Cyanobacteria

Structure and Characteristics

1. Prokaryotic Algal Cell Structure (Cyanobacteria)

Cyanobacteria are prokaryotic organisms with a distinct cell structure, divided into two main parts:

1. **Outer Cellular Covering**
2. **Cytoplasm**

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2. Outer Cellular Covering

A. Slime Layer or Mucilaginous Sheath

- A characteristic feature of cyanobacteria.
- Consists of fibrils arranged within a matrix for a homogeneous appearance.
- Composed of peptic acids and mucopolysaccharides.
- Retains absorbed water and protects against desiccation.

B. Cell Wall

- Located between the slime layer and plasma membrane.
- Rigid and structurally complex, similar to bacterial cell walls.
- Composed of **four layers** (Carr & Whitton, 1973):
  - **L I**: Transparent space between L II and plasma membrane.
  - **L II & L III**: Composed of mucopolymers (alanine, glucosamine, peptidoglycan, muramic acid, glutamic acid, α-diaminopimelic acid).
  - **L IV**: Wavy and made of liposaccharides and proteins.

C. Plasma Membrane

- Found below the cell wall.
- Composed of **protein-lipid-protein layers**.
- Sites of biochemical functions similar to mitochondria, ER, and Golgi bodies in eukaryotic cells.

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3. Cytoplasm of Cyanobacterial Cell

The cytoplasm is divided into:

1. **Chromoplasm** (Pigmented outer region)
2. **Centroplasm** (Colorless inner region)

A. Chromoplasm

- Contains **thylakoids/photosynthetic lamellae**, which house pigments:
  - **Chlorophyll a**
  - **Carotenoids**
  - **Phycobilins**: C-phycocyanin, allophycocyanin, C-phycoerythrin.
- Photosynthetic lamellae are arranged in parallel rows or distributed irregularly.
- Contains **granules (cyanosomes or phycobilisomes)**, which store phycobilin pigments.

B. Centroplasm

- Inner colorless region, often called **nucleoid or incipient nucleus**.
- Contains **DNA fibrils** (not surrounded by histone proteins).
- **Plasmids (transposons)** are present, similar to bacteria.
- Contains **70S ribosomes** for protein synthesis.

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4. The Cytoplasm

- Similar to bacterial cytoplasm.
- Lacks eukaryotic organelles (chloroplasts, mitochondria, ER, Golgi).
- Contains:
  - **Photosynthetic apparatus** (thylakoids).
  - **Ribosomes** (70S).
  - **Subcellular inclusions**:
    - Glycogen (α-granules)
    - Polyphosphate bodies
    - Polyhedral bodies
    - Cyanophycin granules
    - Genetic material (DNA)

(i) Photosynthetic Apparatus

- Contains **thylakoids or lamellae**, structurally complex.
- **Photosynthetic pigments**:
  - **Chlorophyll a** (primary pigment).
  - **β-carotene**.
  - **Accessory pigments (phycobiliproteins)**:
    - Phycocyanin (PC)
    - Allophycocyanin (AP)
    - Allophycocyanin-B (APB)
    - Phycoerythrin (PE)
- Thylakoids contain **phycobilisomes**, which trap light energy and funnel it to chlorophyll a.

- Pigments allow cyanobacteria to photosynthesize in deep waters.

(ii) Ribosomes

- Sites of **protein synthesis**.
- Identical to bacterial **70S ribosomes**.

(iii) Glycogen (α-Granules)

- Stores **excess photosynthetic products**.
- Used for energy during low CO_2 availability or darkness.

(iv) Polyphosphate Bodies

- Spherical structures of high molecular weight **polyphosphates**.
- Also called **metachromatin or volutin granules**.
- Serve as **phosphate storage**, used during phosphate scarcity.
- Develop in cyanobacteria from **phosphate-rich environments**.

(v) Polyhedral Bodies

- Store **RUBP carboxylase enzyme**, used in carbon fixation.

(vi) Cyanophycin Granules

- Found in **nitrogen-rich environments**.
- Composed of **arginine and aspartic acid**.

(vii) Genetic Material

- **Naked DNA fibrils**, dispersed in the **central cytoplasm**.
- No **membrane-bound nucleus**.
- **Genome copies** per cell vary (e.g., Agmenellum has 2–3 copies).
- **Molecular weight** ranges from **2.7 to 7.5 × 10⁹ daltons**.

(viii) Plasmids

- Naturally occurring **cryptic plasmids**.
- **Circular DNA** structure.
- Function largely unknown but **genetic transfer** has been observed.

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5. Chromatic Adaptation (Gaidukov Phenomenon)

- Discovered by **Gaidukov (1902) in Oscillatoria sancta**.
- Also called **complementary-chromatic adaptation**.
- Cyanobacteria **alter pigmentation** based on **light wavelength**:

  - **Red light** → Increased **phycocyanin** (blue-green).
  - **Green light** → Increased **phycoerythrin** (red).
- Wavelength effects:
  - **540 nm (green light)** → Induces phycoerythrin synthesis.
  - **650 nm (red light)** → Reverses phycoerythrin synthesis.
- Controlled **genetically** via **adaptochromes** (photoreceptive pigments).
- Allows cyanobacteria to **adjust to light conditions** in their environment.