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For 2nd year of Botany/ Chemistry
Microbiology (Algae)

Cyanobacteria (Blue Green Algae)

- The division Cyanobacteria belongs to Kingdom Monera.
- Cyanobacteria has one class, i.e. Cyanophyceae / Myxophyceae.

- **Characteristics of Cyanophyceae :-**
  - Procaryotic algae as G- ve bacteria.
  - Cell wall: amino sugars and amino acids.
  - bluish-green due to the presence of blue, green and red pigment
  - Pigments: Chlorophyll (a ،f) and phycobiliproteins (phycocyanin, allophycocyanin and phycoerythrin).
  - Storage product: glycogen

- **Characteristics of Cyanophyceae :-**
  - have a wide range of tolerance to the environmental conditions.
  - have 150 Genera and 2000 species.
  - Cyanobacteria blooms produce cyanotoxins, killing livestock.
  - *Spirulina*: high- protein dietary supplement

They have some similarities with bacteria

- (i) Cellular organization is same, they are prokaryotic as their organelles are not membrance-bound.
- (ii) Lack cellulose in cell walls.
- (iii) They have only haploid life cycle (i.e. no alternation of generation).
- (iv) Reproduction through fission.
- (v) DNA is not associated with histone proteins in their chromosomes.

Habitats

- 1- Cosmopolitan
- 2-Moist rocks or soil and deserts, volcanoes
- 3-Sea, lakes, recovers, pond, springs
- 4-grow on snow or hot springs
- 5- grow in acidic and alkaline environment
- **6-** stagnant/flowing, shallow/ deep and fresh salt waters
- 7-They grow as endophytes, as constituents of lichens, as endosymbiont in diverse animals.
- **7-**highly osmatic pressure

Classification of Cyanobacteria

- There are three orders:
- 1- Chroococcales:-
  - *single cells or
  - * loosely cells bound into gelatinous irregular colonies
- 2- Oscillatoriales:
  - filamentous cyanobacteria
- 3- Nostocales:
  - filamentous cyanobacteria with heterocysts.

Thallus Organization

- Thallus in Cyanophyceae has a range of organization as follows:
- 1. Unicellular, e.g. Coccoid and palmelloid genera
- 2. Filamentous, e.g. Unbranched and branced genera
- **3.** Colonial, e.g. Any of the above forms held in common gelatinous matrix.

- Flagella are absent but some members move by gliding.

Morphology of Cyanobacteria

- Morphology of Cyanobacteria
  - Unicells
    - Free-living
    - A mucilaginous
  - Trichome
    A shortage of CO_2
  - Filament
    - uniseriate
    - multiseriate

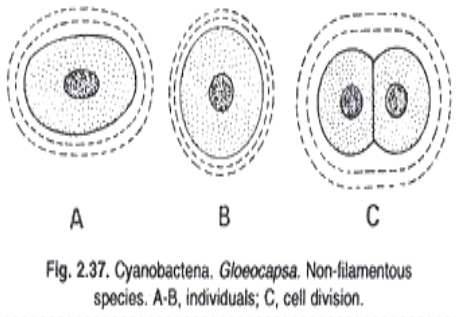
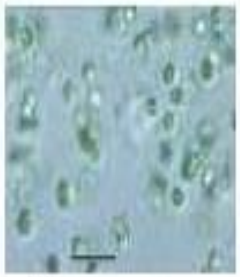


Fig. 2.37. Cyanobactena. *Gloeocapsa*. Non-filamentous species. A-B, individuals; C, cell division.

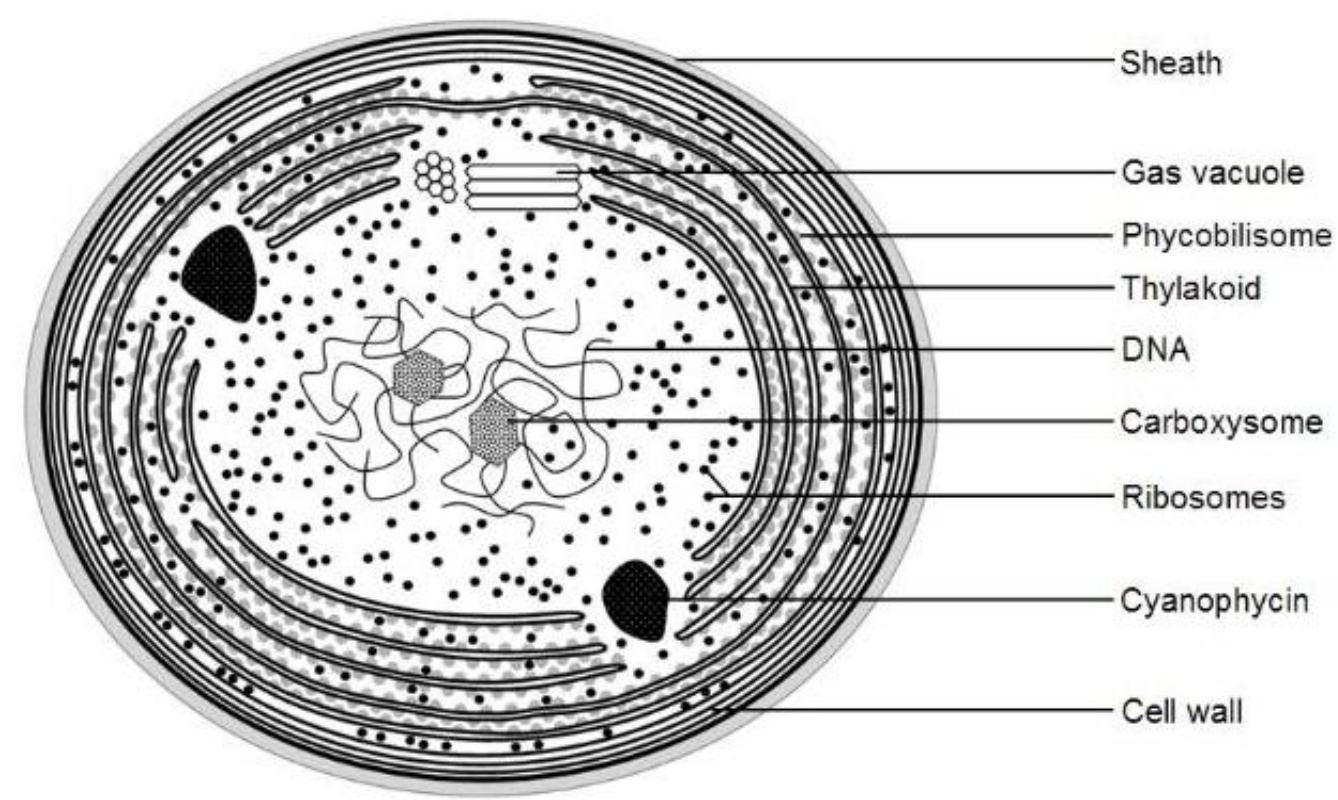

Chroococcus


Gloeocapsa


Oscillatoria

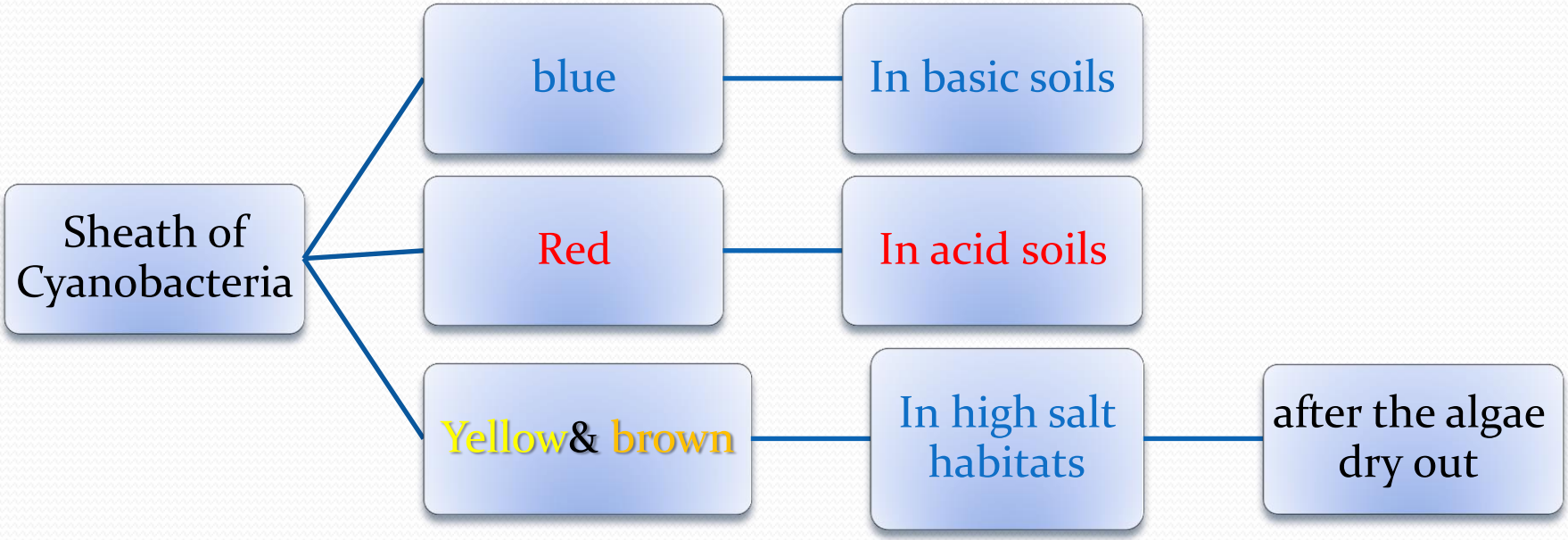

Gloeotrichia

Cyanobacerial cell structure



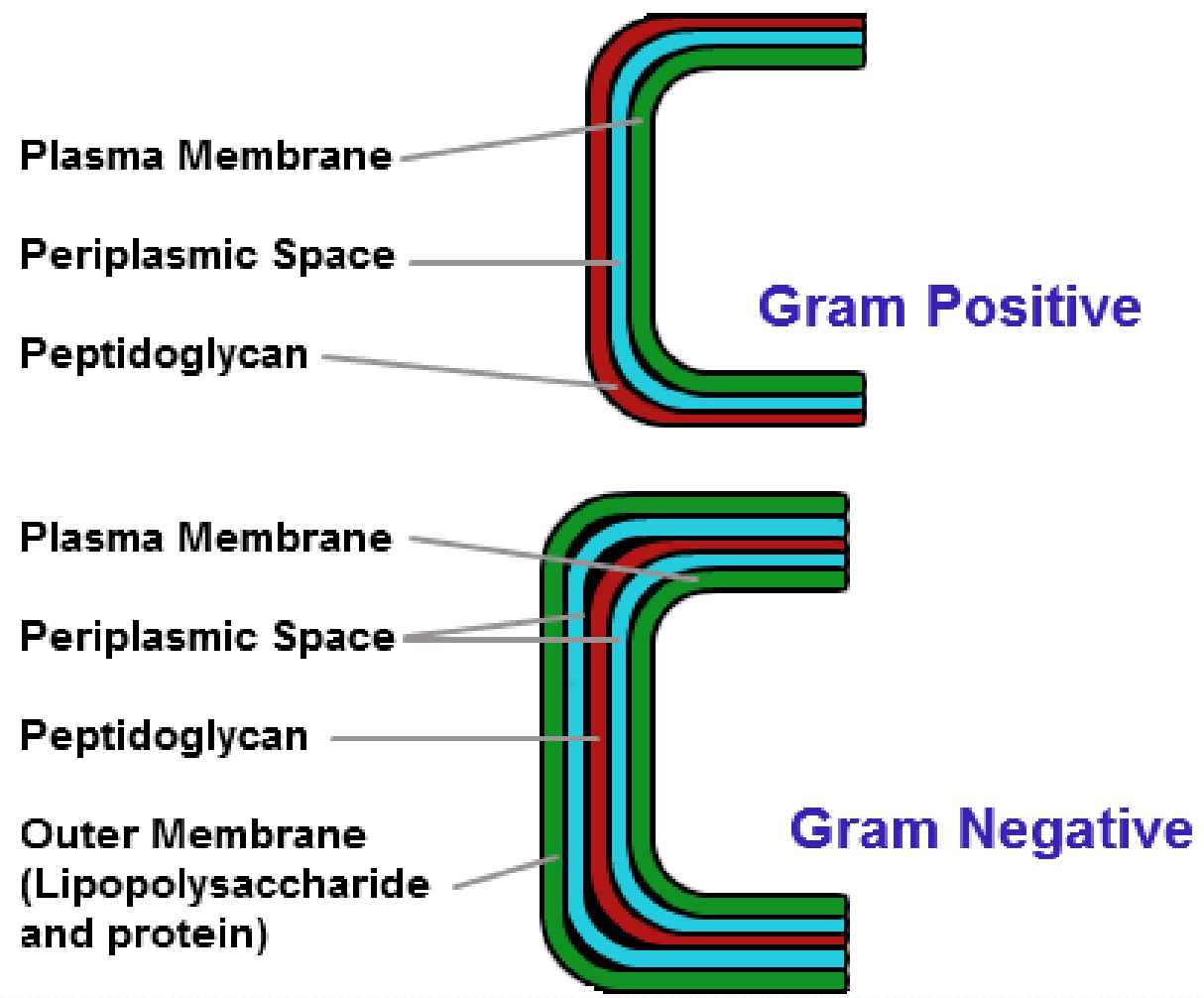
Sheaths composed of mucilage **capsule** or **extracellular polymeric substances (EPS)**. The sheath protects cells from drying.

- A shortage of CO_2 causes cessation of sheath production.
- An excess of fixed CO_2 forms of the sheath

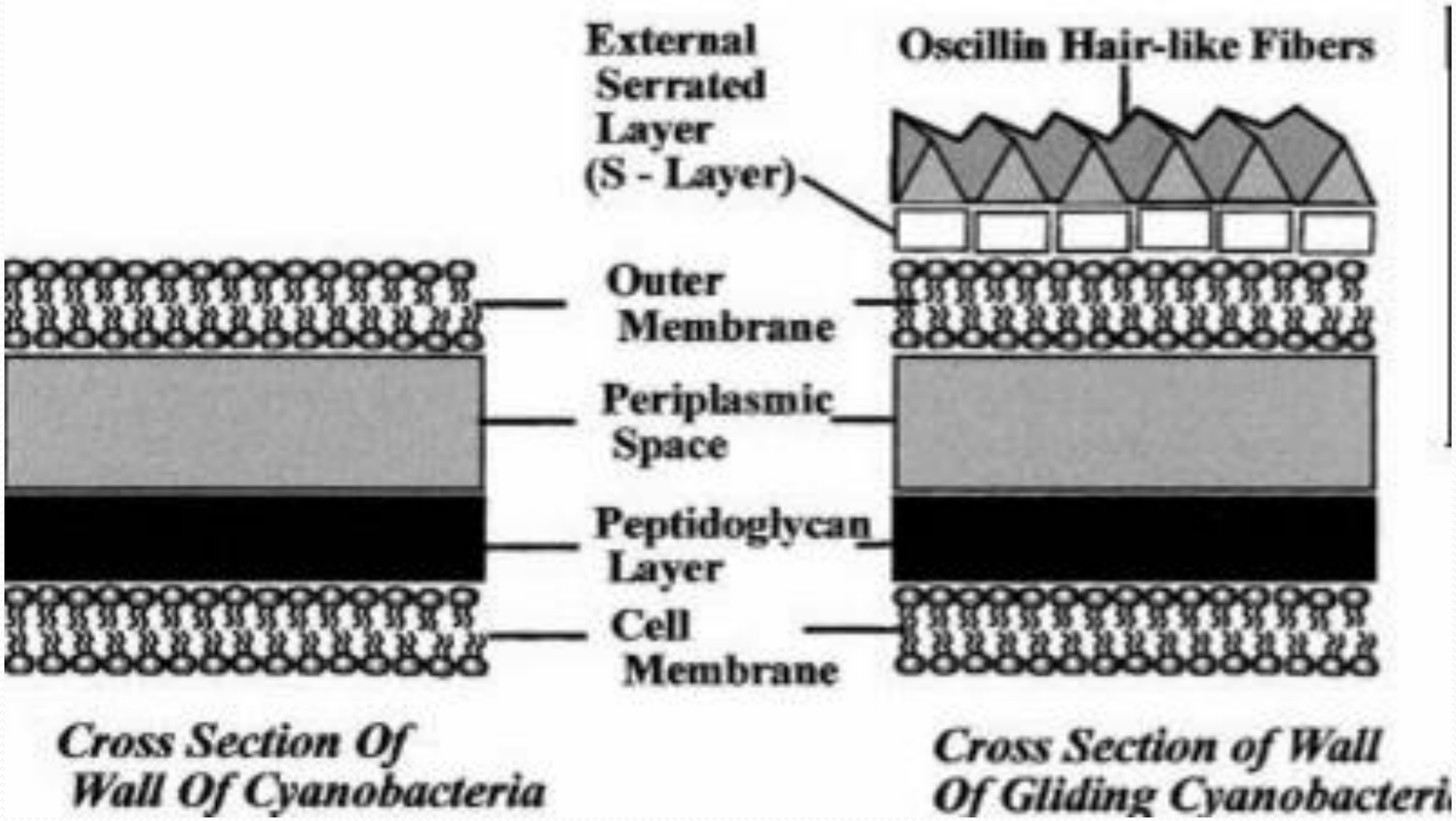


Cell wall

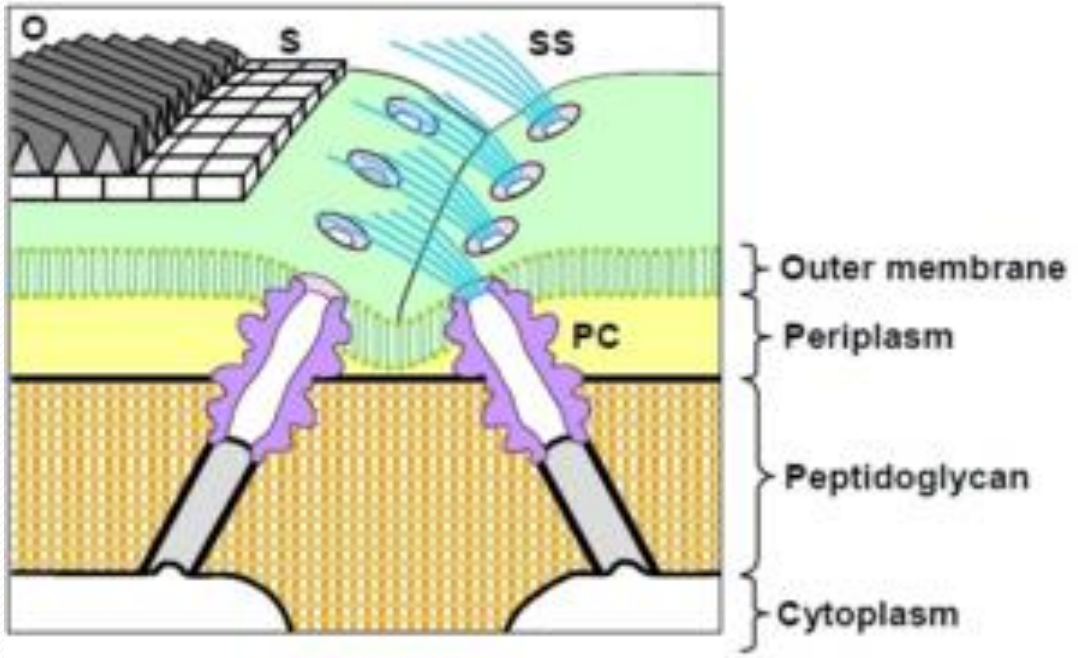
- **Cell wall characters**:-
- 1- As the cell wall of G (-ve) bacteria.
  - 2- its structure :-



- **Gliding Movement**
- Cyanobacteria that can glide have an additional two wall layers on the outside(External serrated layer (S-layer) and Oscillin hair like fibers and



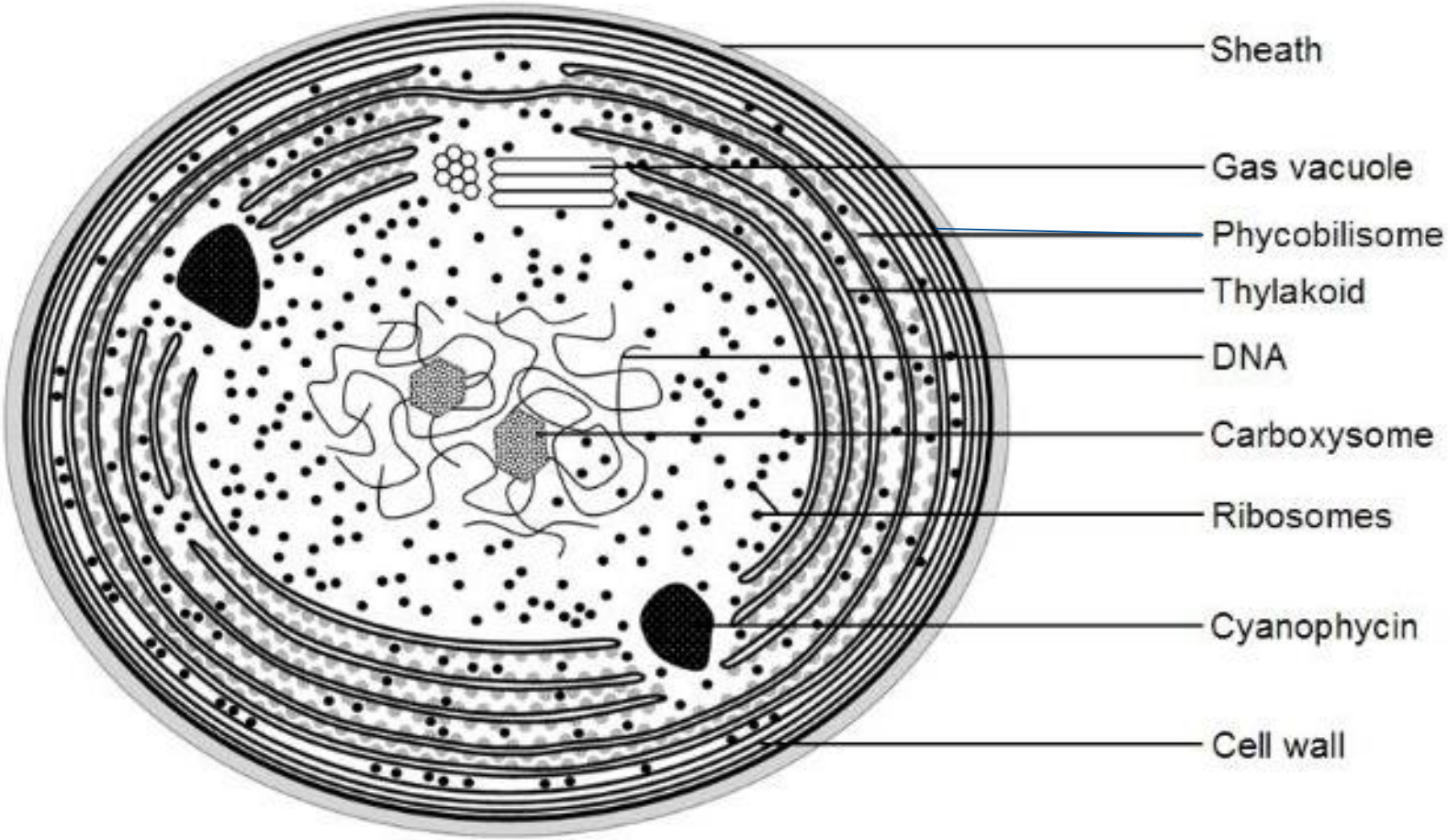
- **Properties of gliding cells**
  - A good example of giliding *Oscillatoria*
  - capable of gliding on a solid .
  - secrete & leave slime sheet behind them during movements.
  - **Slime** propel the filaments in one direction or the other, or rotating on its axis
  - helps cyanobacteria to reach optimal lighting levels for photosynthesis



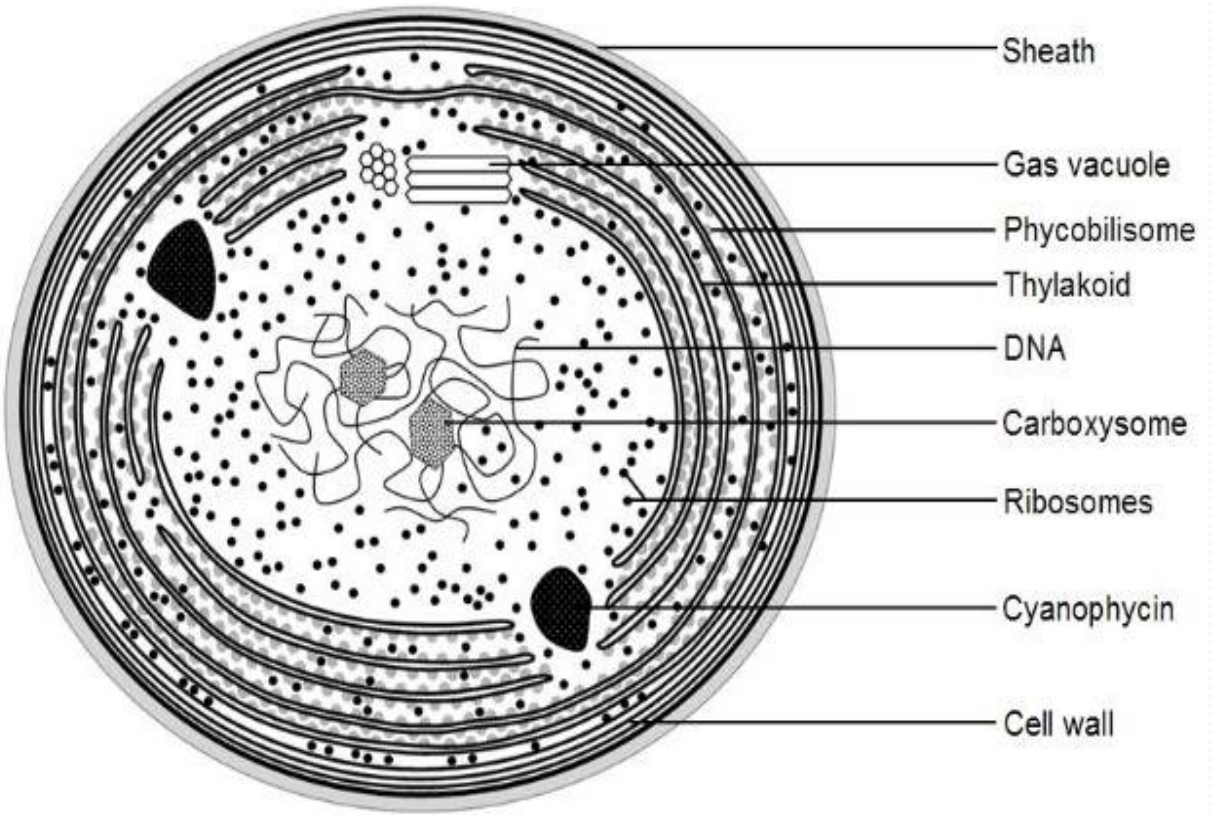
4- Protoplasmic structure

I- Central protoplasm (colorless region or nucleoplasm**)**

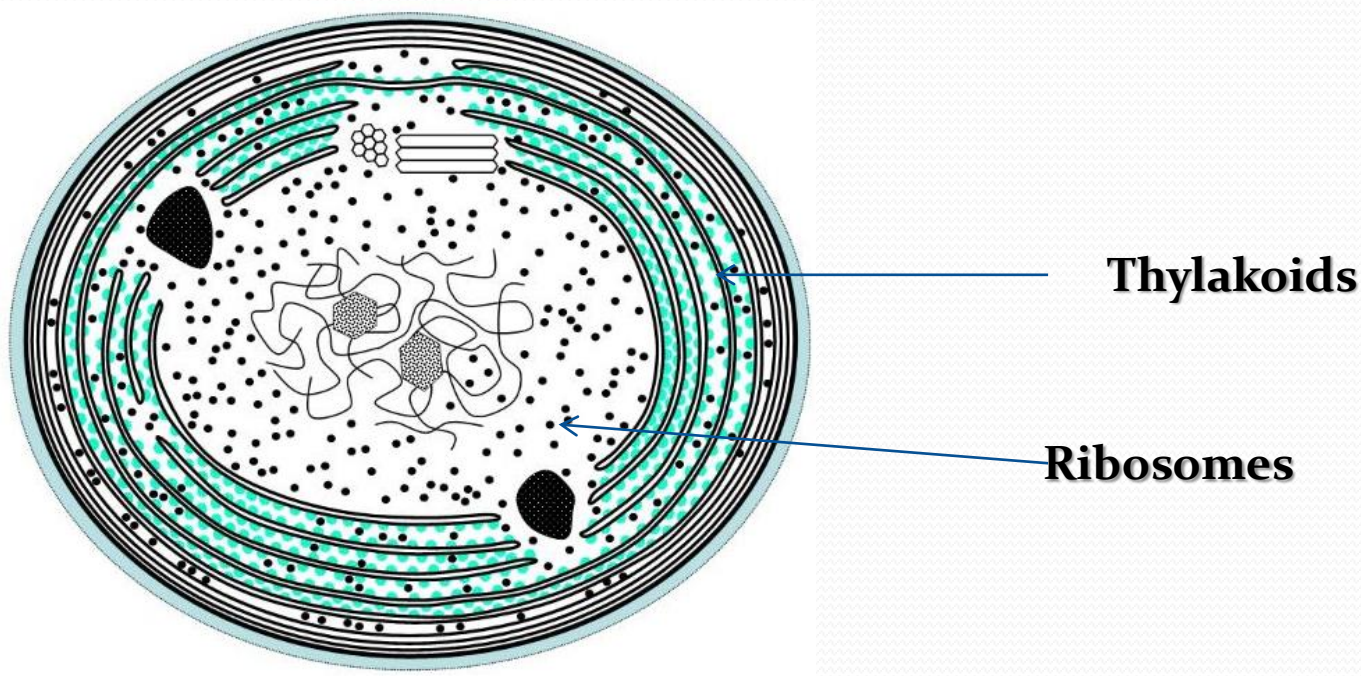
II- Peripheral protoplasm (color region)



- **I- Central protoplasm (colorless region or** nucleoplasm**)**
  - circular fibrils of DNA-
    - not associated with basic proteins (histones).
  - The size of DNA in unicellular cyanobacteria
    - = bacterial genome size
    - > mycoplasmas genome size.

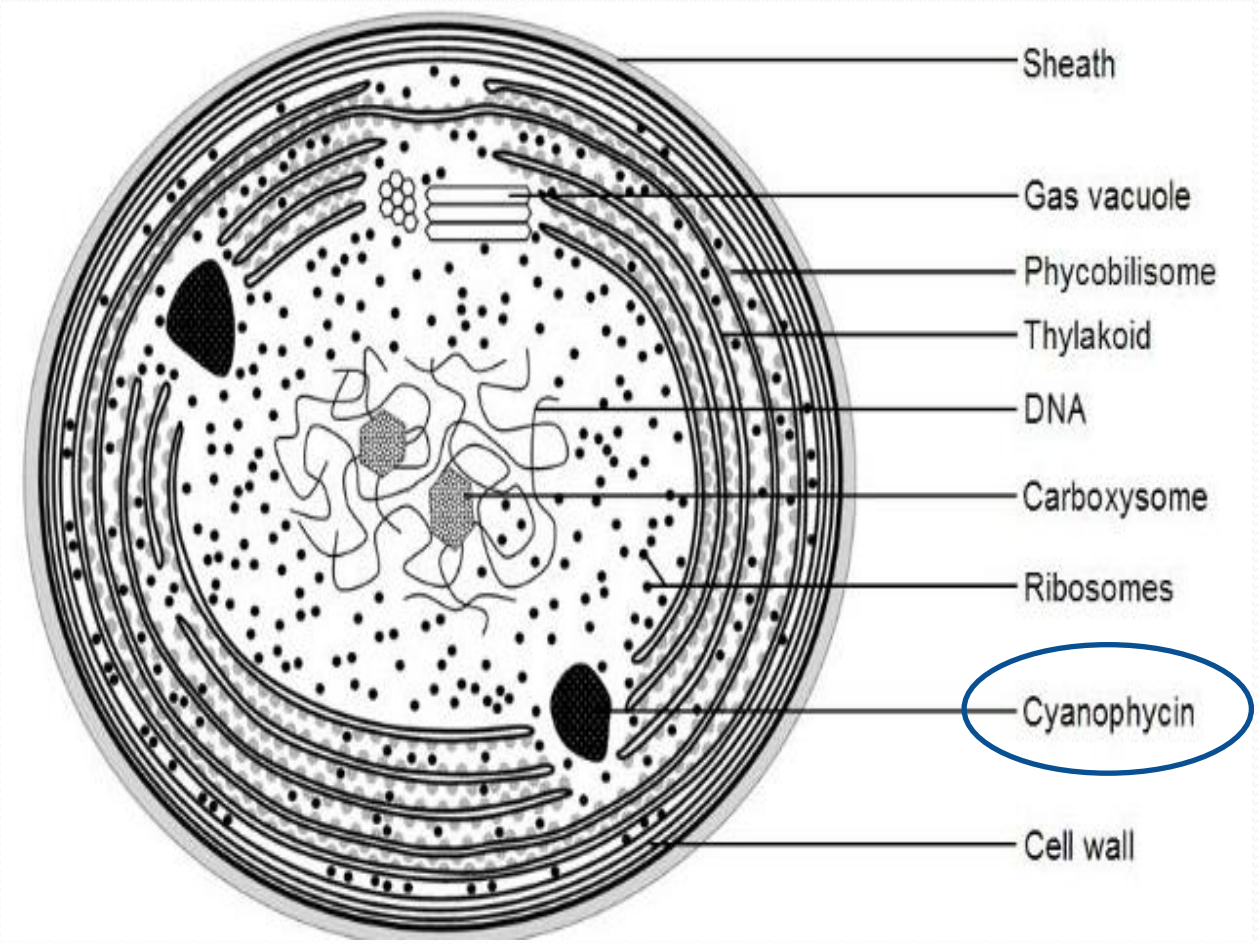


- **II- Peripheral protoplasm (color region)**
- composed principally of **thylakoids**
  - associated with phycobilisomes and glycogen granules.
- 70S ribosomes dispersed throughout the cell with high density in the central region (nucleoplasm).
- Some structures will be explained as follows:-



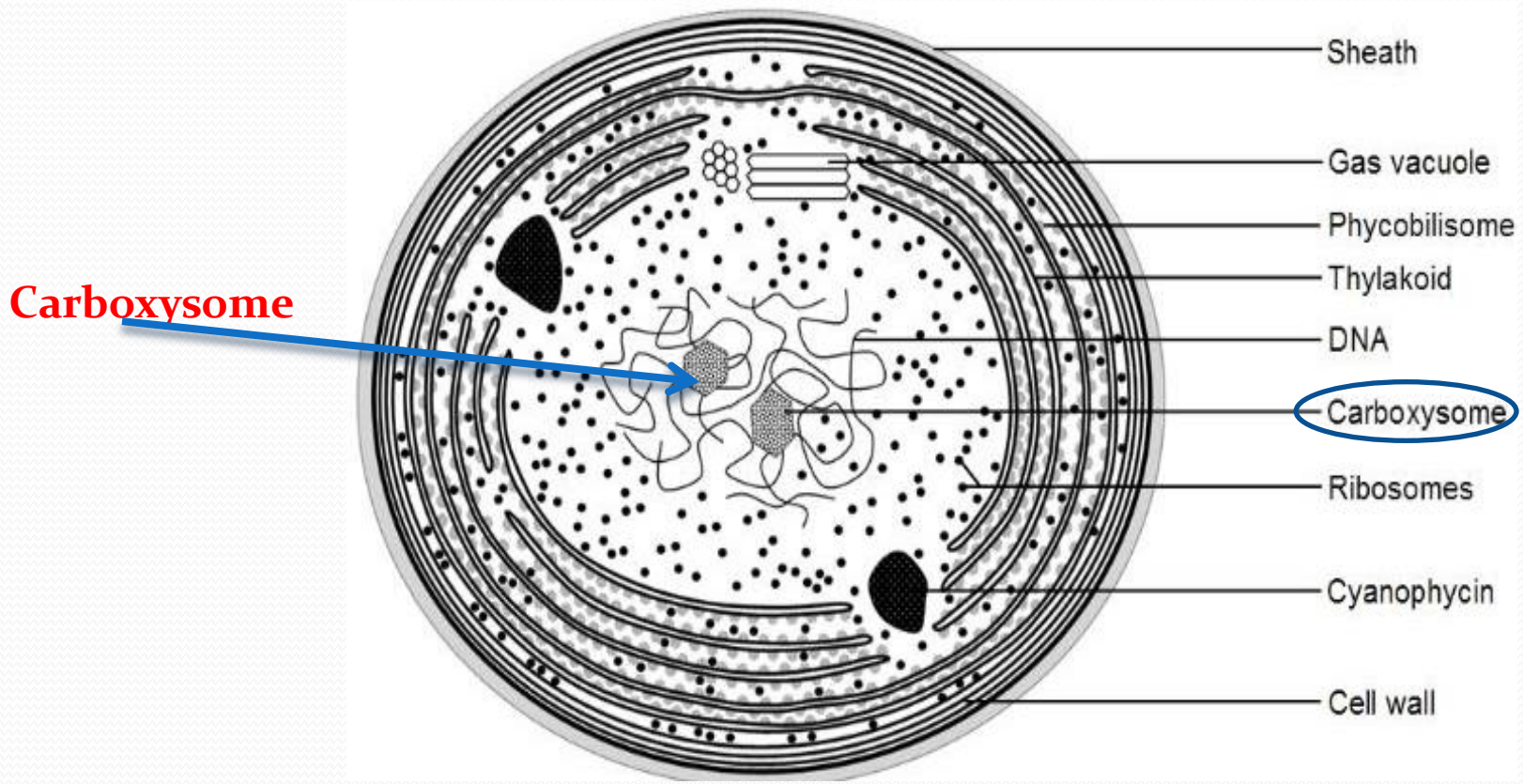
A -Cyanophycin granules:-

- Polypeptides (chain of amino acids)
- Located near the cell periphery.
- Involved in **nitrogen metabolism**.



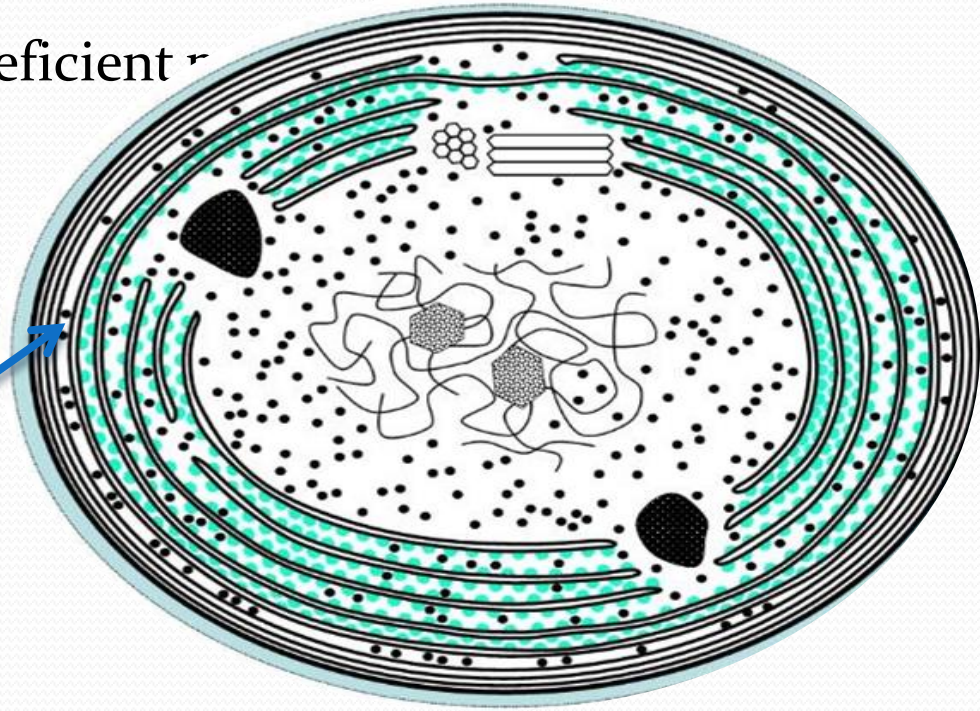
B- Carboxysomes :-

- Polyhedral bodies
- **Consist of the main enzyme involved in photosynthesis** (Rubisco).
- Rubisco (ribulose -1,5-bisphosphate carboxylase).



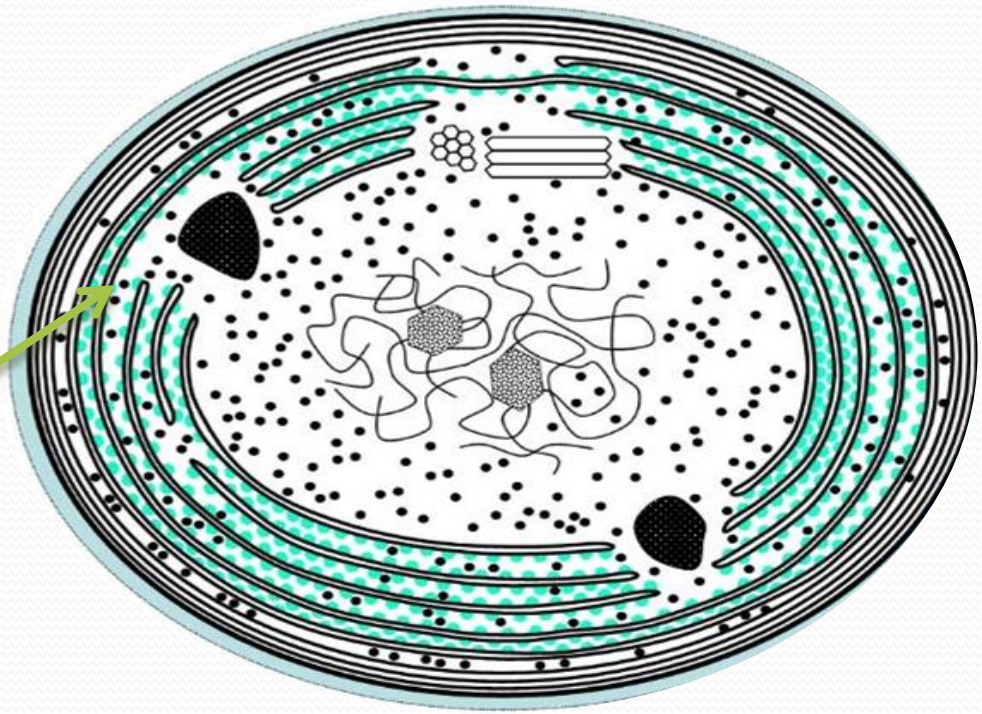
C-Volutin granules

- **(Polyphosphate bodies)**
  - Spherical
  - similar to lipid bodies of eukaryotic cells.
  - contain **stored phosphate**,
  - **absent in** young growing cells or
    - cells grown in a phosphate-deficient r
  - **but present** in older cells.



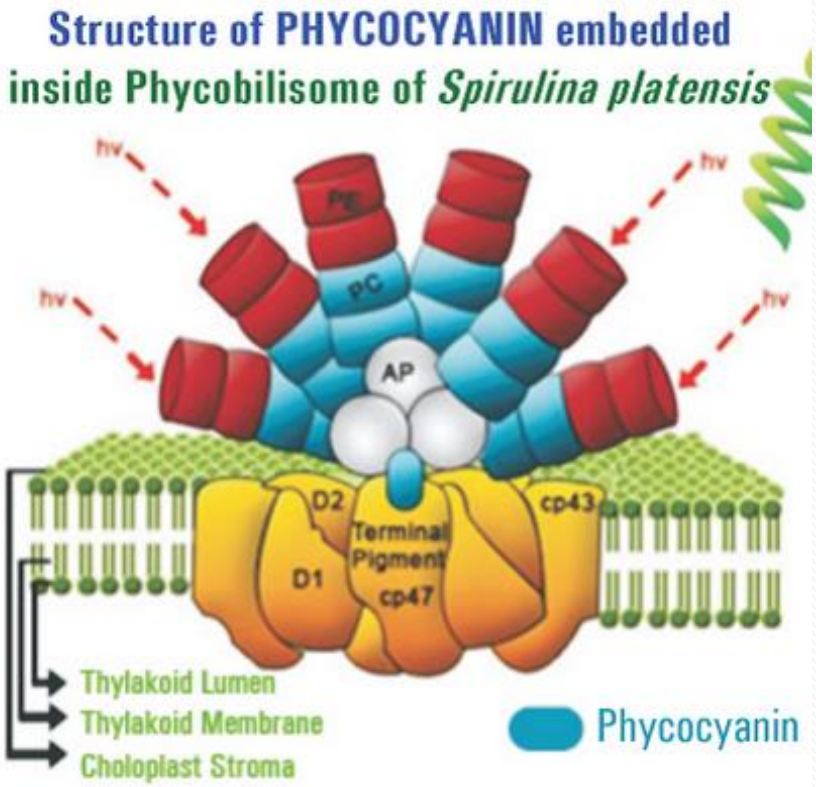
D- Glycogen granules

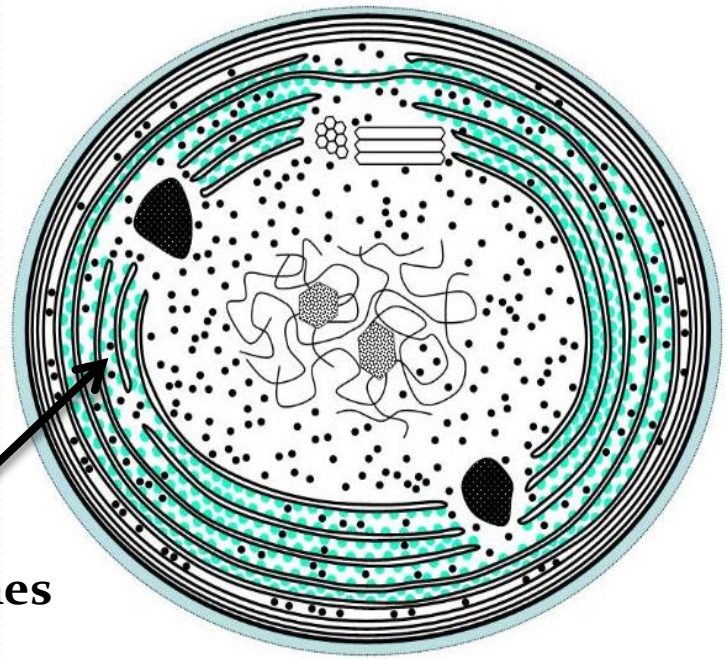
- Tiny glycogen granules or rods
- In the space between the thylakoids
- Act as a store of **glucose or carbohydrate**.
- **Called Polyglucan granules (α-granules).**



E-Pigments

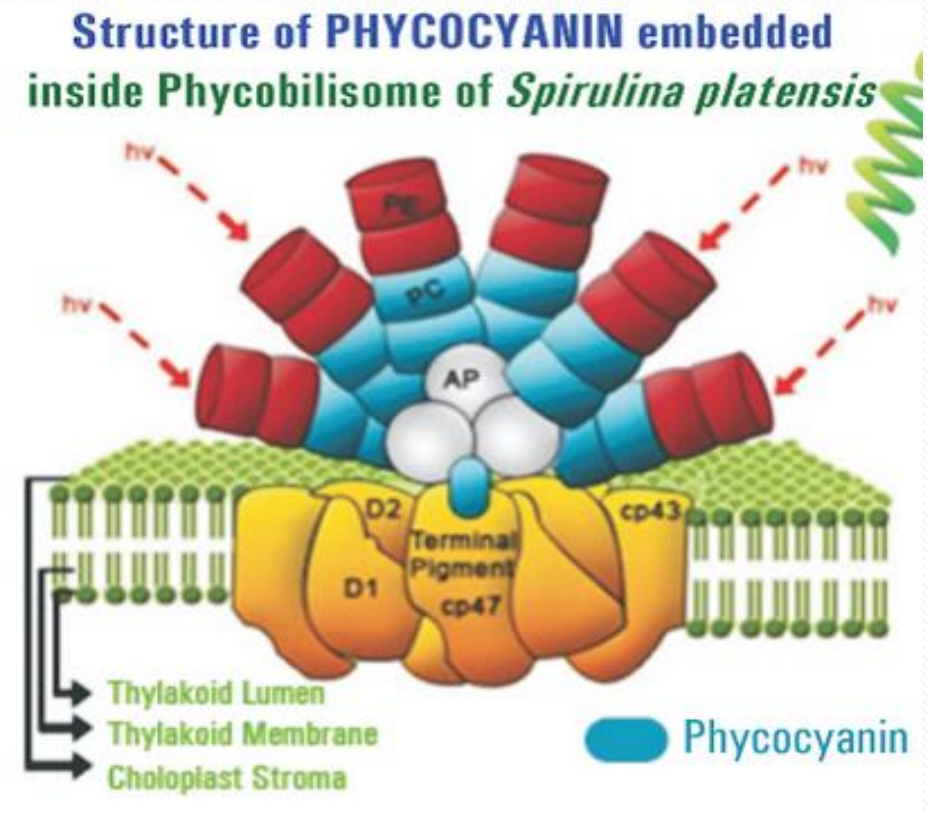
- The major components:-
  - **Chlorophyll** *a* &f; **Phycobilin**)
  - **Phycobilin** [(phycoerythrin (red) + phycocyanin(blue)].
- **Cells have thylakoids** (in the thylakoid membrane).





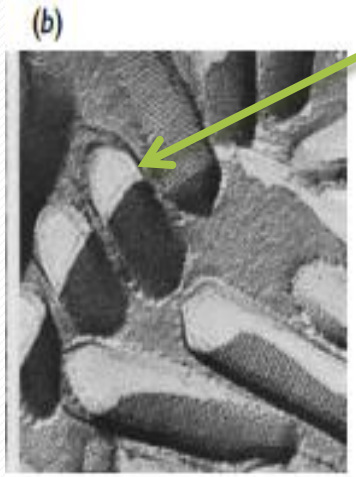
Phycobilisomes

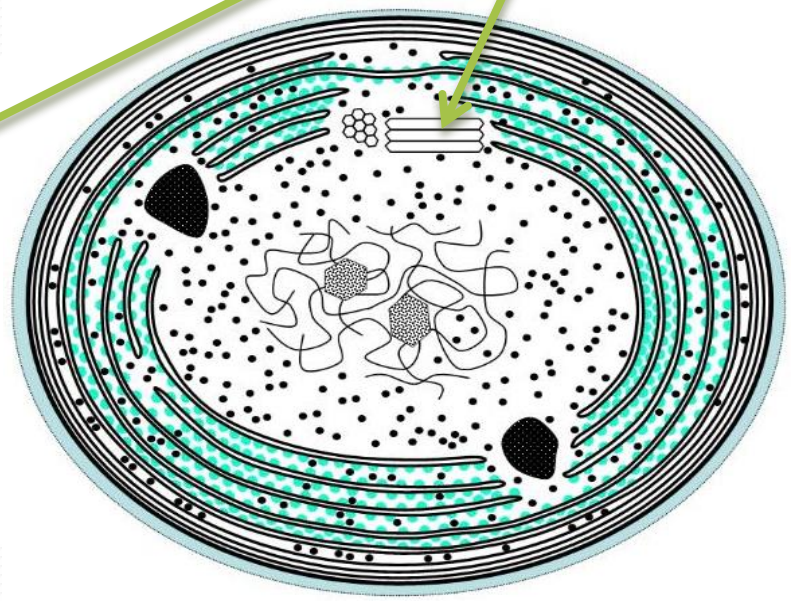
- **Phycobilin = [phycoerythrin + phycocyanin].**
- **Phycobiliproteins = (phycobilin+ protein)**
- **Phycobilisomes = [Phycobiliproteins attached to thylakoid memberane]**
  - Pigment concentration changed in response to light quality and growth conditions.



- What's the role of accessory pigment ?
- **The accessory pigments :-**
- **1- Screen (يحجب) and protect the chlorophyll from damaging UV light.**
- 2- Trap photons and funnel them to the chlorophyll.
- 3- Act as **antennae**, that increase the wavelengths of light used for photosynthesis

- **F- Gas vacuoles (** vesicles):-
- Composed of hollow cylindrical tubes with conical ends or
- clusters of protein gas-filled rods.
- In aquatic forms.
- **Function:-**
  - regulate buoyancy,
  - Help the cells to float at optimal light levels for photosynthesis in the water column.
- The loss of gas vacuole resulting from the increased turgor pressure led to sinking or negative buoyancy





5- Filament structure

- Besides the previous structures, the filament has additional structures as **Akinete – Heterocyst**
- **Akinete**

A vegetative cell is developed into akinete by:-

1-The gradual disappearance of gas vacuoles.

2-An increase in cell size

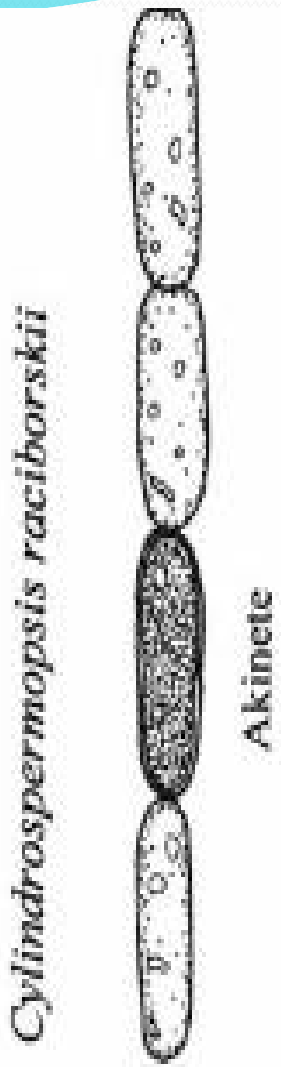
3-An increase in cytoplasmic density and number of ribosomes.

4-An increase in storage products

- a) High conc. of glycogen
- b) High conc. Of cyanophycin

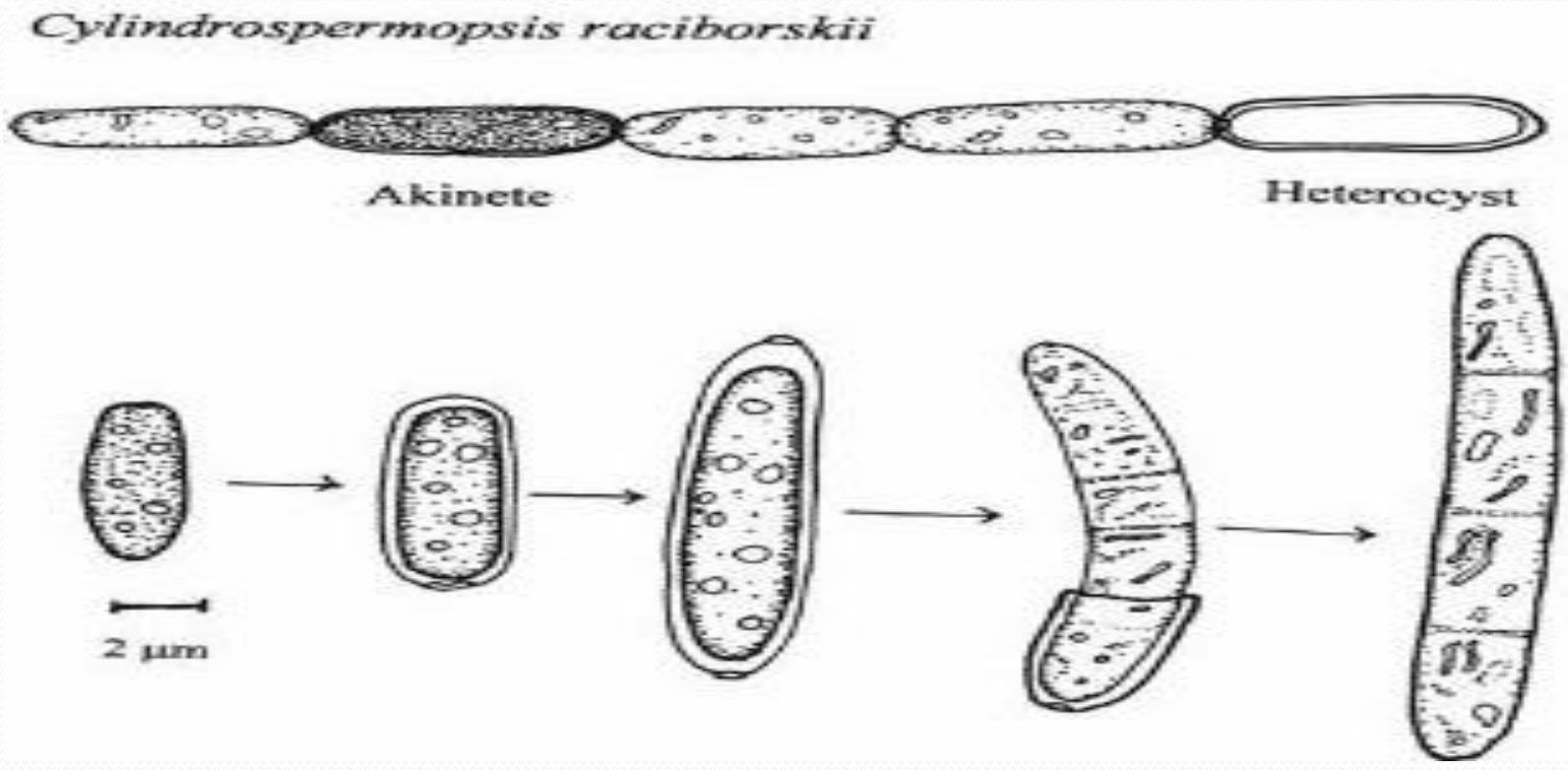
5-Their greater resistance to cold compared with vegetative cells.

6-lose their photosynthetic and respiratory capabilities



The germination of an akinete

- Akinete has greater resistance to harsh conditions compared with vegetative cells.
- when the environmental conditions became suitable for growth, the akinete germinate to full filament.
- The germination is a **reverse of the differentiation process**



2-Heterocysts

- **Also, a vegetative cell can be developed into heterocyst and characterized by the following Characteristics than the vegetative cell.**
- **Characteristics:-**

1- they larger than vegetative cells

2- appear empty in the light microscope

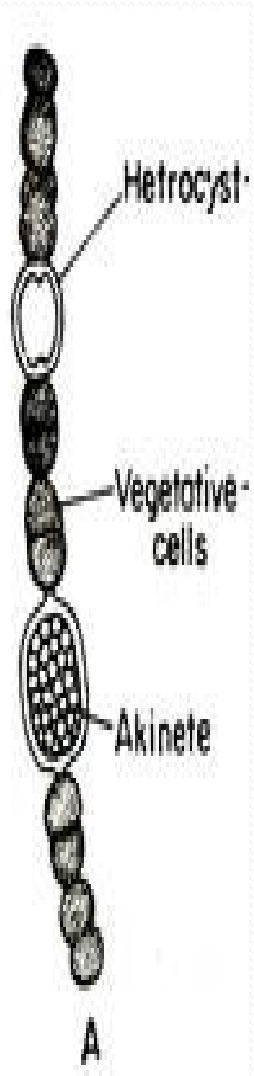
3-photosynthetically inactive

4- don't fix CO_2, nor produce O_2

5- surrounded by a thick laminated cell wall that limits

ingress of atmospheric gases, including O_2

7- The internal environment of heterocysts is virtually anoxic (ideal for nitrogenase- O_2 senstive enzyme).



Reproduction of Cyanobacteria

- Cyanobacteria reproduce by two methods only; vegetative and asexual **reproduction**.
- **1- Vegetative reproduction** is generally in four ways:

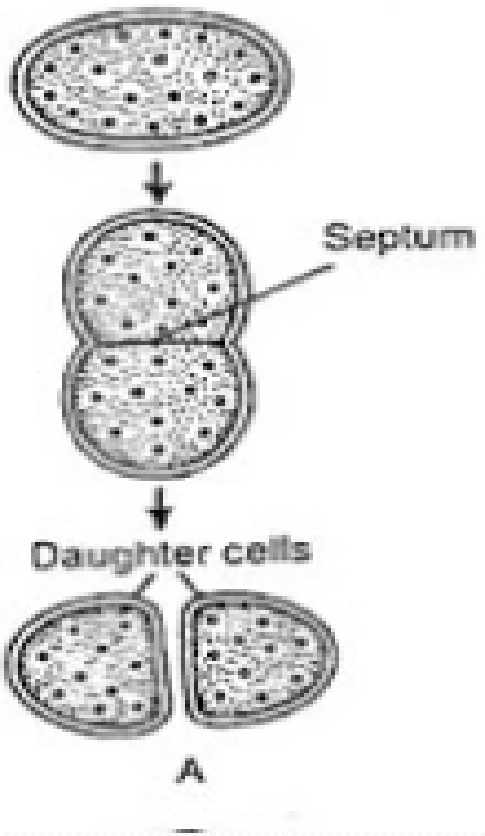
  (i) Binary fission,

  (ii) Fragmentation

  (iii) Hormogonia:

Reproduction of Cyanobacteria

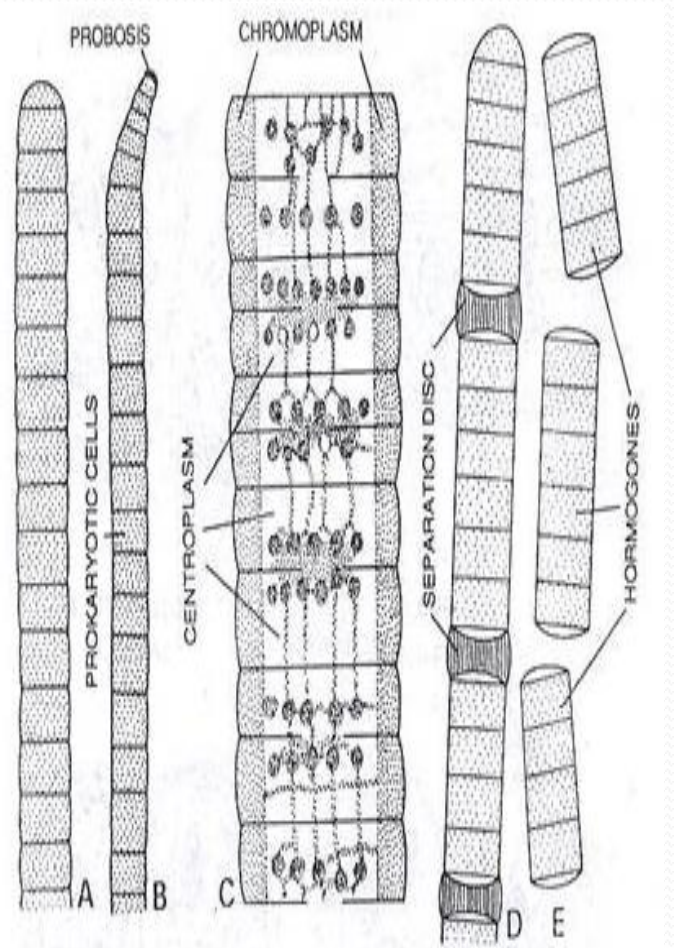
- **1- Vegetative reproduction** is generally in four ways:
- **(i) Binary fission**,
  - A cell divides into two in roughly equal halves. Nucleus divides mitotically first and then the cytoplasm. Each grows to original form. This is the most common type.



Reproduction of Cyanobacteria

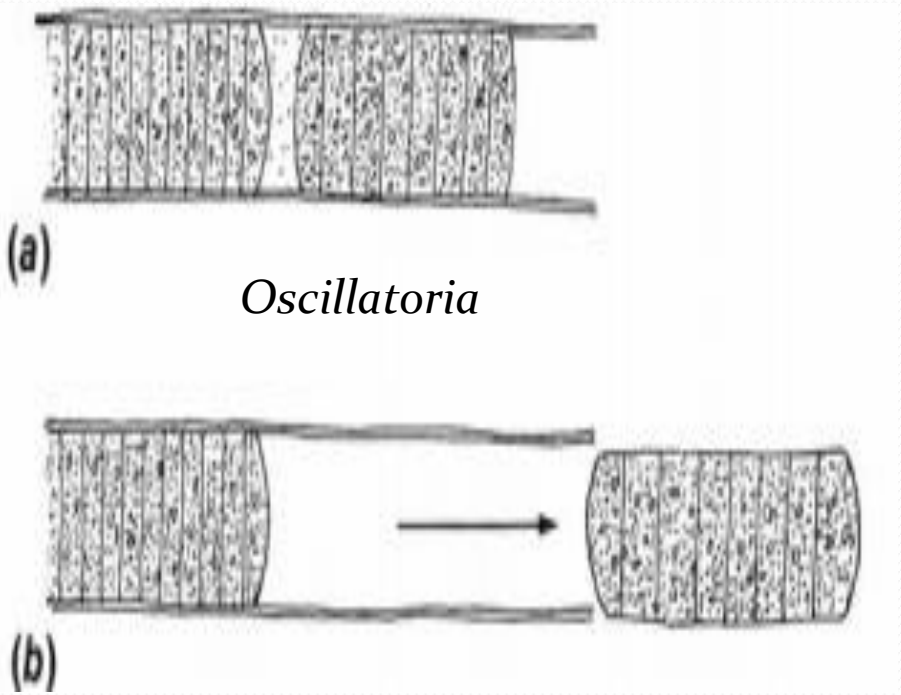
- **1- Vegetative reproduction** is generally in four ways:
  - **(ii) Fragmentation:**

  Filaments break into small pieces. Each piece grows into new filament. Mostly occurs in colonial forms.



anobacteria. *Oscillatoria* sp. Vegetative structure and vegetative reproduction. A, C
roboscidea; C, cell structure (detailed); D, formation of hormogones; E, hormogone

- **(iii) Hormogonia:**
  - Trichomes break up within the sheath into short segments called hormogonia or hormogones. Each segment grow into a new filament (e.g. in *Nostoc* and *Oscillatoria*).



Oscillatoria

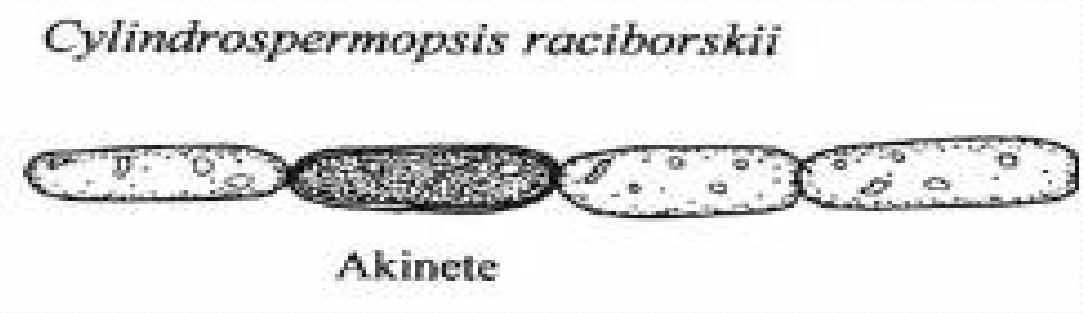
Nostoc

Asexual reproduction

- Cyanophyceae reproduce by non-motile, asexual spores as follows:-

1- Akinetes (resting spore):

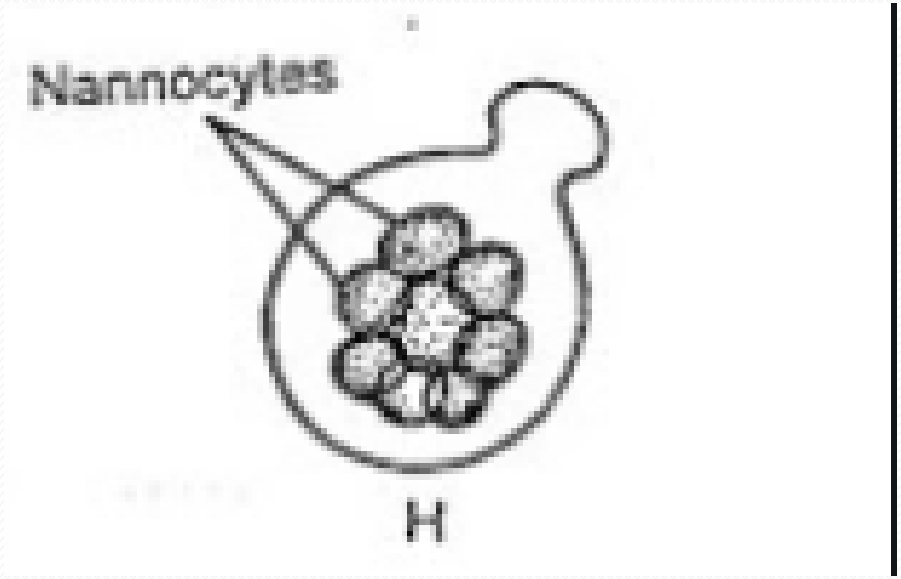
- Are found close to heterocysts.
- Cells increase in size and a thick layer is formed around them.
- Under favourable conditions, new filaments are formed from them, e.g. *Cylindrospermum*.



2-Nannocytes

In non-filamentous algae, like *Microcystis*, *Merismopedia*

- The repeated cell-division occur, forming numerous cells (naked protoplast) within the parent cell.
- They are extremely small as compared to vegetative cells. They germinate *in situ* to give rise to new typical colonies.



3- Spores

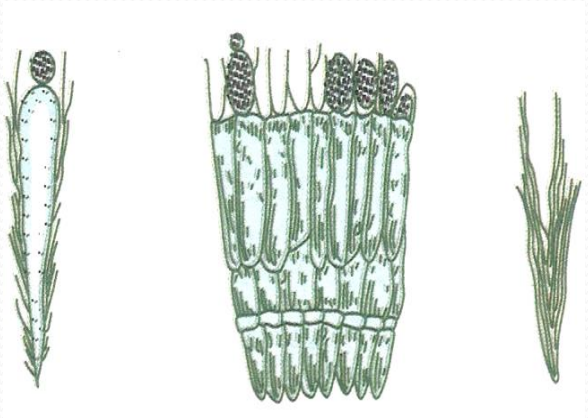
- The sporulation is the commonest type of asexual reproduction. Spores are of two types:-

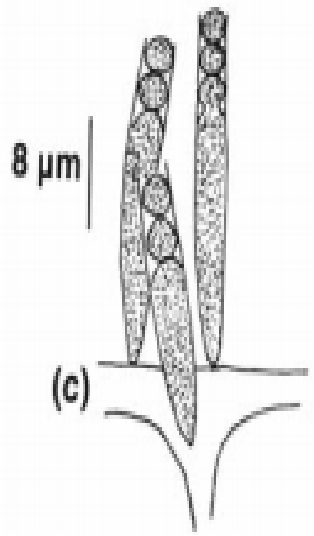
- **<u>Baeocytes (endospores)</u>:-**
- 1- Formed by coccoid (spherical) cyanobacteria.
- 2-The protoplasm divides several times in different planes without growth between successive divisions.
- 3- Smaller than the original cell.
- 4-Similar to bacterial endospores.
- 5-release through an apical pore after secreting a wall around it and enlarge to mature organisms,
- In *Dermocarpella*,

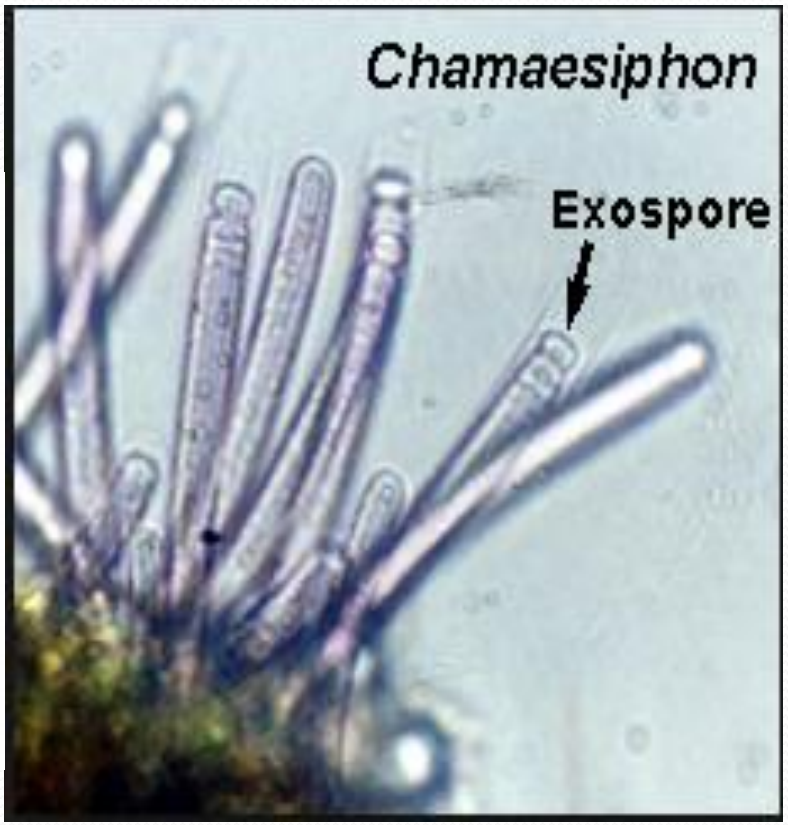
Baeocytes (endospores)

B- Exospore

- Spores are successively cut of at the distant end of the protoplast by transverse division.
- These are exospores. Each spore is surrounded by a delicate membrane, e.g. *Chamaesiphon*







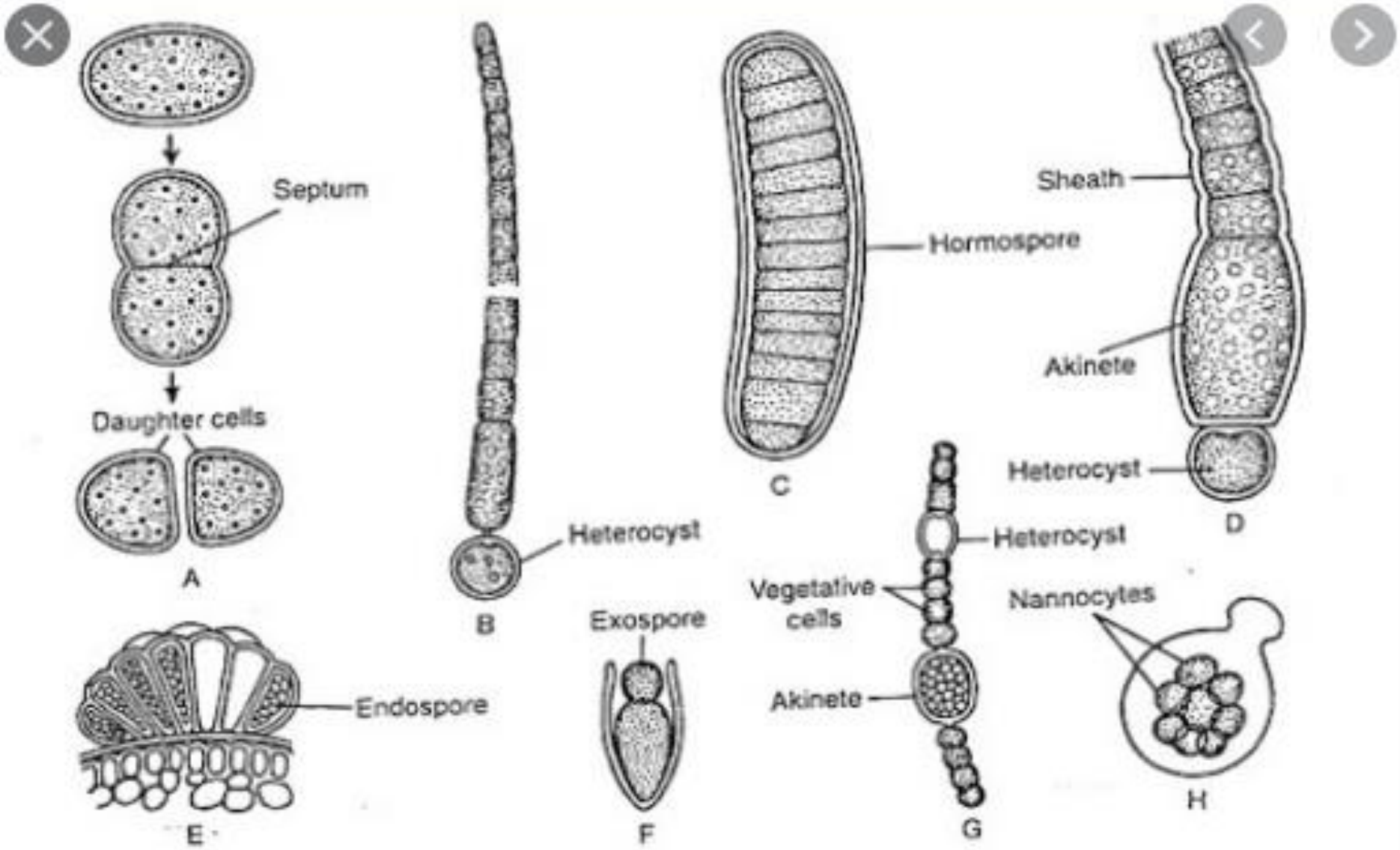


Fig. 3.27 : Vegetative and asexual reproduction in Cyanophyceae : A. Cell division (*Synechococcus* sp.), B. Fragmentation of filament (*Cylindrospermum muscicola*), C. Hormospore (*Westiella lanosa*), D. Akinete (*Gloeotrichia natans*). E Endospore (*Dermocarpa prasina*), F. Exospore (*Chamaesiphon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

Questions

1-Write short notes on the following :-

- - Habitats of Cyanobacteria
- - Classification of Cyanobacteria

2-What is the function of:-

- Carboxysomes
- Cyanophycin

3- Discuss

- **- Asexual reproduction Cyanobacteria**
- **- Cell structure in Cyanobacteria**
- Heterocysts development
- Akinete differentiation
- **Thallus Organization in Cyanobacteria**