

BSc. Biological Science

Lecture-1 Algae

By Dr Dharam Singh

Department of Environmental Sciences

The algae are chlorophyll-containing primitive plants, which are prokaryotic and eukaryotic. Algae have unicellular to multicellular body structure. It has no true root, stem and leaves, thus leading to their classification as lower plants. The body of algae is called thallus. Algae belong to a polyphyletic group. The study of algae is called phycology. The term algae was first used by Carolus Linnaeus in 1753. Algae are the first to evolve photosystem II and release oxygen by photolysis of water during the process of photosynthesis. Algae perform more than 50% of global photosynthesis and they are responsible for oxygen in every second breath we take. Algae also occur in freshwater lakes, ponds and streams as well as on and in soil, rocks, ice, snow, plants and animals.

The definitions of algae as given by some phycologists are:

1. F. Fritsch, (1935) defined algae as the holophytic organisms (as well as their numerous colorless derivatives) that fail to reach the higher level of differentiation characteristic of the archegoniate plants.
2. G. M. Smith, (1955) defined algae as simple plants with an autotrophic mode of nutrition.
3. V. J. Chapman, (1962) defined algae as among the simplest in the plant kingdom.
4. G. W. Prescott, (1969) defined algae as those chlorophyll-bearing organisms (and their colorless relatives) which are thalloid, i.e., having no true roots, stems and leaves or leaf-like organs.
5. R. N. Singh, (1974) defined that the algae are by and large simple plants which display a spectrum of photosynthetic pigments and evolve oxygen during the process of photosynthesis.

Cell Structures in Algae

Cell wall of algae: Cell wall of most algae is cellulosic which contains hemicellulose, mucilage, pectin and other substances like alginic acid, fucoidin, fucin, calcium carbonate, silica etc. in different combinations in different groups of algae. Electron microscopic studies reveal that the cellulosic wall is composed of cellulose microfibrils of varying thickness that remain variously oriented in a granular matrix.

The diatom cell wall is silicified and shows characteristic secondary structures. In Cyanophyceae, the cell wall is composed of mucopeptide consisting mainly of a peptide of few

amino acids covalently bonded to amino-sugars, glucosamine and muramic acid. This mucocomplex is also present in the cell wall of bacteria. A true cell wall is absent in certain algae like *Gymnodinium* and *Pyramimonas*. Instead they possess a boundary membrane known as pellicle.

The Chloroplast: Chloroplasts are the very prominent feature of algal cells. They bear the photosynthetic pigments. It is a double-membrane structure. Various forms of chloroplasts are known to occur in different types of algae, of which eight main types are usually recognised : cup shaped (e.g., *Chlamydomonas* and *Volvox*), discoid (e.g., *Chara*, *Vaucheria* and centric diatoms), parietal (e.g., Chaetophorales, Phaeophyceae, Rhodophyceae, many Chrysophyceae and pinnate diatoms), girdle shaped or C-shaped (e.g., *Ulothrix*), spiral (e.g., *Spirogyra*), reticulate (e.g., *Oedogonium*, *Hydrodictyon* and *Cladophora*), stellate (e.g., *Zygnema*), and ribbed (e.g., Volvocales). The basic structure of chloroplast is almost similar throughout the plant kingdom.

Pigments: Algae from the various Phyla show different colors and these often afford a quick identification. The colour frequency varies with the change in environmental condition and accurate classification depends on chemical analysis of the photosynthesis pigment also. The pigments that provide the actual colour of the thallus are of various types. There are mainly three types of photosynthetic pigments:

- 1) Chlorophylls
- 2) Carotenoids
- 3) Biliprotein

A) Chlorophylls: There are five types of chlorophylls found in algae, Chl- a, b, c, d, and e. Of them, chlorophyll 'a' is present in all groups of algae. Chlorophyll 'b' is found only in Chlorophyceae, Chlorophyll 'c' in Phaeophyceae, Cryptophyceae, Bacillariophyceae and Chrysophyceae, Chlorophyll 'd' in some red algae, and chlorophyll 'e' in certain Xanthophyceae.

B) Carotenoids: Carotenes and xanthophylls together constitute the carotenoids. They are accessory photosynthetic pigments.

Five types of carotenes are found in algae:

1. α -carotene in Chlorophyceae, Cryptophyceae and Rhodophyceae;
2. β -carotene in all algal groups, except Cryptophyceae;
3. c-carotene in Chlorophyceae;
4. e- carotene in Bacillariophyceae, Cryptophyceae, Phaeophyceae and Cyanophyceae

5. Flavacene in members of Cyanophyceae.

C) Xanthophylls: Several types of xanthophylls are found in algae. Of them lutein, violaxanthin and neoxanthin are found in the members of Chlorophyceae and Phaeophyceae. Fucoxanthin is the main xanthophyll pigment in Phaeophyceae and Bacillariophyceae, whereas myxoxanthophyll, myxoxanthin and oscilloxanthin are found only in Cyanophyceae.

D) Phycobilins: Phycobilins are water-soluble linear tetrapyrroles. They are biliproteins of either red (phycoerythrin) or blue (phycocyanin) in colour. They are found only in Rhodophyceae and Cyanophyceae. They function as accessory pigments by absorbing and transferring the light energy to the reaction centre.

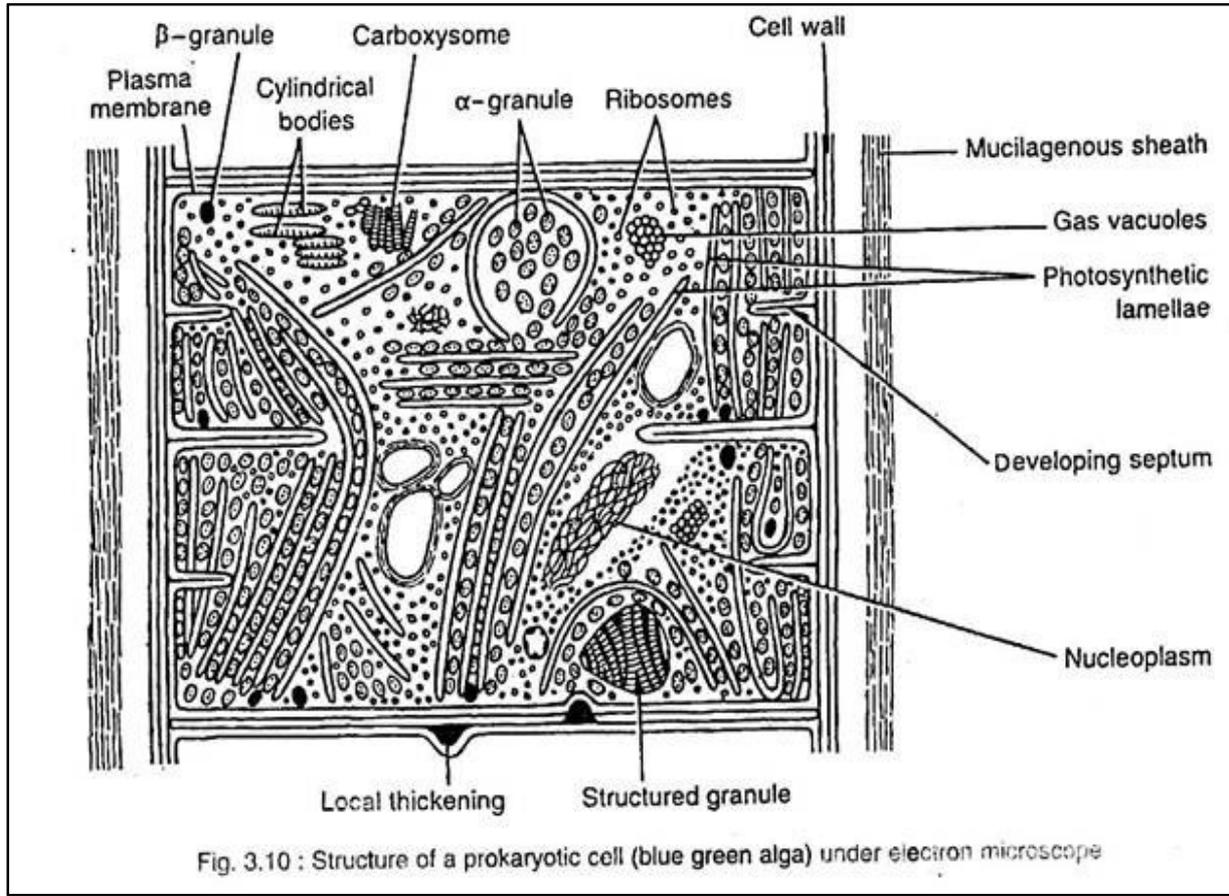
II. The Protoplast:

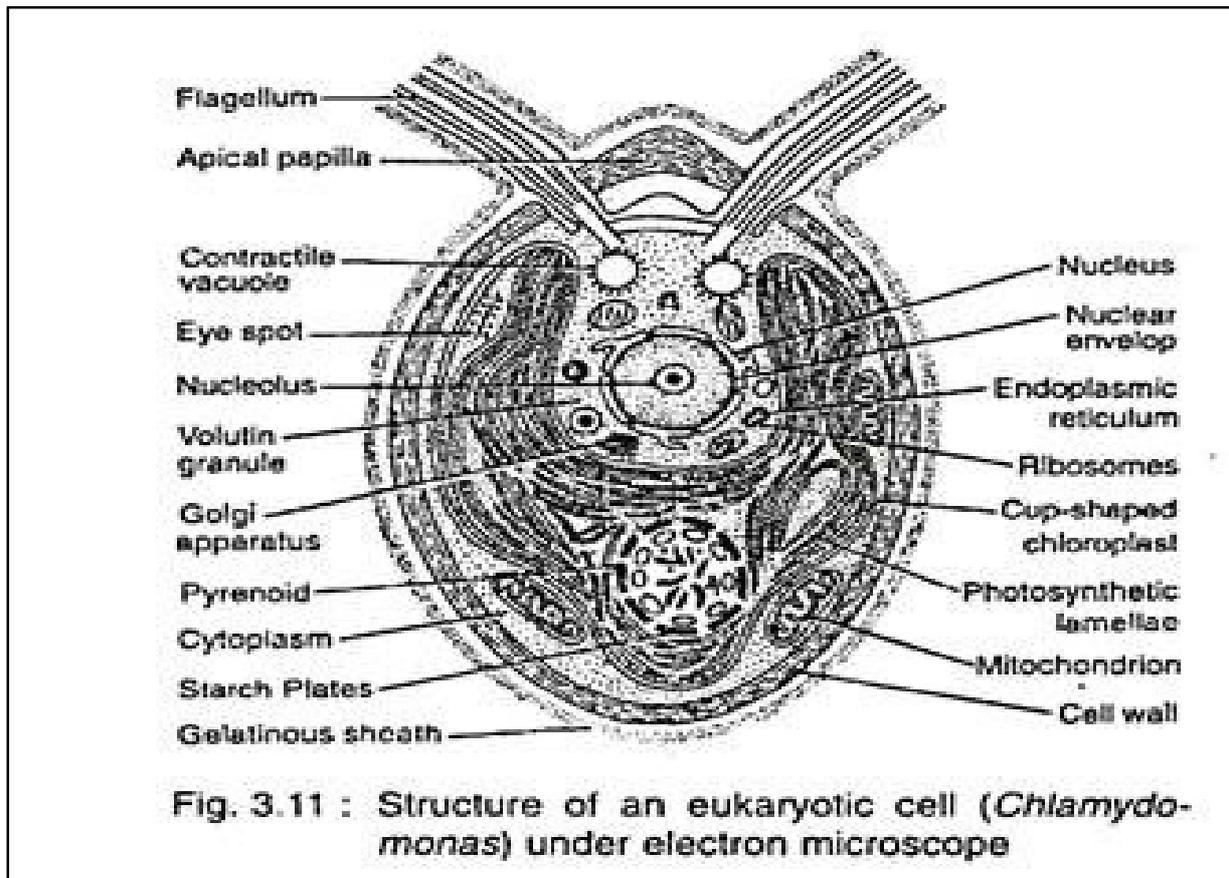
The protoplasmic content of a cell is called protoplast. The eukaryotic algal protoplast is surrounded by a lipo-proteinaceous external boundary, called cell membrane, and consists of one or more usually spherical or ellipsoidal nucleus and cytoplasm. The cell membrane is made up of lipid and protein and is fluid mosaic in nature like all other biological membrane systems. It is very thin and elastic and selectively permeable. It controls the passage of materials in and out of the cells.

In all eukaryotic algae (Chlorophyceae etc.), the nucleus is a well-organised spherical or elliptical body. It remains surrounded by a distinct nuclear membrane. The inner side is occupied by a chromatin reticulum embedded in a matrix called karyolymph. The nuclear membrane is double layered. The outer membrane is continuous with the endoplasmic reticulum. Each nucleus contains one or more nucleoli or endosomes. The number of nucleoli varies in different algae. It may be one, two or more. The chromosomes may have a localised or diffused centromere. The number of chromosomes vary from species to species—the lowest number being $n=2$ (e.g., *Porphyra linearis*), while the highest is $n=592$ (*Netrium digitali*).

In eukaryotic algal cell there are membrane bound cell organelles like chloroplasts, mitochondria, golgi apparatus, endoplasmic reticulum and, in some cases, eye spot or stigma. In prokaryotic algal cell (Cyanophycean members), the nucleus is not bounded by any membrane. Instead, the protoplast is differentiated into the outer peripheral chromoplasm containing photosynthetic pigments and an inner colourless centropiasm where the genetic material is not found within the membrane-bound nucleus and the DNA strands do not combine with histones to form chromosomes.

Thus the centropiasm represents the incipient nucleus in Cyanophyceae. The nucleus in Dinophyceae is also not truly eukaryotic, although it is membrane-bound, but chromosomes and mitotic apparatus are absent. The cytoplasm of algal cell is divided into cell organelles and cytosol.





Pyrenoids: Pyrenoids are proteinaceous bodies present in chloroplasts or chromatophores the very characteristic of algal chloroplasts. They are usually associated with the synthesis and storage of starch. In Bacillariophyceae they accumulate lipid. The number of pyrenoid may be one (e.g., *Chlamydomonas*) or more than one (e.g., *Oedogonium*) per chromatophore.

Mitochondria: Mitochondria are found in all algal cells except Cyanophyceae. Each mitochondrion is surrounded by a double membrane envelope. The inner membrane of plant mitochondria encloses an aqueous matrix of solutes, soluble enzymes and the mitochondrial glucose. The inner membrane is larger than the outer membrane and undergoes invagination producing sac-like cristae of variable shape and number — usually with a narrow neck. The whole mitochondrion is again encircled by an outer membrane lying close to the inner one, leaving an inter-membrane space which is continuous with the inter-cristal space.

The matrix is finely granular and highly proteinaceous. The organelle is semiautonomous in nature as it contains a circular DNA and ribosomes of its own, with the help of which it can

synthesise some of its proteins. There is usually more than one mitochondrion per cell, but in *Micromonas* (Chlorophyceae) each cell contains a single mitochondrion. The cells of blue green algae lack mitochondria. The cytoplasmic membrane is the site of biochemical functions normally associated with the well-defined membranous organelles in eukaryotic cells. Like bacteria the cell membrane invaginates to form a structure called the mesosome where the respiratory enzymes are localized.

Endoplasmic Reticulum (ER): Electron microscopic studies indicate that the algal cells contain an extensive membrane network of interconnecting tubules and cisternae (flattened sac), called the endoplasmic reticulum. The ER membranes traverse the entire cytoplasm. The reticulum consists of interconnected parallel cisternae associated with ribosome, attached to the cytoplasmic face of the membrane. This form of ER is known as rough endoplasmic reticulum (RER) which is a major site of protein synthesis. On the contrary the ER membranes that do not bear ribosome are called smooth endoplasmic reticulum (SER).

Golgi Apparatus: Golgi bodies are found in all algal cells except blue-green algae, and can be seen under the electron microscope. The Golgi apparatus is a component of the endomembrane system of the cell and appears to serve as an intermediate between the endoplasmic reticulum and plasma membrane. Golgi bodies may be found in the region of the nucleus (e.g., *Chlamydomonas*), near plastids (e.g., diatom and *Bulbochaete*), or it may be found anywhere in the cell. Golgi bodies are composed of 2-20 flat vesicles which are arranged in stacks.

Each stack is called dictyosome. All dictyosomes collectively form the Golgi apparatus. It functions in the packaging of materials for export to the cell's exterior. It is also responsible for the formation of new plasma membrane to support growth or to replace the lost one.

Eye-Spot or Stigma: The motile vegetative and reproductive cells of algae have a pigmented spots in the anterior, middle or posterior part of the cell, known as eye-spot or stigma. It is involved directly or indirectly in light perception. The stigma is usually found within the thylakoids run longitudinally through the eye-spot in between two rows of granules. Eye spots are of five (05) types:

1. Type A- Found in chloroplast and has no association with flagella. Ex- Chlorophyceae and Cryptophyceae.
2. Type B – Found in chloroplast and associated with a swollen flagellum. Ex- Chrysophyceae, Pheophyceae & Xanthophyceae.

3. Type C- Found as independent clusters of osmophilic granules and are present at anterior of cell near to flagellar swelling. Ex- Euglenophyceae

4. Type D – Having osmophilic granular structure with membranous lamellae , situated near flagellar base. Ex- Dinophyceae.

5. Type E – More advanced and largest, having lens, retinoid and pigmented cup. Ex- Dinophyceae

Vacuoles: Almost all the algal cells, except the members of Cyanophyceae, possess one or more vacuoles. Each vacuole is bounded by a distinct membrane called tonoplast. Three types of vacuoles are found in motile forms:

(i) Simple vacuole: They are very small in size and show periodic contraction and expansion. They are also called contractile vacuoles. They throw out the metabolic wastes of the cells. They also regulate the water content of the cell by discharging the excess amount at short interval. So they are secretory in function.

(ii) Complex Vacuole: This is the characteristics of Dinophyceae and Euglenophyceae. It consists of a tube-like cytopharynx, a large reservoir and a group of vacuoles of varying sizes. The vacuoles perform the function of osmoregulation inside the cell. Sometimes, the vacuoles also store reserve food materials such as laminarin and chrysolaminarin.

(iii) Gas Vacuoles: In the cells of the members of Cyanophyceae there are gas containing cavities occurring as stacks of small transparent cylinders of uniform diameter. Their walls are freely permeable to gases. The gas vacuoles give buoyancy to the planktonic forms and also serve as protective screens against incident bright light.

Flagella: Motile vegetative or reproductive cells are present in all groups of algae except Cyanophyceae and Rhodophyceae. The movement is achieved by the beating action of small filiform or thread-like protoplasmic appendages, called flagella. They vary in number, length, position and presence or absence of hairs in different numbers. The number varies from one to four or many. They are mainly of two types:

1. Whiplash or Acronematic: These are hairless smooth surfaced-.flagella and

2. Tinsel or Pleuronematic: They are having one or more rows of lateral *fine filamentous hairs* known as mastigonemes or flimmers . They are further categorised into:

a. Pantonematic. Where the mastigonemes are arranged in two opposite rows.

b. Pantoacronematic. Pantonematic flagellum with a terminal fibril is called pantoacronematic.

c. Stichonematic. It has one-sided mastigonemes.