8.9A: Cyanobacteria

LEARNING OBJECTIVES

Describe the characteristics associated with Cyanobacteria including: cell types, forms of motility and metabolic properties

- Explain the following laws within the Ideal Gas Law

Cyanobacteria, also known as blue-green bacteria, blue-green algae, and Cyanophyta, is a phylum of bacteria that obtain their energy through photosynthesis. The ability of cyanobacteria to perform oxygenic photosynthesis is thought to have converted the early reducing atmosphere into an oxidizing one, which dramatically changed the composition of life forms on Earth by stimulating biodiversity and leading to the near-extinction of oxygen-intolerant organisms. According to the endosymbiotic theory, chloroplasts in plants and eukaryotic algae have evolved from cyanobacterial ancestors via endosymbiosis.

DISTRIBUTION AND EFFECT ON ECOSYSTEMS

Cyanobacteria can be found in almost every terrestrial and aquatic habitat. Aquatic cyanobacteria are probably best known for the extensive and visible blooms that can form in both freshwater and the marine environment. These can have the appearance of blue-green paint or scum. The association of toxicity with such blooms has frequently led to the closure of recreational waters when blooms are observed. Cyanobacteria include unicellular and colonial species. Colonies may form filaments, sheets, or even hollow balls. Some filamentous colonies show the ability to differentiate into several different cell types, including:

- Vegetative cells, the normal, photosynthetic cells that are formed under favorable growing conditions.
- Akinetes, the climate-resistant spores that may form when environmental conditions become harsh.
• Thick-walled heterocysts, which contain the enzyme nitrogenase, vital for nitrogen fixation. Heterocysts may also form under the appropriate environmental conditions (anoxic) when fixed nitrogen is scarce.

Heterocyst-forming species are specialized for nitrogen fixation and are able to bind nitrogen gas to ammonia (NH₃), nitrites (NO⁻₂) or nitrates (NO⁻₃). These molecules can be absorbed by plants and converted into protein and nucleic acids.

Figure: Cyanobacteria: Cyanobacteria, also known as blue-green bacteria, blue-green algae, and Cyanophyta, is a phylum of bacteria that obtain their energy through photosynthesis

Figure: Blue-green algae cultured in specific media: Cyanobacteria cultured in specific media. Cyanobacteria can be helpful in agriculture as they have the capability to fix atmospheric nitrogen to soil.

Hormogonia

Many cyanobacteria form motile filaments called hormogonia, that travel from the main biomass to bud and form new colonies elsewhere. The cells in a hormogonium are often thinner than those found in the vegetative state, and the cells
on either end of the motile chain may be tapered. To break away from the parent colony, a hormogonium often must tear a weaker filament cell, called a necridium.

### CYANOBACTERIUM CELLS AND MOTILITY

Individual cells of a cyanobacterium typically have a thick, gelatinous cell wall. They lack flagella, but hormogonia and some species may move about by gliding along surfaces. Many of the multi-cellular filamentous forms of Oscillatoria are capable of a waving motion; the filament oscillates back and forth. In water columns some cyanobacteria float by forming gas vesicles, like in archaea. These vesicles are not organelles as such. They are not bounded by lipid membranes but by a protein sheath.

### PHOTOSYNTHESIS AND OTHER METABOLIC PROCESSES

Cyanobacteria use the energy of sunlight to drive photosynthesis, a process where the energy of light is used to split water molecules into oxygen, protons, and electrons. As with any prokaryotic organism, cyanobacter does not show nuclei nor internal membranes; many cyanobacter species have folds on their external membranes which function in photosynthesis. Cyanobacteria get their color from the bluish pigment phycocyanin, which they use to capture light for photosynthesis.

Photosynthesis in cyanobacteria generally uses water as an electron donor and produces oxygen as a by-product, though some species may also use hydrogen sulfide as occurs among other photosynthetic bacteria. Carbon dioxide is reduced to form carbohydrates via the Calvin cycle. In most forms the photosynthetic machinery is embedded into folds of the cell membrane, called thylakoids.

Because of their ability to fix nitrogen in aerobic conditions they are often found in symbiotic partnerships with a number of other groups of organisms, including but not limited to fungi (lichens), corals, pteridophytes (Azolla), and angiosperms (Gunnera).

Many cyanobacteria are able to reduce ambient levels of nitrogen and carbon dioxide under aerobic conditions, a fact that may be responsible for their evolutionary and ecological success. The water-oxidizing photosynthesis is accomplished by coupling the activity of photosystem (PS) II and I (Z-scheme). In anaerobic conditions, they are also able to use only PS I—cyclic photophosphorylation—with electron donors other than water (for example hydrogen sulfide), in the same way as the purple photosynthetic bacteria.

They also share an archaeal property, the ability to reduce elemental sulfur by anaerobic respiration in the dark. Their photosynthetic electron transport shares the same compartment as the components of respiratory electron transport. Their plasma membrane contains only components of the respiratory chain, while the thylakoid membrane hosts both respiratory and photosynthetic electron transport.

### Classification

The cyanobacteria were traditionally classified by morphology into five sections, referred to by the numerals I-V. The first three—Chroococcales, Pleurocapsales, and Oscillatoriales—are not supported by phylogenetic studies. However, the
latter two—Nostocales and Stigonematales—are monophyletic, and make up the heterocystous cyanobacteria. Some cyanobacteria produce toxins, called cyanotoxins. This results in algal blooms, which can become harmful to other species including humans if the cyanobacteria involved produce toxins.

Key Points

- Cyanobacteria can be found in almost every terrestrial and aquatic habitat.
- Cyanobacteria include unicellular and colonial species.
- Cyanobacteria use the energy of sunlight to drive photosynthesis, a process where the energy of light is used to split water molecules into oxygen, protons, and electrons.
- Many cyanobacteria are able to reduce nitrogen and carbon dioxide under aerobic conditions, which may be responsible for their evolutionary and ecological success.

Key Terms

- cyanobacteria: Cyanobacteria, also known as blue-green bacteria, blue-green algae, and Cyanophyta, is a phylum of bacteria that obtain their energy through photosynthesis.
- photosynthesis: The process by which plants and other photoautotrophs generate carbohydrates and oxygen from carbon dioxide, water, and light energy in chloroplasts.
- heterocyst: A specialized nitrogen-fixing cell formed by some filamentous cyanobacteria.