydomonas debaryanum, Ulothrix, Ectocarpus, Spirogyra, Cladophora
- Anisogamous - Chlamydomonas braunii
- Oogamous - Chlamydomonas coccifera, Sargassum, Volvox, Fucus and Chara

Note:

- Chlamydomonas exhibits complete evolution of sexual reproduction.
- In Chlamydomonas debaryanum gametes are flagellated and similar in size. asogamy)
- In Chlamydomonas braunii gametes are motile and dissimilar in size. (Anisogamy)
- Most of the species of Chlamydomonas show isogamy.
- In Spirogyra gametes are non-flagellated (non-motile) and similar in size (isogamy)
- In Cladophora, green algae isogametes are biflagellate. (Isogamy)
- In Eudorina (Green algae) fusion between two gametes dissimilar in size (Anisogamy)

Lifecycle type in algae can be
Haplontic - Volvox, Spirogyra,
Diplontic - Sargassum and Fucus;
Haplodiplontic - Polysiphonia, Ectocarpus, Kelps.
Embryo stage is absent.

Classification of Algae

- Whittaker classified Algae on the basis of photosynthetic pigments into three classes -Red algae, brown algae, and green algae

Algae is divided into following classes

- CHLOROPHYCEAE - GREEN ALGAE
- PHAEOPHUCEAE - BROWN ALGAE
- RHODOPHYCEAE - RED ALGAE

COMPARISON OF SOME CHARACTERISTICS OF ALGAE					
KINGDOM	NAME OF ALGAE	PHOTOSYNTHETIC PIGMENTS		TYPE OF RESERVE FOOD	FLAGELLA
		CHLOROPHYLL	OTHER		
	Green Algae	a + b	B- 8-carotene and other carotenoids	Starch	Isokont and (2-8) anterior position

Planta	Brown Algae	a + c	Fucoxanthin	Laminarian starch, mannitol	Heterokont, (2) laterally inserted
	Red Algae	a + d	Phycobilins (phycoerythrin & phycocyanin)	Floridean starch	Absent

Chlorophyceae (Green Algae)

- Green algae is the most advanced algae.
- It is believed that green algae is the ancestor of the higher plants.
- On the basis of pigments (Chl 'a', Chl 'b', Carotenoids), stored food (starch) & cell wall (made up of cellulose or pectin).
- Habitat: Green algae is cosmopolitan in nature.

Different Forms of Thallus of Green Algae (Structure)

Unicellular:

- **Chlamydomonas**: Motile unicellular algae. The algae moves with the help of flagella.
- Chlorella: Non motile unicellular alge. Calvin discovered ''Calvin Cycle'' by experimenting on Chlorella
- Acetabularia - (Umbrella plant) - It is the largest unicellular plant. The diameter of its cell is 10 cm. Hammerling experimented on Acetabularia.

Coenocytic –

Some green algae are Coenocytic i.e. multinucleated. Eg. Caulerpa

Note: According to five kingdom system the algae described above should be placed in Protista but exceptionally its life cycle is similar to green algae. Therefore they are placed in plantae.

Colonial –

Some green algae are found in colonies. They form colony of cells.

- The number of cells in a colony is fixed. Such colony is called coenobium.
- The number is decided at development stage.
  Eg. Volvox - Motile colony
  Hydrodictyon - Non motile colony (called as water net)

Multicellular filamentous:

Mostly algae are multicellular filamentous.

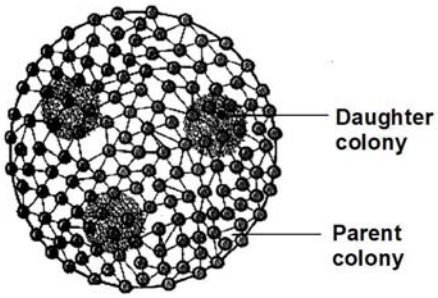
- Unbranched filament: eg. Ulothrix - Known as pond wool Spirogyra - Known as pond silk (they reproduce by conjugation (fusion of gametangia)
- Heterotrichous branched: Some green algae have two types of branches prostrate and erect.
  Eg. Fritschiella, Cladophora, Stigeoclonium, Coleochaete, Chara.

Multicellular thalloid or Parenchymatous:

Some algae are multicellular in length & width.

Eg. Ulva - Also called as sea lettuce

- Shape of chloroplast in algae: Discoidal-Chara; Plate like - Chlorella; Reticulate- Oedogonium, Cladophora; Stellate - Zygnema; Girdle shaped-Ulothrix; Cup shaped, Volvox; Spiral or ribbon shaped-Spirogyra.
- Pigments: Chl a, b, carotenes (α, β and γ type), xanthophyll like lutein.
  Note: Green algae are usually grass green due to dominance of pigment Chl-a and Chl-b.
- Stored food: Starch is reserve food material and stored in one or many storage bodies called Pyrenoids located in the chloroplast. Pyrenoids contain protein in centre and starch in periphery.
- Cell wall: Consists of cellulose (inner layer) and also have pectose (outer layer) & xylan.
- Reproduction: Vegetative reproduction-fragmentation or by formation of different type of Spores.
  Asexual reproduction - Flagellated zoospores produced in zoosporangia.



Volvox

Ulothrix

Sexual reproduction takes place through isogamy, anisogamy and oogamy.
E.g. Volvox, Ulothrix, Spirogyra and Chara.
Note: Calvin used Chlorella and Scenedesmus for studying photosynthesis. Ordovician period of palaeozoic era is called the age of algae.

Life Cycle

- Three types of life cycles occur in green algae – haplontic, Diplontic and Haplodiplontic.
- In haplontic life cycle the dominant phase is haploid. It is characterised by zygotic meiosis
  E.g. Ulothrix, Spirogyra, Chlamydomonas.
- Diplontic life cycle, e.g. Caulerpa.
- The haplodiplontic life cycle possesses well developed multicellular haploid (Gametophyte) and diploid (sporophyte) thallus.
- It is characterised by sporic meiosis produce Zoospore which germinate to produce the sexual haploid gametophyte. E.g. Ulva, Cladophora.

Economic Importance

- Food: Codium, ulva used as salad or vegetable.
  Chlorella is used as food because after spirulina, Chlorella has largest amount of protein.
- Antibiotics : Chlorellin antibiotic is obtained from Chlorella
- Space research: In space, Chlorella is used as a source of food and O_2.
- Parasitic algae: Cephaleurose viresence algae remains parasitically in the leaves of tea plant and cause disease 'red rust' of tea.

Phaeophyceae (Brown Algae)

General characters:

- They are found primarily in marine habitat.
- They show great variation in size and forms – Simple branched filamentous form–Ectocarpus.
- Profusely branched (Parenchymatous structure) form – Kelp
- Some brown algae are giant (large sized) that are called kelps or sea weeds
  E.g. Macrocystis – length is 30–60 m, Nereocystis–length is 20–30 m, Laminaria – Length is 2–12 m.
- Plant body is differentiated into hold fast (for fixation with substratum), stipe (Stalk) and lamina (Leaf like for photosynthesis).
- Conducting tubes or trumpet hyphae are found in larger brown algae or kelps. It helps in food Conduction (Analogus to sieve tubes of higher plants).
- The vegetative cells have a cellulosic wall usually covered on the outside by a gelatinous Coating of algin, fucin and fucoidin.
- The protoplast contains, in addition to plastids, a centrally located vacuole and nucleus.
- Pigments – Chl-a, Chl-c carotenoid (β-carotene) and xanthophyll (Fucoxanthin).
  Note: Colour of brown algae varies from olive green to various shades of brown due to different amount xanthophyll pigment.
- Reserve food is laminarin or mannitol (complex carbohydrate) and oil.

Phycocolloids / Hydrocolloid:

- The cell wall of brown algae contain some gelatinous coating of colloid substance like fucinic acid, alginic acid and fucoidin in outer layer which are known as phycocolloids.
- Phycocolloids protects brown-algae against dessication and shocks.
- Phycocolloids are used in ice-cream to make them more viscous.
- Alginates, salts of alginic acid used for dentury measurement.
- The cells of brown algae have chloroplast, centrally located vacuole and nucleus.

Reproduction -

- Vegetative reproduction-fragmentation.
- Asexual reproduction in most brown algae is by biflagellate zoospores that are pear-shaped and have two unequal laterally attached flagella.
- Sexual reproduction takes place through isogamy, anisogamy and oogamy.

Note -

- Union of gametes may take place in water or within the oogonium (oogamous species).
- Both asexual biflagellate zoospores and sexual gametes are pear shaped (pyriform) and have two unequal, laterally attached Heterokont flagella.
- Zygotic meiosis absent but sporic meiosis occurs.

Special Name:

- Postelsia – It is known as Sea palm.
- Ancyclonema – It is called Ice bloom because it grows on marine ice.
- Sargassum – It is known as Gulf weed because Sargassum is a free floating algae.
- It grows rapidly in North Atlantic Ocean and covers thousands of hectares of area. Therefore this region is called as Sargasso Sea.
- Laminaria (Kelps) - It is called as Devil's Aprin other forms are Ectocarpus, Dictyota and Fucus.

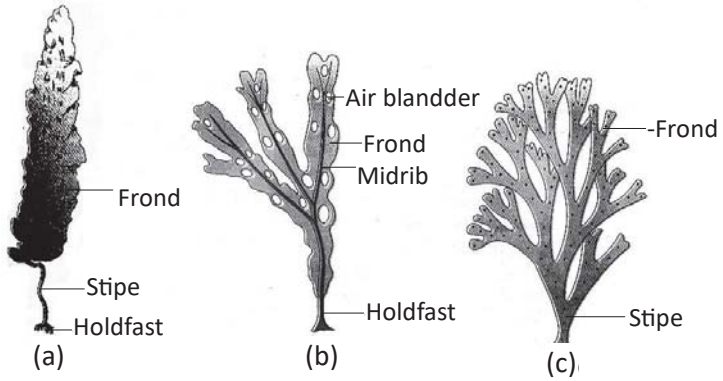


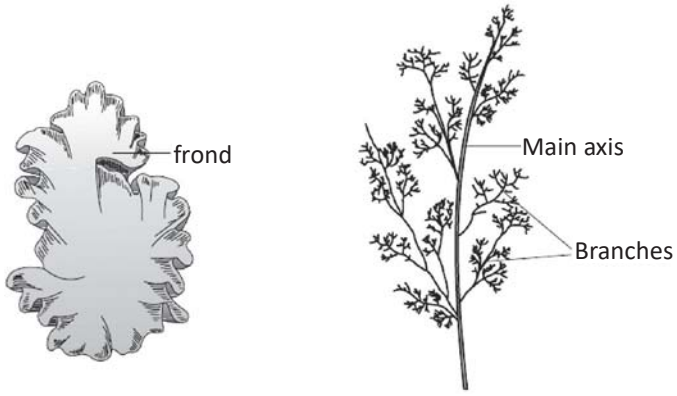
Fig: Laminaria (a), Fucus (b), Dictyota (c)(TB)

Economic importance:

- Algin: It is nonsulphated phycocolloid and obtained from Laminaria, Macrocystis, Fucus, and Sargassum. It is used in flame proof plastics, security glass, gauze and surgical threads, shaving creams, tooth paste, cosmetic creams, shampoos, sauces, sizing textiles, etc.
- Iodine: It is extracted from Laminaria and Fucus.
- Mannitol: It is used as food and added to inks, plastic, paints and varnishes. It is half as sweet as sugar and is a good substitute of sugar for diabetic patients.
- Food: Some brown algae are used as food in some countries. Kombu is rich in carbohydrate and formed by Laminaria. Alaria yields a product called sarumen in japan..

Rhodophyceae - Red Algae

- Red algae is second most ancient algae after blue green algae i.e. they are developed after blue green algae. Eg. Polysiphonia
- Red algae mainly found in marine (more in warmer areas) water.
- Exceptionally Batrachospermum is found in fresh water (river) and Porphyridium is found on land.
- There is no motile stage found in life cycle of red algae and BGA i.e. cilia & flagella are absent.
- Red algae are multicellular but exceptionally Porphyridium is unicellular. The thallus of red algae are multicellular with complex body organization i.e. psedoparenchymatous.



Porphyra Polysiphonia

- Cell wall of red algae is complex and made up of cellulose & pectin.
- The cell wall of red algae is also complicated like blue green algae.
- Their cell wall has many different type of substance such as xylan, mannan, galactose, polyuronic acid, polysulphate esters.
- In some Red algae calcium carbonates is also present in the cell wall. Due to which their thallus become stony. These algae form lime stone & coral reefs
  Eg. Corallina and Lithothamnion
- The prominent primitive pit connection develop in between cells after fertilization, Help in post fertilization development.

Pigments – Chl-a, Chl-d carotenoid (β-carotene) and phycobilins (R-phycoerythrin – red colour and R - phycocyanin - Blue colour).

Red algae occur in both -

- Well lighted region / close to surface of water – Abundance of R - phycocyanin (Blue colour).
- Low lighted region / great depths in ocean - Abundance of R - phycoerythrin (Red colour).
- Reserve food is floridean starch. It is highly branched as cyanophycian starch. Thus floridean starch and cyanophycian starch both are similar as amylopectin and glycogen in structure.

Floridean Starch -

- It is a primitive type of starch.
- Structurally floridean starch is similar to the cyanophycean starch of blue green algae.
- Starch of higher plants is less branched yet floridean starch& cyanophycean starch is highly branched.
- Glycogen is also highly branched so that floridean & cyanophycean starch is structurally similar to glycogen and amylopectin.

Phycocolloids:

Agar, Carrageenin and funori (Type of glue) phycocolloids are found in the cell wall of red algae.

Reproduction

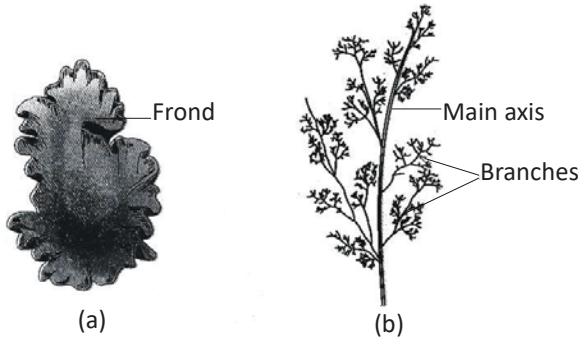
- Vegetative : By fragmentation
- Asexual : Non motile spores [By monospore, carpospores, tetraspore]
- Sexual Reproduction - By non-motile gametes.
- Sexual reproduction is oogamous type accompanied by complex post fertilisation development.
- The female sex organs are called carpognia. Carpogonia bear receptive neck tichogyne.
- They are apparently similar to archegonia of bryophyta.
- Carpogonia is unicellular & jacketless but archegonia is multicellular & jacketed.
- The male sex organs of red algae are known as spermatangia.
- Non-motile spores like gametes are formed in spermatangia which are known as spermatia.

Life Cycle Life Cycle

- Exceptionally life cycle of Polysiphonia is diplohaplontic (Haplo Diplontic) but triphasic as carp sporophyte, tetra sporophyte and gametophyte plant appear in life cycle.

Note –

- Flagellated cells / motile gametes / motile spores are completely absent in life cycle.
- Batracospermum red algae - fresh water, blue coloured
- Harveyella red algae - pigment absent, colourless non-photosynthetic and parasite on other algae.
- Gaidukov's effect - colour of red algae and blue green algae changes according to depth in sea (Chromatid adaptation)



(a) Porphyra (b) Polysiphonia (TB)

Economic importance:

Phycocolloids (Sulphated):

- Agar-agar is obtained from Gelidium, Gracilaria etc (these algae are called agarophytes). It is used to solidify culture medium. It is also used as laxative stabilizer or thickener in preparing jams, jellies, creams, pudding, baby food, ice cream, bakery products.
- Carrageenin is obtained from cell wall of chondrus Crispus and Gigartina. It is used in confectionary, bakery, jelly, creams, as clearing agent in liquors (Beer) and leather finishing, as emulsifier in chocolates, ice-creams, sauces, toothpastes paints and cosmetics.

  Food: Some red algae are edible e.g. Laver (Porphyra), Dulse (Rhodymenia), Irish moss (Chondrus).

TABLE: Divisions of Algae and their Main Characteristics

Classes	Common name	Main pigment	Stored food	Cell wall	Flagellar Number and Position of Insertion	Habitat
Chlorophyceae	Green algae	Chlorophyll a, b	Starch	Cellulose	2-8, equal, apical	Fresh water, brackish water, salt water
Phaeophyceae	Brown algae	Chlorophyll a, c fucoxanthin	Mannitol, laminarin	Cellulose and algin	2, unequal lateral	Fresh water (rare) brackish water, salt water
Rhodophyceae	Red algae	Chlorophyll a, d phycoerythrin	Floridean starch	Cellulose, pectin and poly sulphate esters	Absent	Fresh water (some), brackish water, salt water (most)

Thallophyta

- The term ‘‘Thallophyta’’ was given by ‘‘Endlicher’’.
- According to two kingdom classification, all the algae, fungi, lichen and bacteria are placed in thallophyta, because their plant body is similar to thallus.
- All the thallophytes are non-vascular.
- In thallophyta plant is haploid i.e. gametophyte
  Eg. Green Algae, Red algae, Yellow green algae, Dinoflagellate, Cellular slime mould.
  Note: Exceptionally in some thallophytes, plant is diploid i.e. sporophyte Eg. Brown algae, Diatoms, Acellular slime molds.
- In thallophyta the male sex organs are called as Antheridia and female sex organs are called as Oogonia.
- Sex organs are unicellular & Jacket less (Jacket layer of sterile cells)
- The sexual reproduction in thallophyta is isogamous, anisogamous and oogamous.
- In thallophyta, sex. Reproduction takes place through zygotic meiosis, therefore embryo is not formed.

Demerits of Two kingdom classification:

- In two kingdom classification Prokaryotes and Eukryotes placed in the same group.
- In this system photosynthetic green algae and non-photosynthetic fungi are placed in same group i.e. plantae.
- Two kingdom system takes unicellular and multicellular organism together.
- On the basis of cell wall bacteria were considered as plant and put in plantae.
- Position of Euglena was not fixed.