Algae

Distribution, Habitat and Thallus organization

Algae are diverse group of relatively simple, chlorophyll containing, photoautotrophic and oxygen evolving aquatic thalloid (without differentiation into true roots, stems, leaves or leaf like organs) organisms.

The word **algae has its origin from Latin, where alga means seaweed**. The term algae was first used by C. Linnaeus in 1753. Most of them are photo-autotrophic but few are mixotrophic and myzotrophic (sucking through special feeding structure).

Study of algae is known as **phycology** (GK. Phykos- seaweed; logos= discourse or study) or **algology**. Professor M.O.P. Iyenger is regarded as the father of Indian Algology of Phycology. He discovered the terrestrial alga *Fritschiella tuberosa*.

Ecology and distribution:

Algae are mostly aquatic but they are present almost every available ecological habitat on this earth. They are thus ubiquitous in their distribution. On the basis of their habitat they are: 1. Aquatic Algae 2. Terrestrial Algae 3. Parasitic algae 4. Symbiotic Algae 5. Algae with some special habitats.

Aquatic algae: most of algae are aquatic found in fresh water (lakes, ponds, rivers, ditches, tanks, streams, etc.) or sea (marine environment). Bottom dwelling organism are called benthophytes (benthic algae or benthos) or may be present on the surface of water bodies are called Phytoplanktons. Phytoplanktonic algae are called euplankton (*Chlamydomonas*, *Cosmarium*, *Scenedesmus*) if they are free floating from the beginning or as tychoplankton (*Cladophora*, *Oedogonium*, *Zygnema*) if attached in the beginning but later got detached and became free floating. Sometimes planktonic algae show extensive growth in the water bodies and impart greenish colour to water. This is known as water bloom or algal bloom e.g. *Chlamydomonas, Chlorella*, *Scenedesmus, Microcystis* etc.

Fresh water forms such as *Volvox*, *Hydrodictyon*, *Chlamydomonas* etc grow in stagnant water while *Cladophora*, *Oedogonium*, *Ulothrix* etc. prefer to grow in slow running water. Algae grow in running water is called **lotic** algae while in stagnant water is known as **lentic** algae. Some of marine algae are known as Kelps, may reach up to more than 70m (*Macrocystis pyrifera*) in length.

Terrestrial algae or edaphophytes: Algae which grow on or inside the moist soil are known as terrestrial algae. e.g. *Vaucheria*, *Botrydium*, *Fritschiella* etc. grows on the soil surface are known as **saphophytes** A few spp. *Anabaena* and *Nostoc* (BGA) grow inside the soil surface and are known as **cryptophytes**.

Parasitic algae: Algae which grow on some plants and cause plant diseases. E.g. *Cephaleuros virescence* parasite on tea leaves and causes red rust disease in them. *Harveyella mirabilis* are obligate parasite and lack pigmentation. *Rhodochytrium*, *Phyllosiphon*, etc are other examples of parasitic algae. *Polysiophonia lanosa* is a semi parasite on brown alga *Ascophyllum*.

Symbiotic algae: Algae show association with different groups

Algae: *Rhizosolenia* forms association with green algae *Calothrix* sp. **Fungi:** Many green algae and BGA live in symbiotic with fungi and form new group lichens. Green algae *Trebouxia* is the most common photobiont (previously known as phycobiont) in lichen. Other green algae are *Cocomyxa*, *Trentipohlia* etc. BGA are *Nostoc*, *Scytonema*, *Stigonema*, *Gloecapsa* etc.

Bryophytes: *Nostoc* lives in the mucilage filled chambers of *Anthoceros* and *Notothyllus* (Hornworts) thalli.

Pteridophytes: *Anabaena* inhabits leaves of water fern Azolla. The latter is used as a bio fertilizer in paddy fields.

Gymnosperms: *Nostoc* and *Anabaena* live in symbiotic association in the coralloid roots of *Cycas*.

Angiosperms: *Nostoc* inhabits papillose outgrowth of *Gunnera* near the base of their leaves.

Special habitats

1)Thermal algae (thermophytes): They grow in hot water springs at a temperature range of 65-850C, where ordinary plant life is not possible. Only BGA like *Mastigocladus ,Phormidium and Oscillatoria brevis* etc. have been reported from such habitat.

2)Cryophytes: such algae grow in polar regions on ice and snow. E.g. *Chlamydomonas* sp. and *Scottiella* sp. among green algae and *Nostoc* among BGA algae. *Haematococcus nivalis* causes red snow ball in alpine region.

3)Epiphytes: Algae growing on the surface of other plant parts are called epiphytes e.g. species of *Oedogonium*, *Ulothrix* etc., other examples are *Coleochaete nitellarum* grows on *Nitella* and *Chara*. Some algae , such as *Trentepohlia*, *Rhodochytrium*, grows on the surface of angiosperms leaves, called epiphyllophytes. Some algae such as *Pleurococcus* sp. grow on barks called epiphloeophytes.

4) Endophytic algae: Some algae grows within the tissue of other plants, e.g. *Nostoc* grows inside thalli of *Anthoceros*.

5) Epizoic algae or epizoophytes: which grown on the surface of other animals, e.g. *Cladophora* on snails, *Cyanoderma* (red algae) and *Trichophilus* (Green algae) on the scales or outer hairs of Sloth.

6) Endozoic algae or endozoophyte: Algae growing inside animals, e.g. *Chlorella* within the tissue of *Hydra* and sponges.

7) Lithophilic algae: Which grows on rocks e.g. *Polysiphonia*, *Ectocarpus* etc.

8) Other algae some algae like *Dunaliella*, *Chlamydomonas chrenbergii* grows in water with high salt concentration (Halophilic algae). *Fritchiella* grows on acidic soil while *Oscillatoria* sp. grow on alkaline soil.

Range of thallus organization:

Algal plant body is known as thallus. Thallus is a plant body which is not divided into true roots, stem, leaves or leaf like structures. The vegetative structure of algae shows a wide variety and its ranges in form from unicellular to complex multicellular thalli.

- Size ranges from one micron to several meters.
- **On the basis of thallus organization algae are divided into the following groups:**

1. Unicellular forms:

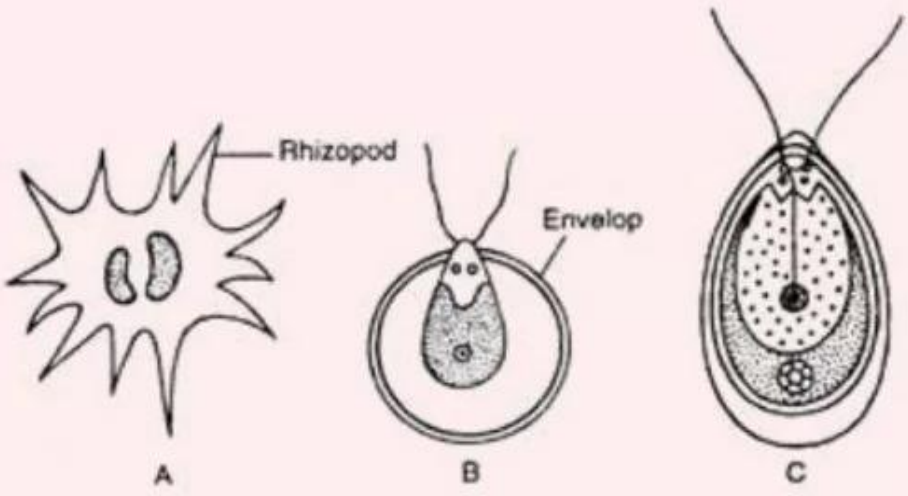
Simple unicellular forms are found in all groups of algae except charophyceae and phaeophyceae.The plant body is made up of single cell. Which may be motile or non motile.

I) **Motile forms:** show presence of flagella or due to presence of periplastic nature.

A) Flagellated motile forms: e.g. *Chlamydomonas*, *Chlorochromonas*.

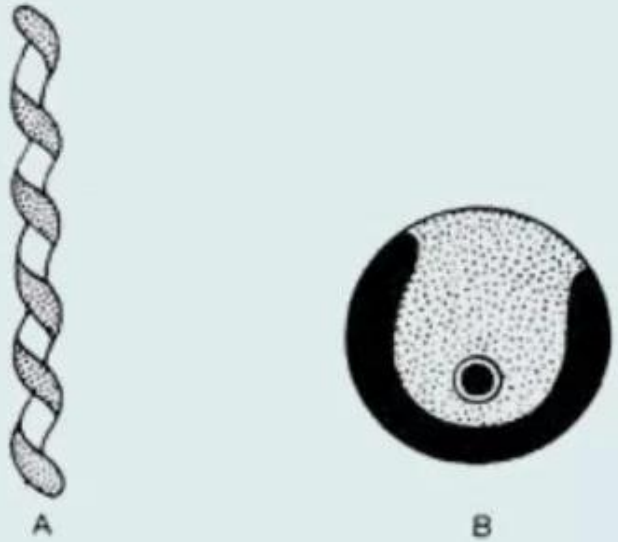
B) Periplastic forms: They have soft cell wall and possesses fine protoplasmic projections known as **rhizopodia**, which helps in amoeboid movement e.g. *Rhizochloris*, *Chrysamoeba*

ii) Non-motile forms: They are non-motile coccidial algae which do not posses flagella, eye spot meant for locomotion, e.g. Diatoms, *Chlorella*, *Chlorococcum* etc.



Unicellular Motile Algae

A. *Chrysamoeba*, B. *Phacotus*, C. *Chlamydomonas*



Unicellular non-Motile Algae

A. *Spirulina*, B. *Chlorella*

2. Colonial thallus: In this form daughter cells which arise as a result of cell division, remain loosely held together in common gelatinous mass. These forms are of two types:

I) Coenobial forms: colonial form with definite number of cells arranged in definite manner. Coenobium are of two types:

a) Motile: They have flagella on their body and are able to move e.g. *Volvox*.

b) Non-motile: They lack flagella e.g. *Hydrodictyon*, *Scenedemus*, etc.

II) Cell aggregation: The daughter cells are not aggregated in a definite manner in the colony thus the colonies are not of constant size and shape. They are of following types

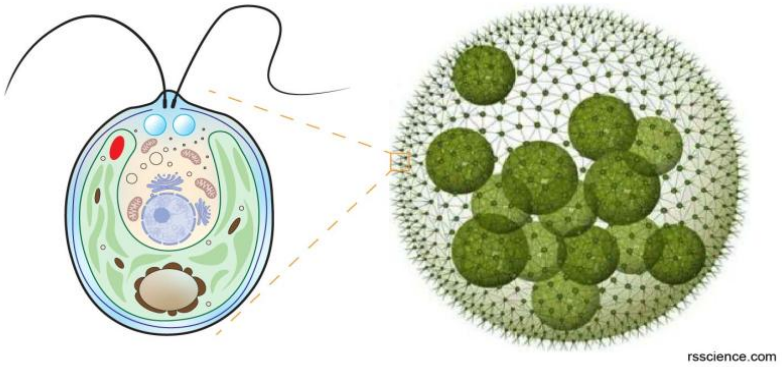
a) Palmelloid forms: Cells remain irregularly arranged in a common gelatinous matrix. They function as independent entities. These forms may be temporary (*Chlamydomonas*) or permanent (*Tetraspora*).

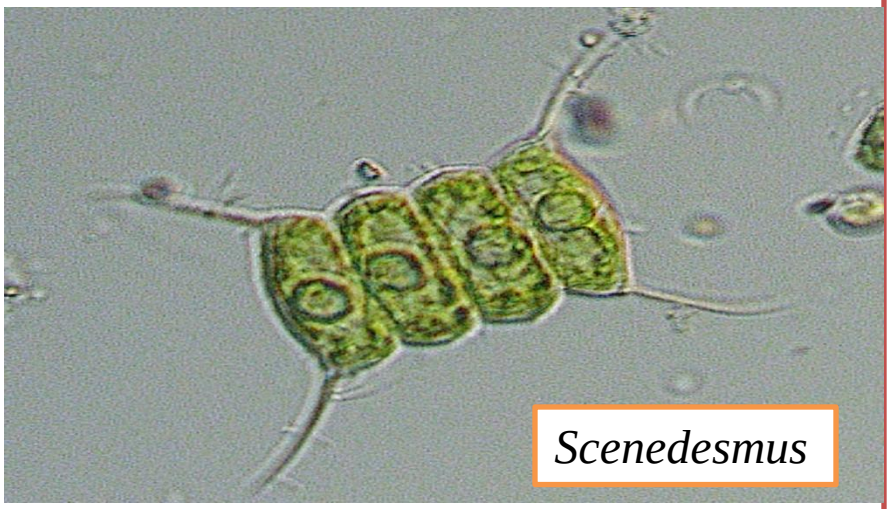
b) Rhizopodial forms: In these colonial forms, cells are aggregated with each other through rhizopodia e.g. *Chrysidiastrum*.

c) Dendroid forms: Cells are aggregated with each other in a branching pattern through mucilaginous strands arising from the base of each cell. Such colonies look like a microscopic tree. E.g. *Ecballocystis*.

Volvox

The emerald green algae of the micro world





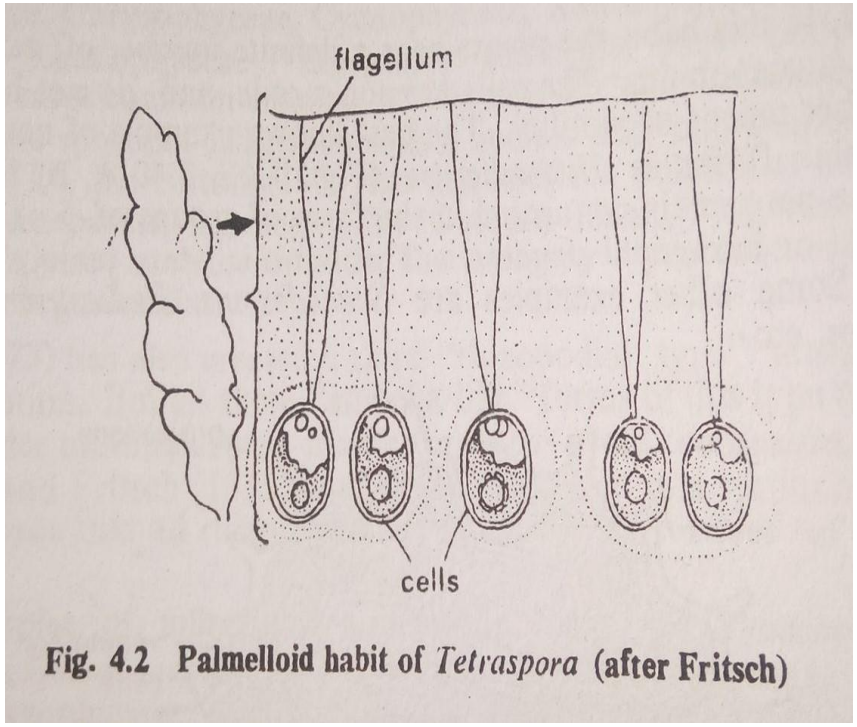
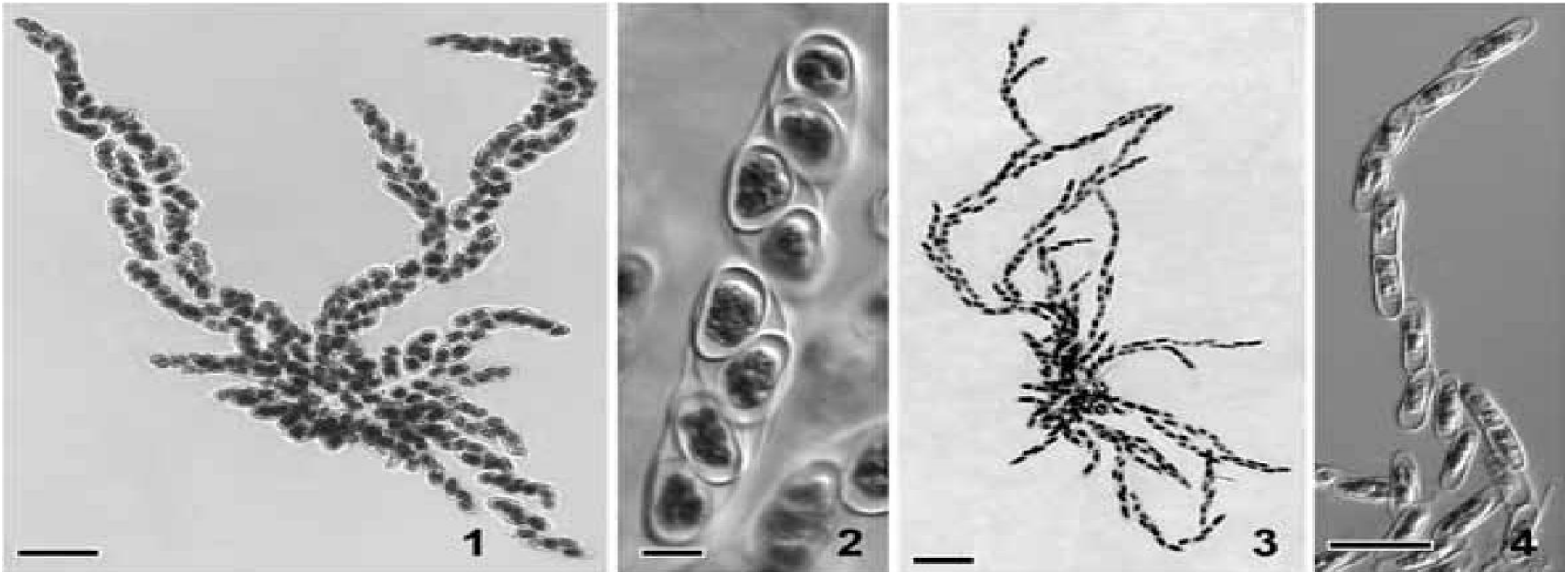


Fig. 4.2 Palmelloid habit of *Tetraspora* (after Fritsch)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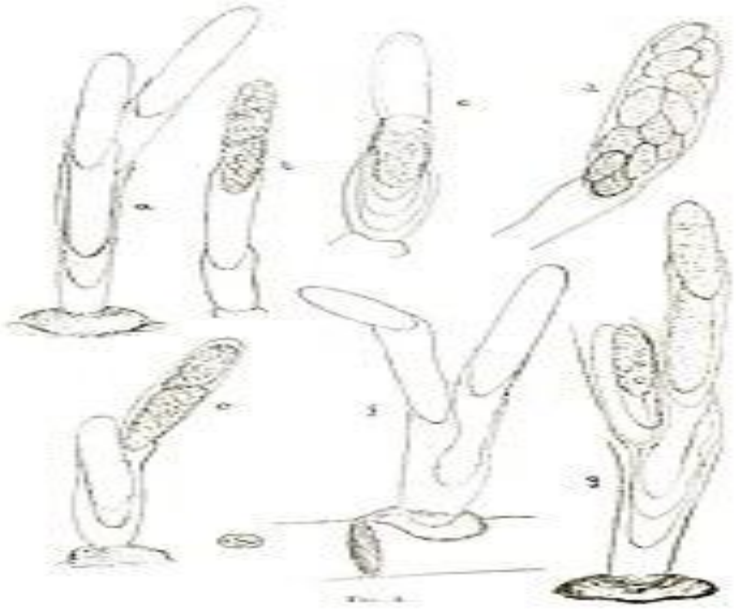


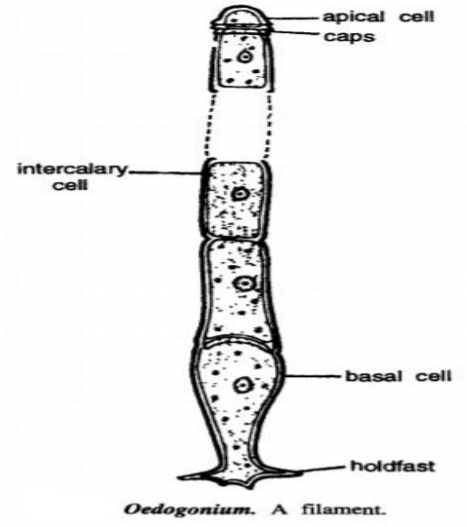
3. Filamentous Forms:

Filamentous forms are formed by repeated transverse divisions of cells. The cells are arranged one over the other in a definite sequence to form a filament. Filament can be uniseriate (composed of single row of cells) or multiseriate (composed of more than one row of cells). The filament may or may not be differentiated into base and apex . Filamentous condition may be of three types:

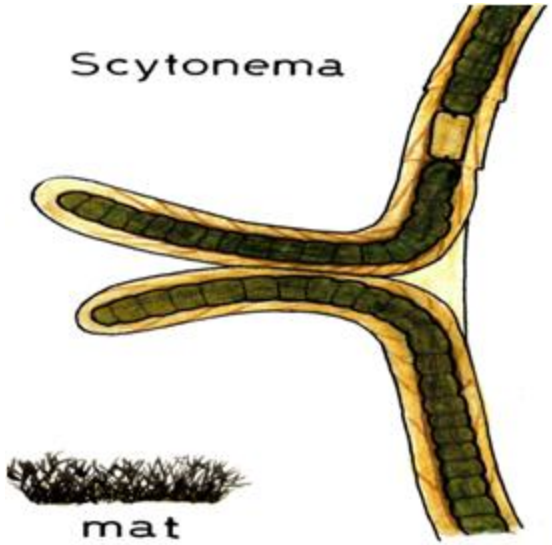
a) Unbranched : *Zygnema*, *Oedogonium* etc.

b) Branched: *Cladophora*

c) Falsely branched: *Scytonema*



Oedogonium. A filament.

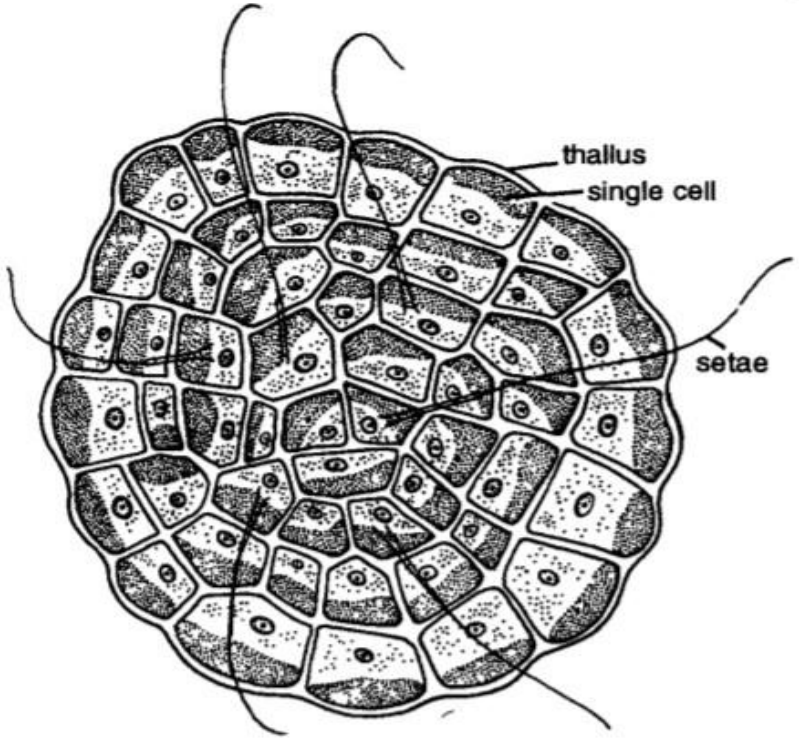


4. Thalloid Habit: When the division of cells is in more than one plane, it results in the formation of a thalloid parenchymatous structure. A pseudoparenchymatous thallus occurs when filaments are compacted together to form a structure that appears parenchymatous. The two important parenchymatous types are:

a) Tubular parenchymatous type: *Enteromorpha*

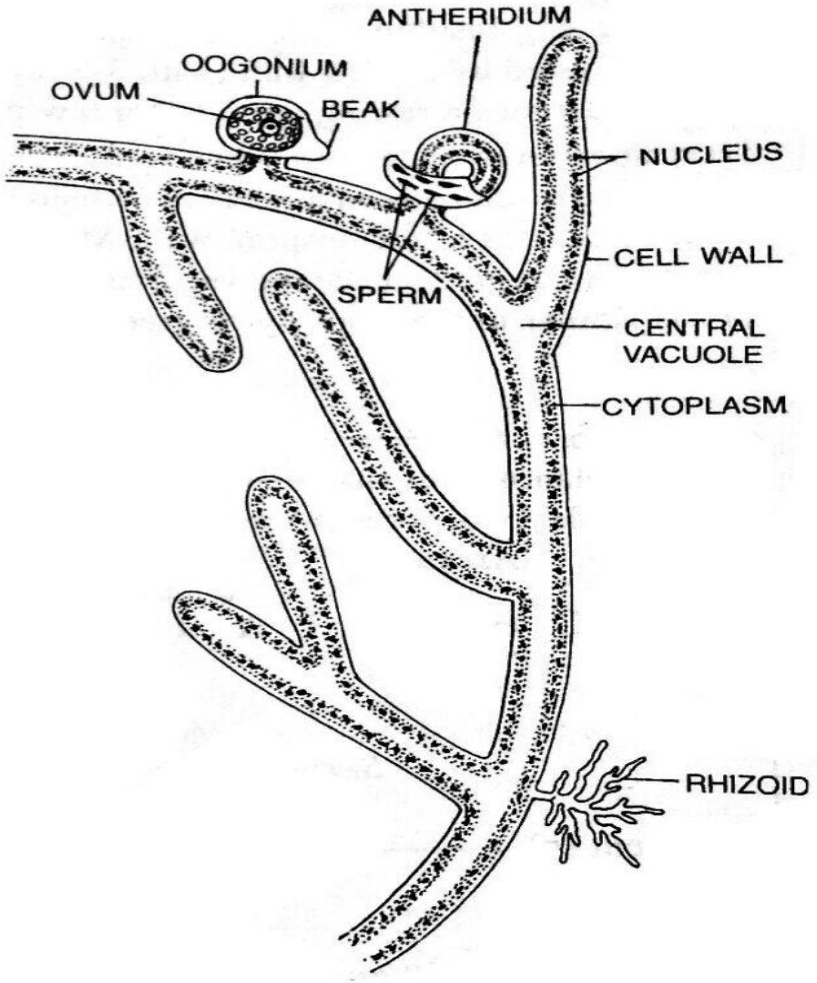
b) Foliose parenchymatous type: *Ulva*, *Porphyra*

5. Heterotrichous habit: This is the most evolved type of habit in which thallus consist of two parts a) prostrate system growing along the substratum b) a project or erect system composed of usually branched filaments. In many members prostrate system may be more developed and the erect system is rudimentary e.g. *Coleochaete*. Members like *Stigeoclonium* show well developed both the prostrate and projecting system.

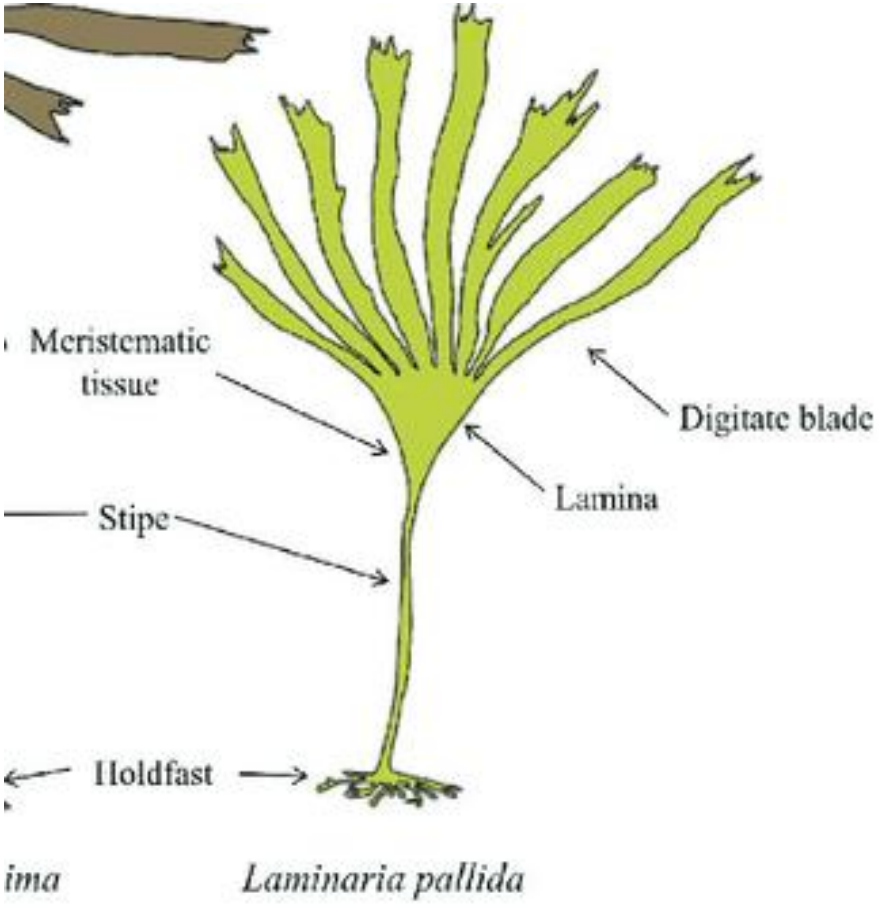


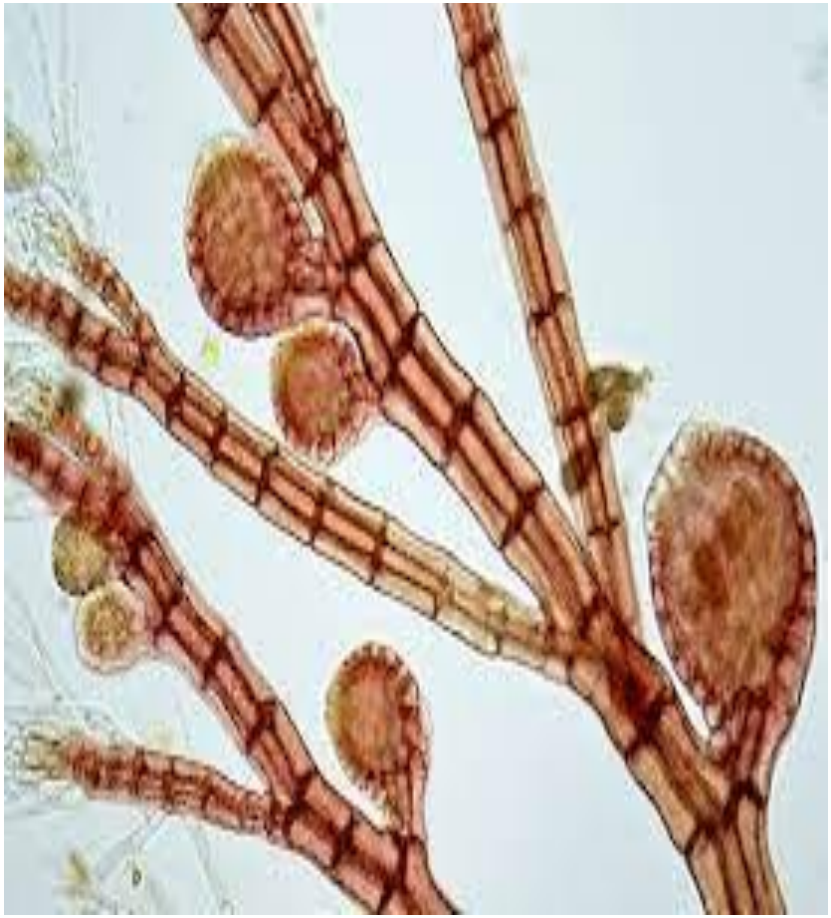
***Coleochaete* sp.** Discoid thallus.

6. Siphonaceous habit: The thallus is nonseptate, multinucleate (coenocytic). A coenocyte may be differentiated into rhizoidal system, rhizomatic system and erect system (e.g. *Caulerpa*) or it may be simply branched (e.g. *Vaucheria*).



7. Complex habit: In many brown algae (e.g. *Laminaria*) and red algae highly complex thallus with root like, stem like and leaf like organs are present. They lack vascular tissue although phloem like conducting cells occur in some kelps. Multiseriate condition with cytoplasmic connections can be seen in many red algae such as *Polysiphonia*.



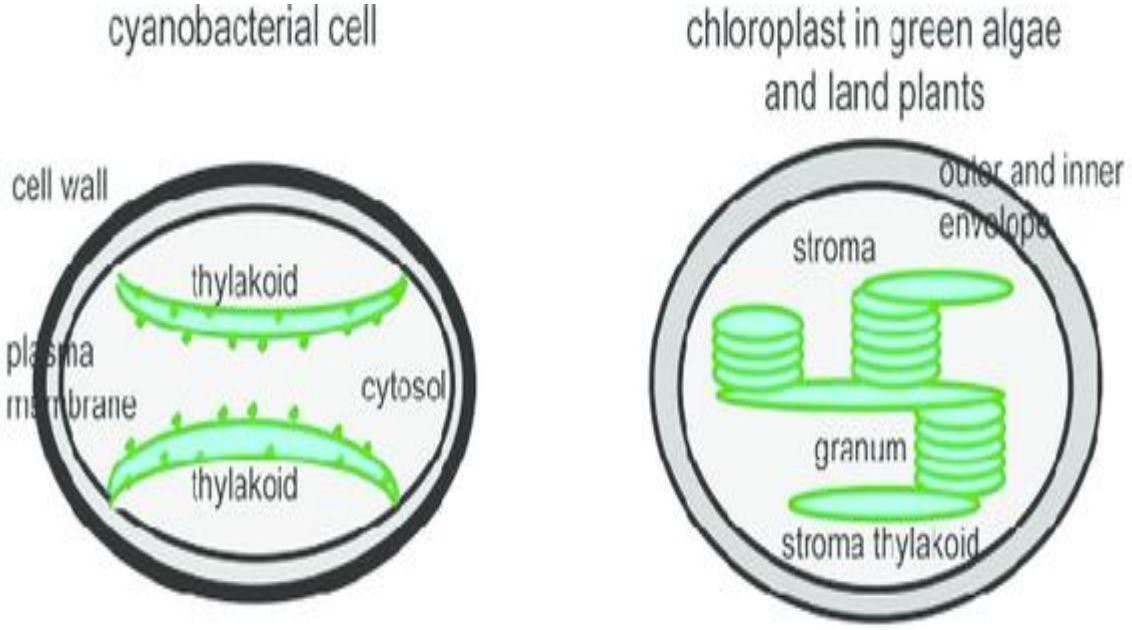


Cell structure in Algae: Algae show two distinct basic types of cell structure, hence they can be divided into two groups - Prokaryotes and Eukaryotes. Prokaryotes include the so called blue-green algae classed earlier as Cyanophyceue or Myxophyceae, but now designated as Cyanobacteria because their cells are prokaryote type. Eukaryotic algae are quite diverse in cell structure and morphology, which is taken into account for classification.

Prokaryotic Algal Cell: Cyanobacteria closely resemble bacteria in their ultrastructure.

Cell Wall and Cell Sheath : The cells of cyanobacteria are enveloped by a gelatinous sheath and also have a distinct cell wall outside the plasma membrane. Its chemical analysis shows that it is made of mucopolysaccharide (peptidoglycan) like that of bacterial cell wall. It has a complex structure, made of a polymer of N-acetylmuramic acid and N-acetyl-glucosamine, that are cross linked by peptides and other compounds. The wall in fact, shows at least four layers and the outermost may contain lipopolysaccharides and proteins. In many cyanobacteria the cell wall is enveloped by gelatinous mucilage. It may be thin and colourless as in planktonic forms. In subaerial forms the sheath is thick, firm and coloured yellow or orange brown and is multilayered. Some aquatic forms like *Scytonema* may also have multilayered and coloured sheath.

Photosynthetic Lamellae: Cyanobacteria have no chloroplasts but only pigmented membranes which occupy the peripheral region of the cells called chromatoplasm. In this area photosynthetic lamellae or thylakoids are present. The lamellae are folded double membranes in which the photosynthetic pigments- chlorophyll a, and several types of carotenoids are embedded. On the surface of the thylakoids are found rows of granules called phycobilisomes, that contain phycocyanin, allophycocyanin and sometimes also phycoerythrin, characteristic of cyanobacteria. It has been found that the thylakoids also contain enzymes required for respiration.



Thylakoid membrane organization and composition in cyanobacteria and plants. Cyanobacterial thylakoid membranes are located directly in the cytosol, are arranged in layers, make contact with the plasma membrane, and have attached phycobilisomes. Thylakoid membranes in green algae and land plants are located inside the chloroplast, are organized in grana stacks interconnected by stroma-exposed lamellae and contain chlorophyll-protein complexes .

Granular Inclusions of Cytoplasm:

The ultrastructure of Cyanobacterial cytoplasm shows several types of granules.

Between the thylakoids glycogen is found in the form of granules of different sizes. Protein granules called cyanophycin granules made up of polymer of two amino acids aspartic acid and arginine are for storage of nitrogen, Another type of granule common in algae growing in waters rich in phosphate, is polyphosphate, a storage form of phosphate. Some algae also contain granules of polybetahydroxybutyrate as big crystals. Another unique granules found in cyanobacteria are polyhedral crystalline bodies known as carboxysomes. They are made up of ribulose-biphosphate carboxylase (RubisCo) enzyme which as you know is required in the photosynthetic fixation of carbon dioxide.

Like all bacterial cells cyanobacteria also contain ribosomes needed for protein synthesis. They are dispersed in the cytoplasm. All prokaryotic ribosomes are of 70S type unlike the

80S type found in eukaryotes.

Gas Vesicles:

Many planktonic cyanobacteria like *Microcystis* contain in their cells elongated, cylindrical vesicles singly or in bundles known as gas vesicles. They make the cells float on the surface of water. When, the gas escapes they collapse, become flat, and the cells sink to the bottom. The wall of the vesicle is made of single layer of protein molecules and is permeable to gases but not to water.

Nucleoplasm:

The central portion of the cell usually referred as nucleoplasm contains the genetic material, DNA, equivalent to the nucleus of eukaryotes. It appears as a network of fibrils, and like that of bacteria it is a long thread in the shape of a ring, generally referred to as circular chromosome. There may be multiple copies of it in a cell. The histone proteins found in eukaryotic cells are not associated with the DNA of cyanobacteria.

Plasmids:

Like in bacteria, DNA is also found in the cells of cyanobacteria as a small covalently linked circular molecule known as plasmid. Plasmids are not a permanent feature of cells, they may be lost and regained further.

Specialised Cells of Cyanobacteria:

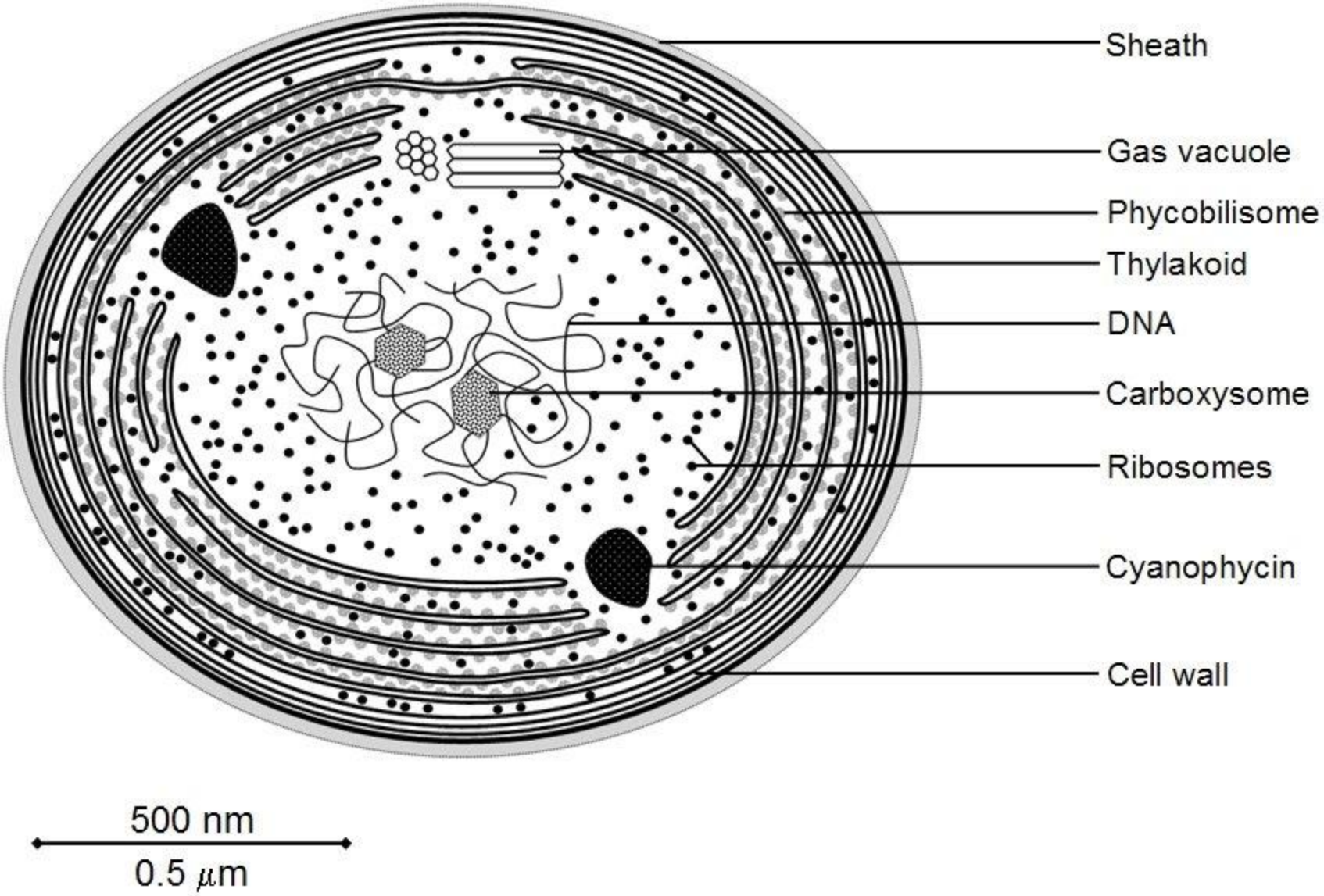
Besides the common vegetative cells, filamentous cyanobacteria show two other types of structures, heterocysts and akinetes. These are briefly described below.

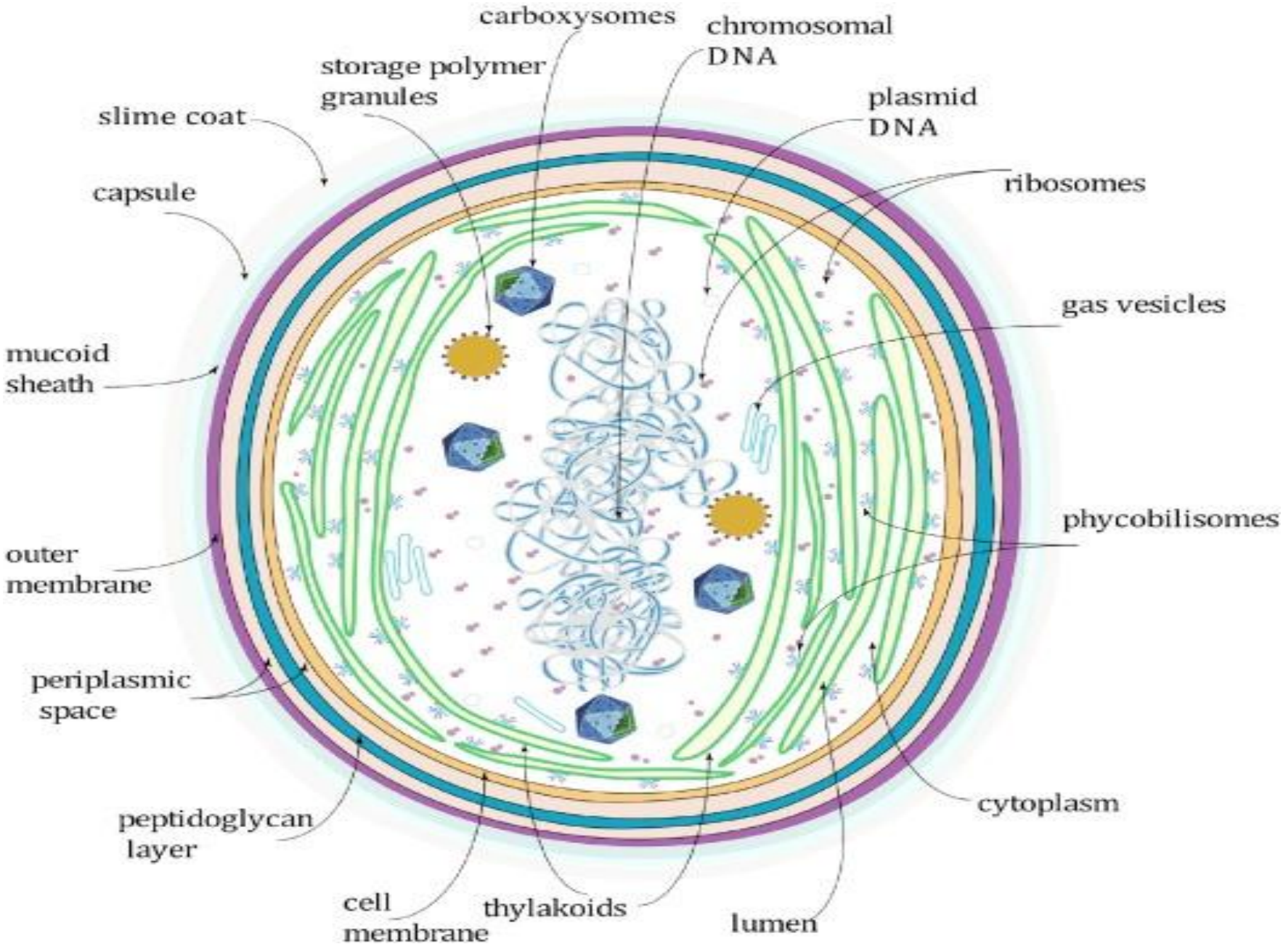
Heterocysts: These are thick walled cells found in filamentous cyanobacteria either in between the vegetative cells (intercalary) or at the ends (terminal) of a filament. Most important function of heterocysts is fixation of atmospheric nitrogen as they contain the necessary enzyme system, nitrogenase.

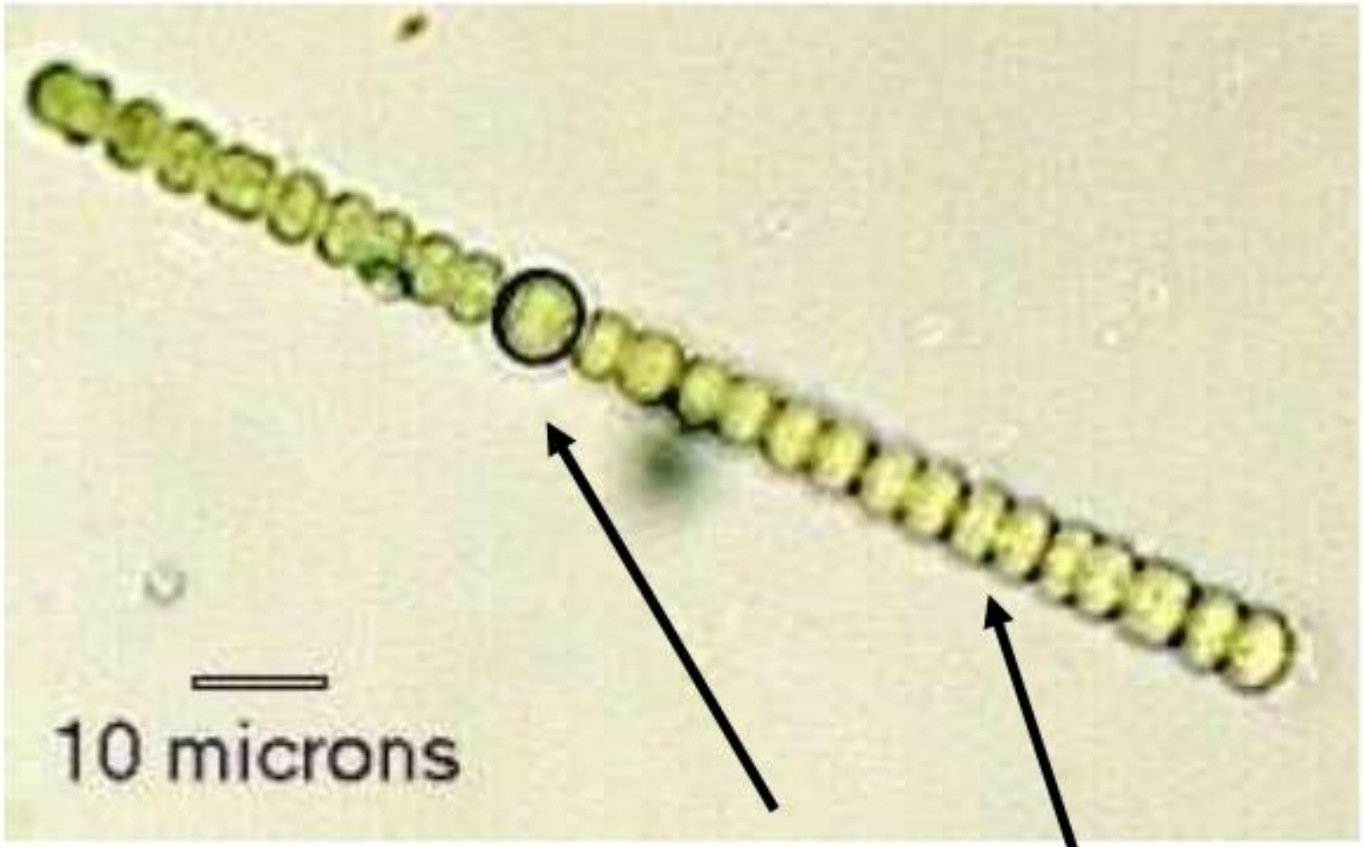
Structure of Heterocyst: Unlike a vegetative cell, heterocyst has a thick wall with three layers which are structurally different. The inner most layer contains certain glycolipids which make the heterocyst impermeable to oxygen, otherwise Oxygen inhibits the action of nitrogenase and prevents nitrogen fixation.

Akinetes: These are thick walled cells also known as spores, meant for perennation. They are generally light brown, deep brown or black in colour. Akinetes can withstand prolonged desiccation and under suitable conditions germinate giving rise to new filaments.

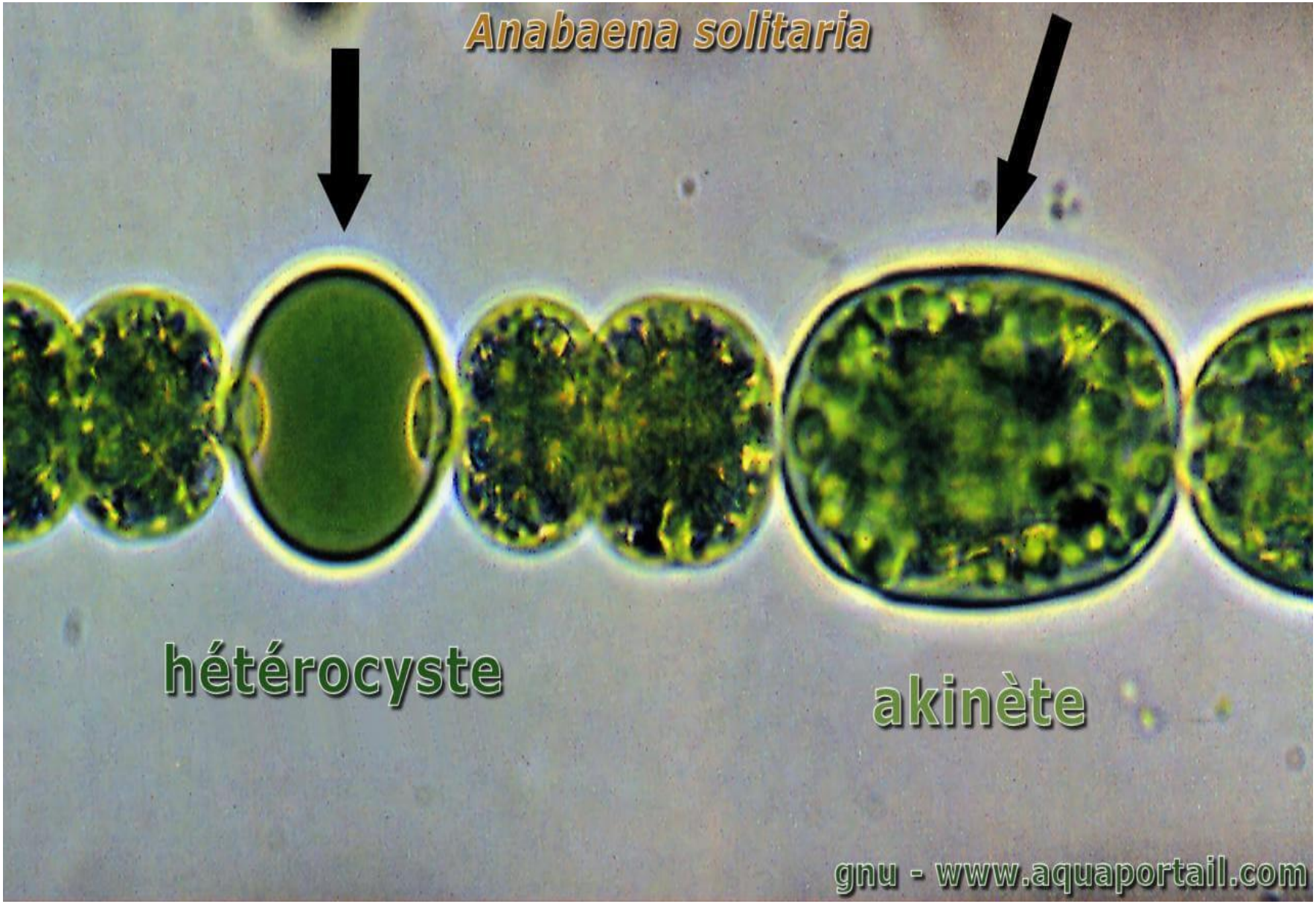
Cross-section through a cyanobacterial cell




carboxysomes
chromosomal DNA
storage polymer granules
plasmid DNA
slime coat
capsule
ribosomes
gas vesicles
mucoid sheath
phycobilisomes
outer membrane
periplasmic space
peptidoglycan layer
cytoplasm
cell membrane
thylakoids
lumen



Anabaena


Anabaena solitaria
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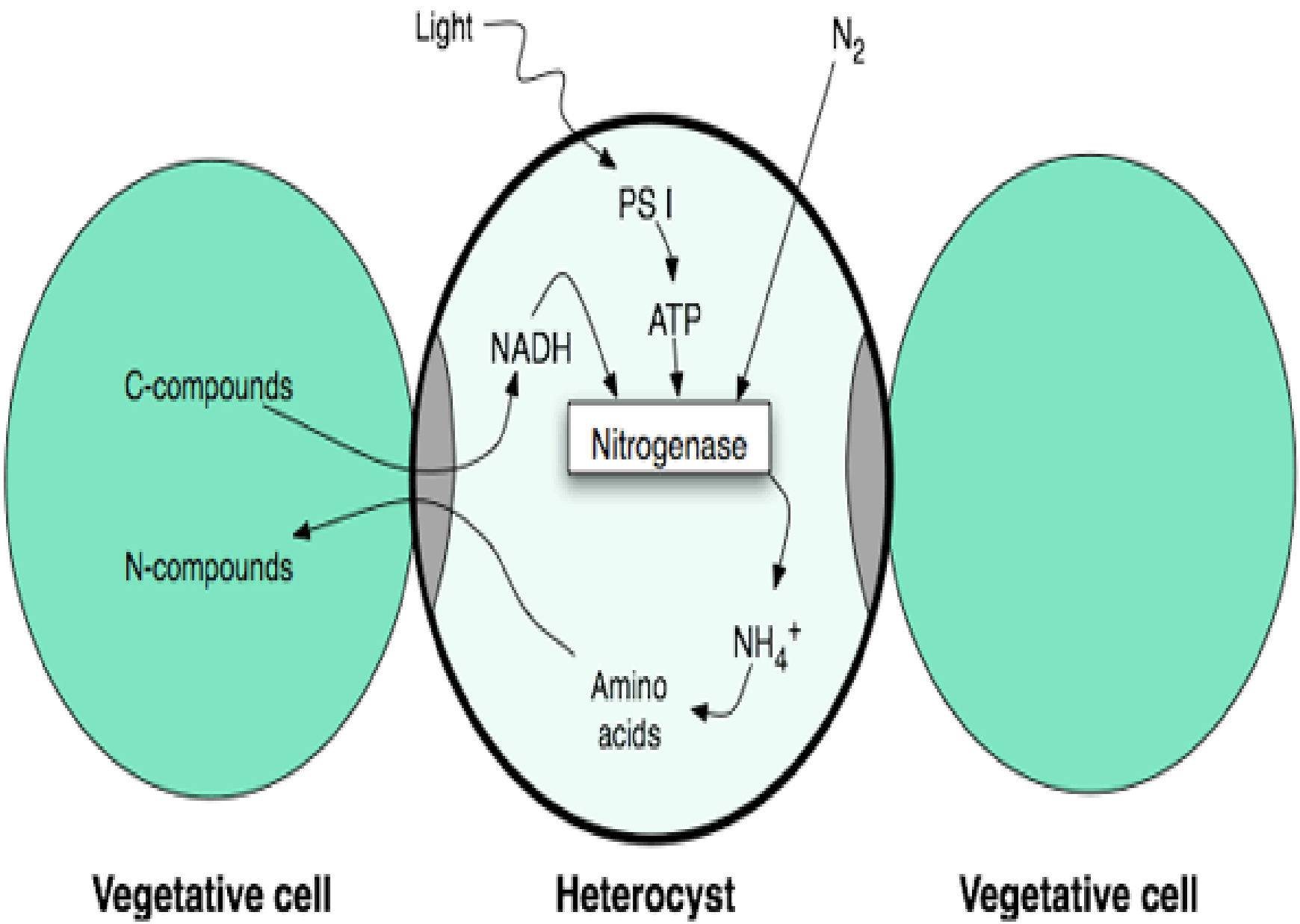
Light
N_2
PS I
ATP
NADH
C-compounds
Nitrogenase
N-compounds
NH_4^+
Amino acids
Vegetative cell
Heterocyst
Vegetative cell

Eukaryotic algae structure

Important features new

THANKS.....