• Distribution. Of BGA/Blue gree algae

- . The aquatic forms mostly occur in fresh water, a., where planktonic (free floating) forms,
- The blue-green algae are widely spread in the aquatic environment
- 1 polluted water
- 2 in clean water
- few, are marine (e.g., Trichodesmium, Darmocarpa)
- The fresh-water blue-greens occur or reservoirs, ponds, springs, open tanks and lakes e.g.,(Oscillatoria, Rivularia),
- Some species are terrestrial. Oscillatoria and Nostoc
- Some species of blue-green algae occur as scums on dirty stagnant water full of decaying organic materials
- A few species are sub-aerial and inhabit damp surfaces where they commonly appear as green slime on wet rocks, flower pots or damp soil.
- .
- There are a sufficient number of thermal Cyanophyceae. They grow on snow and also constitute the principal vegetation of hot springs.They are able to live in water whose temperature is as high as 85°C. The Cyanophyta thus provide a good example of the adaptability of life to extremes of environment (high temperature of hot springs and low temperature of polar regions

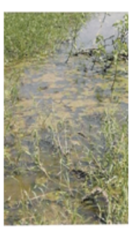
ALGAL BLOOM

- **algae bloom** is a rapid increase in planktonic cyanobacterial number due to rapid cyanobacterial growth and buoyancy results in the sudden appearance of large dense algae population at the surface of lake, ponds and reservoirs of water or marine water systems, this is called algal bloomand is often recognized by the discoloration in the water from their pigments.
- Algal blooms are the result of a nutrient, like nitrogen or phosphorus from fertilizer runoff, entering the aquatic system and causing excessive growth of algae. An algal bloom affects the whole ecosystem

Algal bloom formation

Rivularia is found growing on submerged stones, moist rocks, and damp soils near the riverside. It is found in colonies, and the trichomes are radially arranged within a colony, with each trichome wholly or partially surrounded by a gelatinous sheet. The trichomes have a basal heterocyst.

- 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



A

B

Oscillateria in fresh water algae

Some species of blue-green algae occur as scums on dirty stagnant water full of decaying organic materials

Rivularia is found growing on submerged stones, moist rocks, and damp soils near the riverside. It is found in colonies, and the trichomes are radially arranged within a colony, with each trichome wholly or partially surrounded by a gelatinous sheet. The trichomes have a basal heterocyst.

Rivularia

Trichome

By the repeated cell division in one plane, single row of cells are formed, known as **trichome**. e.g., *Oscillatoria* *Spirulina,*

Filament

The trichome when covered by mucilaginous sheath is called a **filament**.

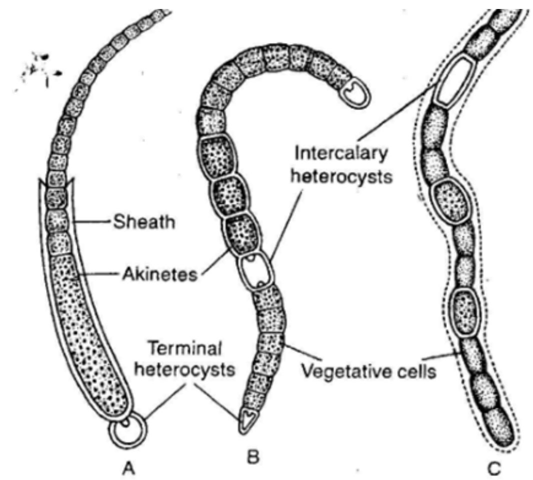
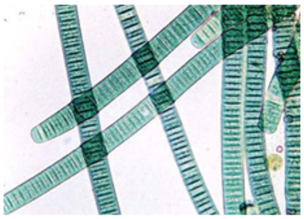


Fig. 3.25 : Heterocysts at different position on the plant body : A. Terminal (*Gloeotrichia*), B. Both terminal and intercalary (*Anabaena desikacharyiensis*) and C. Intercalary (*Nostoc*)

Red Sea's name is that it contains a cyanobacteria **called** Trichodesmium erythraeum, which turns the normally blue-green water a reddish-brown.

Red Sea

oscillatoria



Habitat: Oscillatoria inhabits a wide **range** of environments from **freshwater** to **marine**, plankton to benthos

v

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

Cell structure

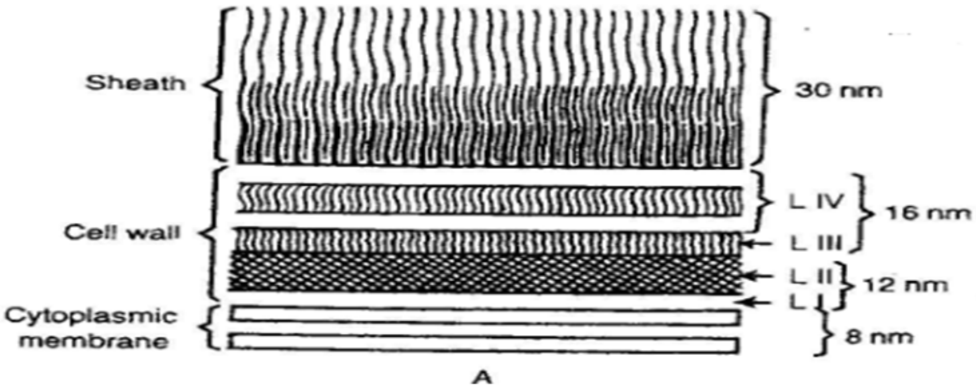
Prokaryotic, 10µ in diamerer,each cell consists of outer covering layer - sheath

- this mucilaginous covering of the cell is thick and dense and is called the *sheath.* The sheath consists of pectic substances
- In a few forms it is extremely delicate and diffluent (*Anacystis monatana).*The mucilage layer (sheath) is in the form of a cylinder around the entire trichome in the Filamentous blue-green algae It may become lamellated or stratified and pigmented (yellowish or brownish). Usually it remains colourless
- but in the unicellular forms it surrounds each cell. The study of fine structure of the sheath revealed that it is undulating, electron-dense and fibrillar in appearance
- In some planktonic forms the sheath is of watery consistency and thus difficult to see.

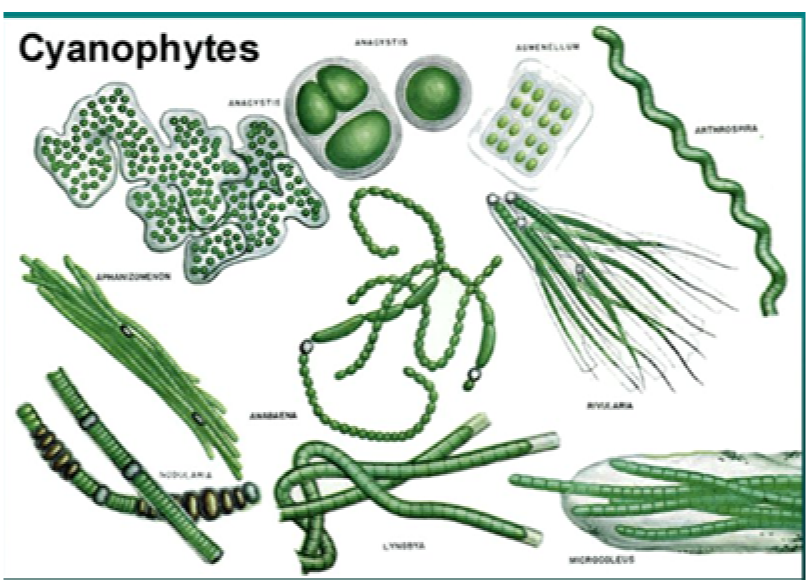
\

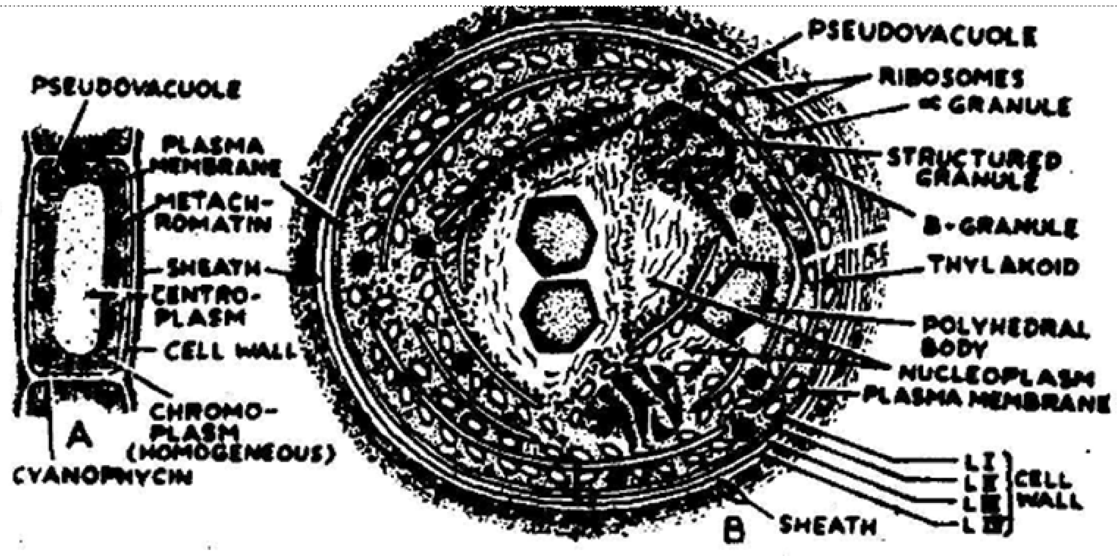
- **Function**-The sheath is useful in many ways
- 1). It serves to hold the cells in the colonies together
- 2). Its slimy nature gives the sheath with great water absorbing and water retaining capacity

- 3). Thus a firm pigmented sheath is an asset to the species growing under conditions of desiccation. It enables them to perennate. The pigmented sheath serves as a light screen.
-
-
- . The microfibrils constituting the sheath are reticulately disposed within an amorphous matrix to give it homogeneous appearance. On the outside the microfibrils are less dense. A zone of less electron density separates the sheath from the cell wall or inner investment.

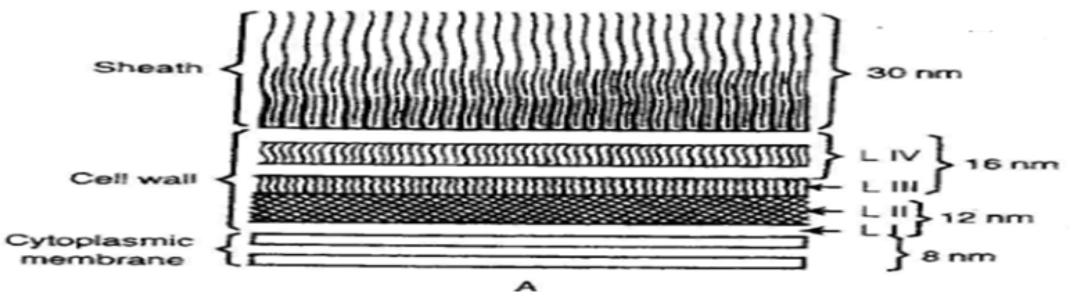


- **. Cell Wall:**
- The cell wall consists of four (4) layers (under E.M.) named as LI, LII, LIII and LIV by Carr and Each layer is about 10µ in thickness. The LI is the layer situated near cell membrane and LIV is the outer-most.
- Cell wall is composed of mucopeptide together with carbohydrates, amino acids and fatty acids like Gram-positive bacteria. The LI and LIII layers are electron transparent, but the LII and LIV layers are electron opaque
-





Protoplast found in two region 1 central region –centroplasm which form transparent central region
2 peripheral denser region surrounding it chromoplasm



- **Cytoplasmic Membrane:**
- The cytoplasmic membrane is also known as plasmalemma pre-sent just inner to the cell wall. It consists of two electron opaque layers separated by a trans-lucent layer
- This layer invaginates at different points inside the protoplast and is the site of different biochemical functions that normally takes place in different organelle like mitochondria, endo-plasmic reticulum and Golgi bodies in the cells of eukaryote.

Cytoplasmic Inclusions:
The cytoplasmic inclusions present in the cyanophycean cell are
ribosomes,
cyanophycean granules,
polyhedral bodies----,carboxysome
polyphosphate bodies,
polyglucoside bodies,
α-granules, β-granules------polygiucan granule
gas vacuoles
The function of the above inclusions is not well-known. Cyanophycean granules are regarded as reserve food, polyhedral bodies, i.e., the carboxysomes contain enzyme ribulose b is phosphate carboxylase oxygenase.

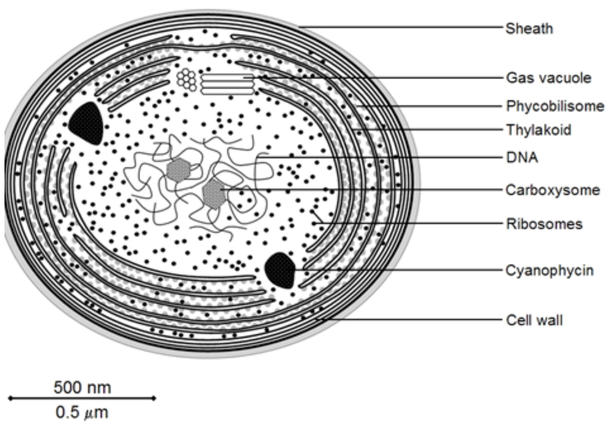
Thylakoids. These are the complex lamellar system, which functions like the protoplasts of eukaryotes. Thylakoids are not bounded by membrane instead they appear as elongated and flattened sacs composed of two unit membranes. Each membrane is about 75Å thick. The neighbouring thylakoids are separated by a flattened space of 50nm. The space is occupied by rows of discoid phycobilisomes, which contain the photosynthetic pigments chlorophyll a, c-phycocyanin and c-phycoerythrin.

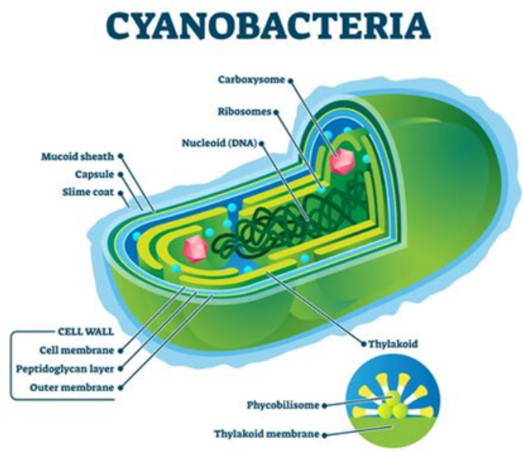
. Nucleoplasm:

The nucleoplasm is usually centrally located and contains numerous fine randomly oriented fibres of DNA. It is diffe-rentiated from the eukaryotic nucleus in absence of nucleolus and nuclear membrane. They are not differentiated from the cytoplasm by any membrane and are present in close association.

The region is with low electron density than the surrounding cytoplasm. The DNA does not organise into chromosomes due to the absence of protein like histones

Cross-section through a cyanobacterial cell



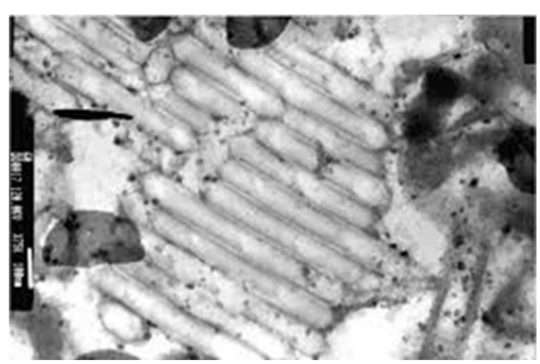


b **Myxophycean starch**: Found in the Cyanophyta, myxophycean starch has a similar structure to glycogen. This reserve product occurs as granules (α-granules), the shape varying between species from rod-shaped granules to 25-nm particles to elongate 31- to 67-nm bodies.

Cyanophycian starch- protein like polymer occur in the cytoplasm, α granular in structure, it is a temporary nitrogen reserver in nitrogen fixing bacteria.

Gas vacuoles

A gas vacuole is composed of gas vesicles, or hollow cylindrical tubes with conical ends, in the cytoplasm of cyanobacteria Gas vesicles do not have true protein-lipid membranes, being com-posed exclusively of protein ribs or spirals arranged similarly to the hoops on a barrel



Member of *Oscillatoria* shows the following two types of movements :

1. **Oscillatory movement**. The apical part of the filament of *Oscillatoria* shows pendulum-like oscillation. Such movement is called oscillatory movement (Fig. 3.31A) and hence the genus is named as "*Oscillatoria*".
2. **Gliding movement**. In this type the filament moves in forward and backward direction towards the axis of the filament. It is also called creeping or axial movement (Fig. 3.31B). This movement is also accompanied by clockwise and anti-clockwise rotations.

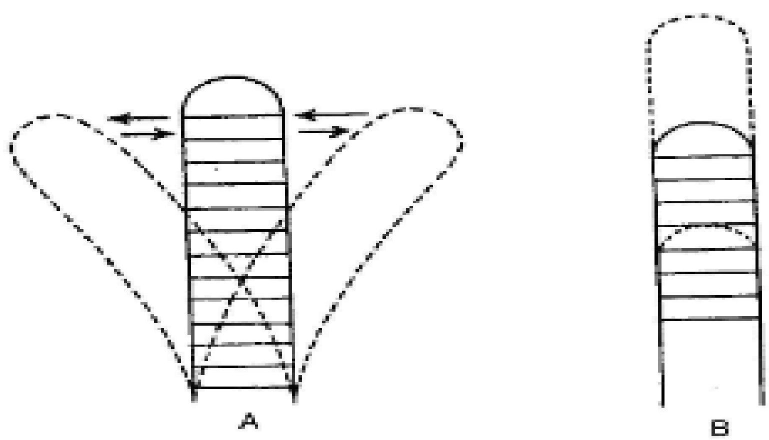
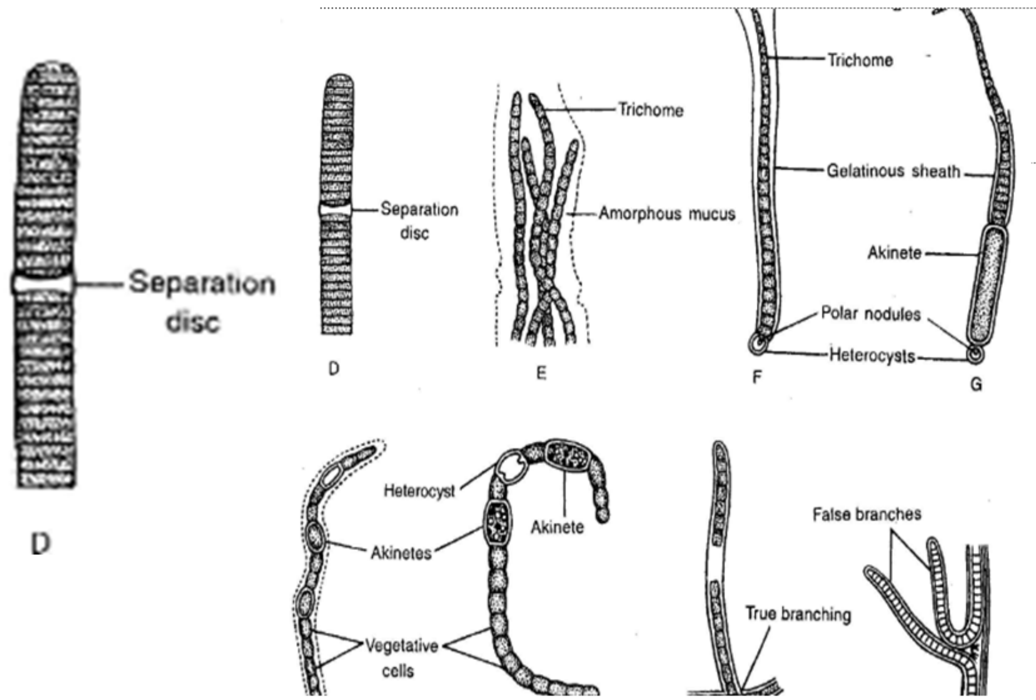
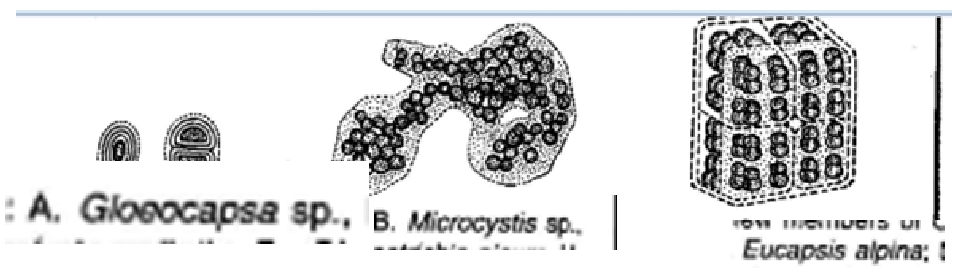


Fig.3.31 : *Oscillatoria* : A. Oscillatory movement, B. Gliding movement



3 : A few members of Cyanophyceae showing thallus organization : A. *Gloeocapsa* sp., B. *Microcystis* sp., C. *Eucapsis alpina*; D *Oscillatoria* sp., E. *Microcoleus* sp., F. *Rivularia poliotis*, G. *Gloeotrichia pisum*, H. *Nostoc* sp., I. *Anabaena* sp., J. *Mastigocladus limilosus*, and K. *Scytonema* sp.

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 :



2. Colonial Forms (Fig. 2.1). In most blue-greens, the cells after division remain attached by their walls or are held in a common gelatinous matrix to form a loose organisation of cells which is termed a **colony**. Of course the cells in the colonies are often aggregated into irregular, palmelloid forms of great variability. *Gloeothece* is an example of an aggregation of a few cells. *Aphanocapsa* (B) and *Aphanothece* are examples of aggregations of numerous cells. The colonies may either be **filamentous** or **non-filamentous**. Each colony is generally enclosed in a gelatinous sheath.

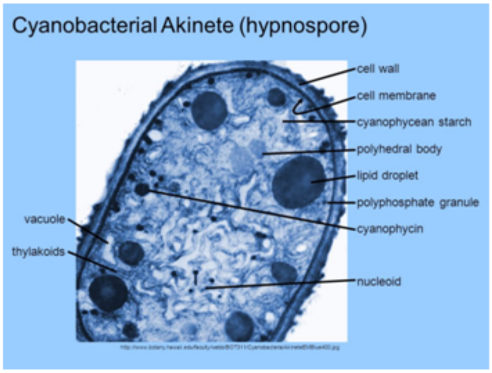
Fig. 2.2. Non-filamentous **Cyanophyceae.** *Eucapsis alpina* (After Clemants and

(a) Non-filamentous colonies (Fig. 2.1). The *non-filamentous* colonies are of various forms. They may be cubical, spherical, square or irregular depending on the planes and direction in which the cells divide. The formation of non-filamentous colonies is regarded to proceed along two lines:–

(i) Cell divisions take place alternately in two planes at right angles to each other. The result is a flat plate of cells (C), or a hollow sphere in which the cells form a single layer near the periphery of the gelatinous matrix (B). Examples of hollow spherical calonies are *Coelosphaerum* and *Gomphophaera.*

(ii) Cell divisions proceed in three planes. If the sequence is regular as is the case in a few genera, the component cells become arranged into a colony having a definite shape. The cubical colony of *Eucapsis alpina* (Fig. 2.2) is the typical example. However, usually the sequence of division is irregular resulting in a colony with no regular arrangement of cells (*Microcystis*, A).

(b) Filamentous colonies (Fig.2.3). The *filamentous* colony is the result of repeated cell divisions in a single plane and in a single direction forming a chain or a thread. It is known as the **trichome**. The cells in the trichome may be held together either by separation walls or a common gelatinous sheath around it. The trichome is usually straight (A) but in *Arthrospira* (C) and *Spirulina* (B) it is more or less permanently spirally coiled. In *Rivularia* it is whip-like with the upper end drawn out into a colourless, multicellular hair (D). The trichome of *Aphanizomenon* tapers towards both ends (E). The trichome with its enclosing sheath is called a **filament**. The filament in some genera such as *Oscillatoria* and *Lyngbya* , has a single trichome (Fig. 2.4) while in others (*Microcoleus vaginatus* and *Hydrocoleus*) it contains several trichomes (Fig 2.5). In some blue-green algae the filament is branched (Fig. 2.6).

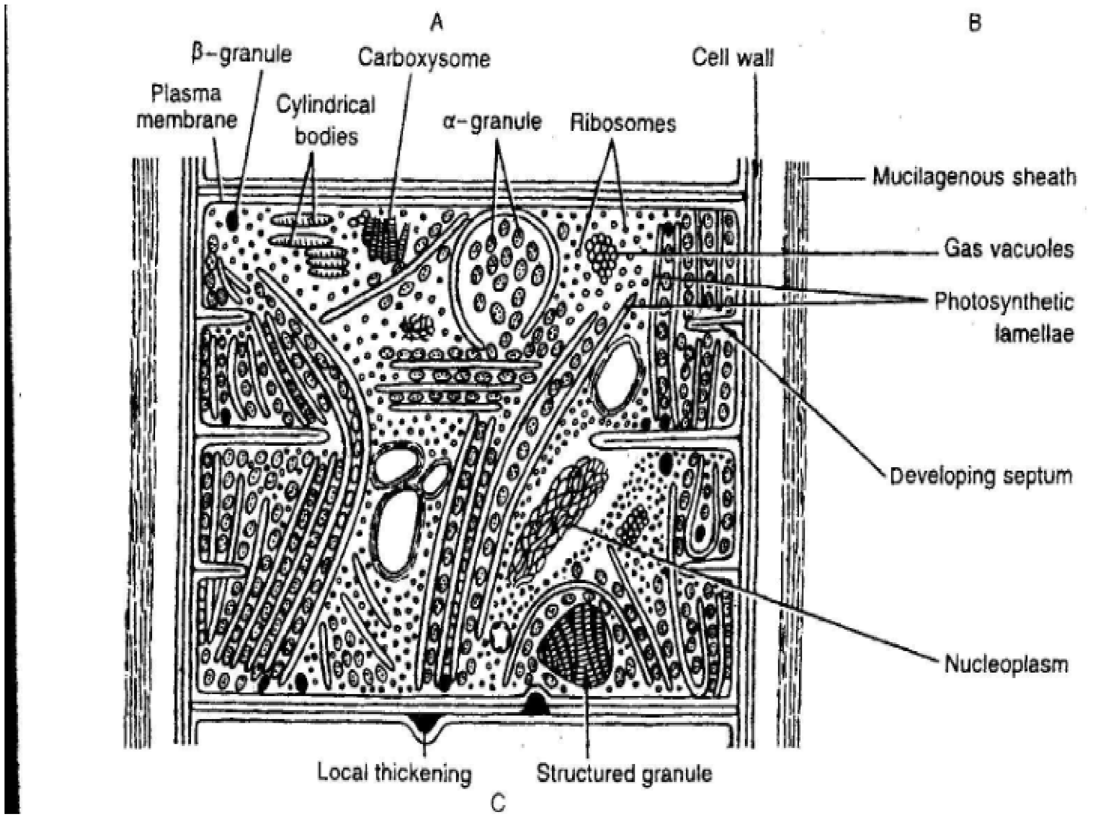


Carboxysomes (polyhedral bodies) are similar to the carboxysomes in bacteria and contain the carbon dioxide-fixing enzyme **ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco)**. There are two types of carboxysomes, α-carboxysomes and β-carboxysomes, which differ in their protein composition. Cyanobacteria with **α-carboxysomes** occur in environments where dissolved carbon is not limiting (e.g., oligotrophic oceanic waters), whereas cyanobacteria with **β-carboxysomes** occur in environments where dissolved carbon is limiting

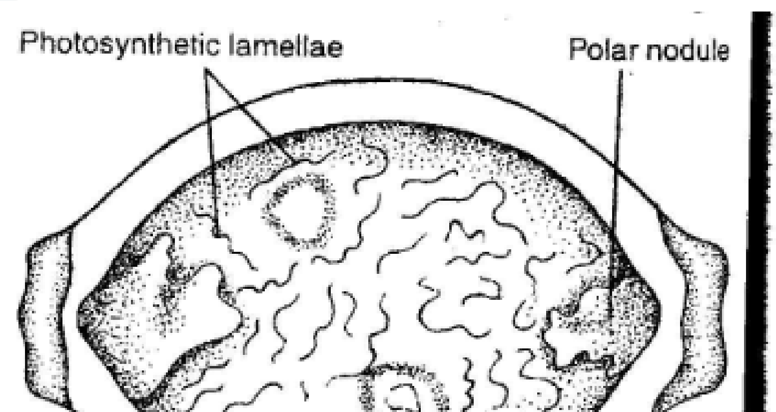
Gaidukov phenomenon or complementary chromatic adaptation

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.


A
B
C
β-granule
Carboxysome
Cell wall
Plasma membrane
Cylindrical bodies
α-granule
Ribosomes
Mucilagenous sheath
Gas vacuoles
Photosynthetic lamellae
Developing septum
Nucleoplasm
Local thickening
Structured granule

Heterocysts are slightly larger than the vegetative cell. It is mainly concerned with the nitrogen fixation and sometimes reproduction too. The heterocysts have thick two layered envelope with inner walls **forms knob like projections into the cell cavity**. These knobs like projections are known as the polar nodules which are rich in enzymes **nitrogenase and hydrogenase.** Reproduction by heterocyst is a rare but they germinate in certain cases. The heterocysts are liberated by breaking their walls.



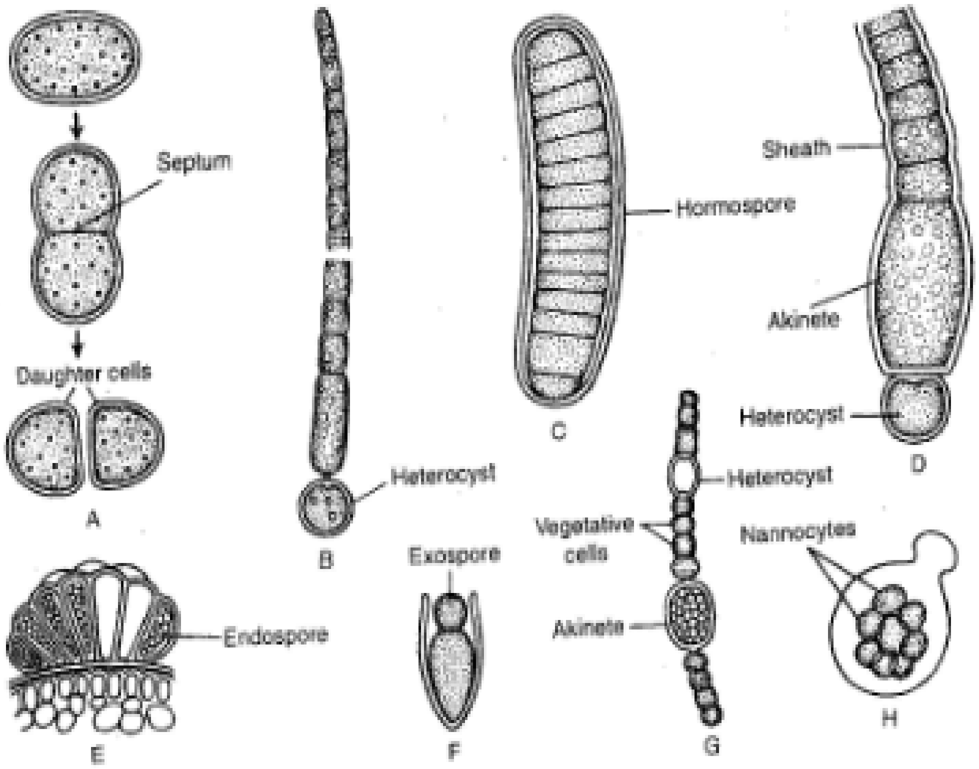
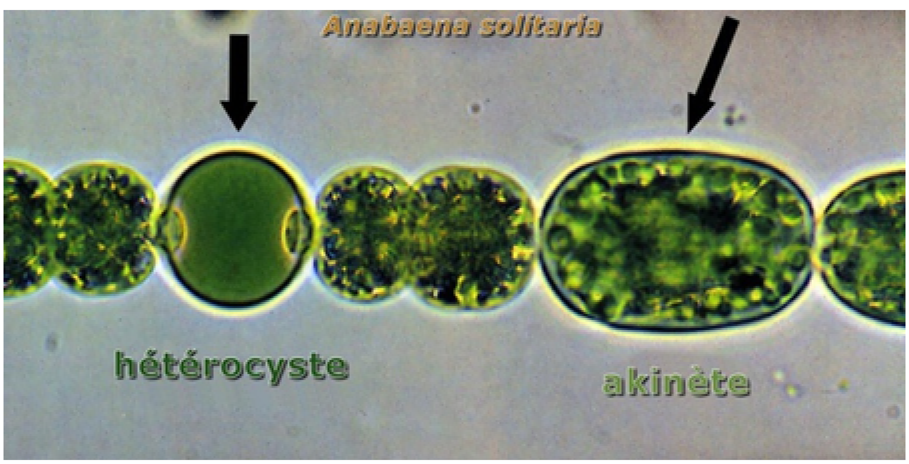


Fig. 3.27 : Vegetative and asexual reproduction in Cyanophyceae : A. Cell division (*Synechococcus* sp.), B. Fragmentation of filament (*Cylindrospermum muscicola*), C. Hormospore (*Westiella lanosa*), D. Akinete (*Gloeotrichia natans*), E Endospore (*Dermocarpa prasina*), F. Exospore (*Chamaesiphon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

1. **Akinetes**. These are **unicellular, resting spores** formed at different positions of the trichome (Fig. 3.38B). They may remain at either or both the sides of the heterocyst or may be away from it. They are intercalary in position, either singly or in chain. Akinetes are larger in size than the normal vegetative cells. They are generally cylindrical with rounded edges. The akinetes store large amount of food. Due to highly resistant thick wall, the akinetes can survive during unfavourable condition. During favourable condition the akinete germinates into a new trichome.
2. **Endospores**. These are small uninucleate spores, reported to develop within the heterocysts of *A. cycadearum*.

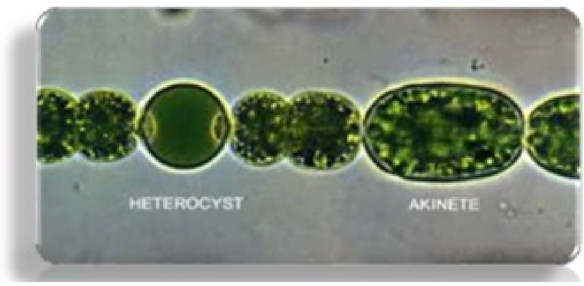


- Akinete is thick walled dormant cell derived from the enlargement of a vegetative cell .
- It is the resting cell of cynobacteria and unicellular fillamentous green algae.
- The akinete are filled with food reserve, and have a normal Cell wall surrounded with three layer of coat.
- Devlopement of akinete

From vegetative cell involve-

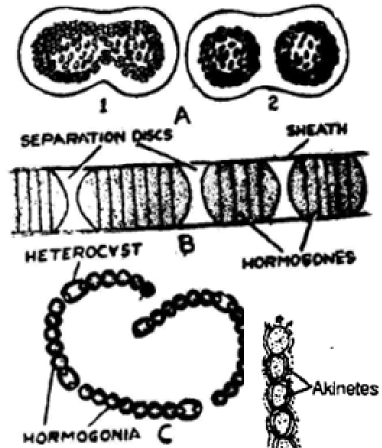
1) Increase in size
2) Gradual diappearence of

Gas vacuole.



(b) Fragmentation (Fig 2.12A). During periods favourable for growth, propagation by frag mentation is common in both the nonfilamentous colony and filamentous forms. Reaching a certai size, the nonfilamentous colony splits into small parts (*Microcystis*, A). Each part which is calle a *fragment* by repeated cell division grows into a new colony. In the filamentous forms, the trichome may break into fragments by mechanical means such as by the bite of animals or stress caused by water currents or death of certain cells weakening the trichome.

(c) Hormogonia formation (Fig. 2.12 B-C). It is a specialized process of vegetative propagation characteristic of the cyanophyceae. Trichomes of filamentous genera of the Nostocales and Stigonematales regularly multiply by breaking of their trichomes within the sheath into short fragments of one to many living cells known as the *hormogones* or *hormogonia* which are generally motile. The hormogones are delimited in two ways namely, *(i)* by the formation of intercalary heterocysts (C) and *(ii)* by the development of intercalary biconcave separation discs or *necridia* (dead cells) at intervals along the trichome (B)



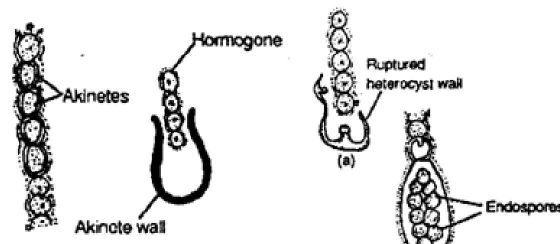


Fig. Akinete germination

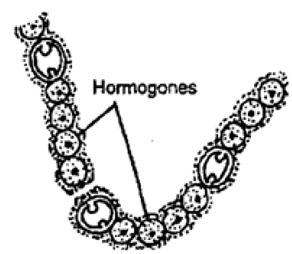


Fig. Hormogones

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