BIOLOGICAL CLASSIFICATION

KINGDOM PLANTAE

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 nonjacketed gametangia**, **absence of embryo stage**.

NATURE-

- (1) Algae are found in both fresh and marine water. Algae are found in many forms like filamentous, colonial.
- (2) 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.
- (3) 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.
- (4) 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.
- (5) Stored food starch.
- (6) Pyrenoid Proteinaceous body surrounded by starch mostly found in chloroplast.
- (7) Main function starch synthesis.

BIOLOGY

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. Zoochlorella and Zooxenthellae (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 favourable conditions and Aplanospores, hypnospore and akinete etc. are formed in unfavourable 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.

- (ii) Plant body of algae is haploid so sexual reproduction take place through zygotic meiosis.
- (iii) So their life cycle is haplontic. But exceptionally brown algae are diploid. [Ex. In Fucus life cycle in diplomatic]
- (iv) Algae reproduce by zygotic meiosis i.e. first division in zygote is meiosis so embryo is not formed.

Sexual reproduction is of three types

(a) Isogamous	-	Chlamydomonas debaryanum, Ulothrix,		
		Ectocarpus, Spirogyra, Cladophora		
(b) Anisogamous	-	Chlamydomonas braunii		
(c) Oogamous	-	Chlamydomonas coccifera, Sargassum, Volvox, Fucus and Chara		

Note:

- (1) Chlamydomonas exhibits complete evolution of sexual reproduction.
- (2) In Chlamydomonas debaryanum gametes are flagellated and similar in size. asogamy)
- (3) In Chlamydomonas braunii gametes are motile and dissimilar in size. (Anisogamy)
- (4) Most of the species of Chlamydomonas show isogamy.
- (5) In Spirogyra gametes are non flagellated (non motile) and similar in size (isogamy)
- (6) In Cladophora, green algae isogametes are biflagellate. (Isogamy)
- (7) 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, green algae
- Algae is divided into following classes
 - 1. AHLOROPHYCEAE GREEN ALGAE
 - 2. PHAEOPHUCEAE BROWN ALGAE
 - 3. RHODOPHYCEAE RED ALGAE

COMPARISON OF SOME CHARACTERISTICS OF ALGAE										
KINGDOM	NAME OF ALGAE	PHOTOSYNTH	ETIC PIGMENTS	TYPE OF	FLAGELLA					
		CHLOROPHYLL	OTHER	RESERVE FOOD						
Plantae	Green Algae	a + b	β -carotene and other carotenoids	Starch	Isokont and (2-8) anterior position					
	Brown Algae	a + c	Fucoxanthin	Laminarian starch, mannitol	Heterokont, (2) laterally inserted					
	Red Algae	a + d	Phycobilins (phycoerythrin & phycocyanin)	Floridean starch	Absent					

CHLOROPHYTA (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.

BIOLOGY

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.

- (a) Unbranched filament : eg. Ulothrix Known as pond wool Spirogyra Known as pond silk
 (they reproduce by conjugation (fusion of gametangia)
- (b) 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
 - (i) 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.



(i) Pigments : chl a, b, carotenes(, and type), xanthophyll like lutein.

Note: Green algae are usually grass green due to dominance of pigment chl-a and chl-b.

(ii) Stored food: Starch is reserve food material and stored in one or many storage bodies called

pyrenoids located in the chloroplast. Pyrenoid contain protein in centre and starch in periphery.

- (iii) Cell wall: Consists of cellulose (inner layer) and also have pectose (outer layer) & xylan.
- (iv) Reproduction: Vegetative reproduction-fragmentation or by formation of different type of spores.

Asexual reproduction - Flagellated zoospores produced in zoosporangia.

Sexual reproduction takes place through isogamy, anisogamy and oogamy.

e.g. Volvox, Ulothrix, Spirogyra and Chara.

Note:

(a) Calvin used Chlorella and Scenedesmus for studying photosynthesis. Ordovician period of palaeozoic era is called the age of algae.

IFE 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 **haplo-diplontic** 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 O₂.
- **Parasitic algae : Cephaleurose viresence** algae remains **parasitically** in the leaves of **tea** plant and cause disease '**red rust**' of tea.

BIOLOGY

Class - Phaeophyceae (Brown Algae):

General characters:

- **1.** 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.
- **4.** Plant body is differentiated into **hold fast (for fixation with substratum), stipe (Stalk) and lamina (Leaf like for photosynthesis).**
- **5.** 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).
- **6.** The vegetative cells have a cellulosic wall usually covered on the outside by a gelatinous coating of **algin**, fucin and fucoidin.
- 7. The protoplast contains, in addition $\frac{12}{10}$ to plastids, a centrally located vacuole and nucleus.
- Pigments Chl-a, Chl-c carotenoid (-carotene) and xanthophyll (Fucoxanthin).
 Note: Colour of brown algae varies from olive green to various shades of brown due to different amount xanthophyll pigment.
- 9. 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.

10. 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 -

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

Life cycle

Mostly Diplo-haplontic (NCERT - Haplo-Diplontic) and Diplontic (Fucus)

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.



Economic importance:

- (1) Algin: It is nonsulphated phycocolloid and obtained from Laminaria, Macrocystis, Fucus, 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.
- (2) Iodine : It is extracted from Laminaria and Fucus.
- (3) 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.
- (4) 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..

RHODOPHYTA - 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**.

- 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 fertilisation, Help in **post fertilisation development**.
- 1. Pigments Chl-a, Chl-d carotenoid (β-carotene) and phycobilins (R-phycoerythrin red colour and R phycocyanin Blue colour).

Red algae occur in both -

- (a) Well lighted region / close to surface of water Abundance of R phycocyanin (Blue colour)
- (b) 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 strach 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 (NCERT - Haplo Diplontic) but **triphasic** as **carposporophyte**, **tetrasporophyte** and gametophyte plant appear in life cycle.

Note -

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



Fig. (a) Porphyra (b) Polysiphonia (TB)

Economic importance:

- (i) Phycocolloids (Sulphated):
- (a) 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.
- (b) 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, icecreams, sauces, toothpastes paints and cosmetics.
- (ii) Food: Some red algae are edible e.g. Laver (Porphyra), Dulse (Rhodymenia), Irish moss (Chondrus).

Classes	Common name	Main pigment	Stored food	Cell wall	Flagellar Number and Position of Insertion	Habitat
Chlorophycea e	Green algae	Chlorophyll a, b	Starch	Cellulos e	2-8, equal, apical	Fresh water, brackish water, salt water
Phaeophycea e	Brown algae	Chlorophyll a, c fucoxanthin	Mannitol , laminari n	Cellulos e and algin	2, unequal lateral	Fresh water (rare) brackish water, salt water
Rhodophycea e	Red algae	Chlorophyll a, d phycoerythri n	Floridea n starch	Cellulos e, pectin and poly sulphate esters	Absent	Fresh water (some), brackish water, salt water (most)

TABLE : Divisions of Algae and their Main Characteristics

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**.

BIOLOGY

• 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.

BRYOPHYTA

- The term "Bryophyta" was proposed by "Robert Braun".
- The study of Bryophytes is known as **Bryology**.
- **Hedwig** is considered to be the **father of Bryology**. But according to some scientist it is believed that **Cavers** is the father of Bryology.
- Father of Indian Bryology is Prof. Shiv Ram Kashyap.

GENERAL FEATURES

- Bryophytes are the **first land plant**.
- It is believed that, they **originated from aquatic plant** and they come on land through water. Because some bryophytes have features similar to **aquatic** plants (eg. presence of **air canals**)
- Bryophytes are known as **amphibians** of the plant kingdom, because they **live in soil** but **need** water to complete their life cycle during sexual reproduction.
- Bryophytes are **not** considered as the successful land plants because **vascular tissue** is absent and they need water for fertilization.
- Due to the absence of vascular tissue bryophytes can not grow very tall.
- The process of water conduction in bryophytes takes place with the help of parenchyma or Hardom tissue (Sphagnum)
- Parenchyma is a living tissue, while Hadrom is dead
- The plant body is dominantly **haploid**, more differentiated than algae i.e. **Multicellular**, **thalloid**, **parenchymatous**.
- Lower bryophytes thalloid, higher are branched (prostate or erect) with stem or leaf like structure.
- Roots are absent in bryophytes (Rhizoids unicelled / multicelled present).
- Stem and leaves of higher bryophytes are functionally similar to the stem and leaves of higher plants.
- Bryophytes are **sciophytes**, i.e., bryophytes prefer to grow in **moist (wet)** and **shady** places.
- Vegetative reproduction is quite common through fragmentation, tubers, gemmae (inside gemma cup), buds, adventitious branches etc.



- (i) Body form:
- The plant body of bryophytes is more differentiated than that of algae.
- It is thallus-like (liverworts) and prostrate or erect (Mosses) and attached to the substratum by unicellular and unbranched rhizoids (Liverworts) or multicellular and branched rhizoids (Mosses).
- They lack true roots, stem or leaves. They may possess root-like (rhizoids), leaf-like (Phylloid) or stem-like (cauloid) structures.
- Thallus is multicellular, thick and **dichotomously branched**.
- The main plant body of the bryophyte is haploid. It produces gametes, hence is called a gametophyte.



Fig. (a) Funaria (b) Sphagnum (TB)

2. Vascular tissues (xylem and phloem) are absent in both gametophytic and sporophytic phases. The conduction takes place through specialized parenchyma.

3. Reproduction:

(b) Asexual reproduction -

Vegetative propagation takes place in **liverworts by fragmentation**, and gemmae while in mosses by fragmentation and budding in secondary protonema.

- (c) Sexual reproduction Oogamous type
- Sex organs are multicellular and surrounded by single layered sterile jacket.

- Male sex organ is called antheridium which is globular or club shaped and forms biflagellated antherozoids or sperms (motile male gamete).
- Flask shaped female sex organ is called archegonium that consists of a swollen venter and a tubular neck.
- Neck is composed of **6 vertical rows of cells** and encloses **4–10 neck canal cells** while venter has **venter canal cell** and a **single egg cell or oosphere (nonmotile female gamete)**.
- Water is essential for fertilization. Archegonia secretes mucilage rich in potassium salts / proteins/sucrose for attracting antherozoids in water.
- Fertilization is internal and takes place by **zoodiogamy**. Diploid zygote formed in the venter by the fusion of one antherozoid with egg cell.
- After fertilization zygote immediately divides mitotically and form multicellular embryo.
- Embryo gives rise to multicellular sporogonium or sporophyte. The latter differentiates into foot, seta and capsule. Sporophyte is completely (e.g.Riccia) or partially (e.g. Funaria) parasite on gametophyte.
- Some cells of the sporophyte capsule called as Spore mother cells or sporocytes undergo sporic meiosis and form haploid meiospores which are alike or homosporous.
- On germination, spore forms new gametophytic plant either directly (e.g. liverworts and hornworts) or indirect by juvenile filamentous, green, multicellular protonema stage (e.g. moss).