

Big Picture

Prokaryotes are divided into two domains: Archaea and Bacteria. Archaea and Bacteria have two different evolutionary histories. Nevertheless, Archaea and Bacteria share some fundamental similarities that make them prokaryotes and not eukaryotes. Prokaryotes tend to be much smaller than eukaryotic cells, lack membrane-bound organelles, and have only one circular DNA molecule. Prokaryotes also inhabit some of the most extreme environments on Earth. Most prokaryotes are chemoheterotrophs, getting their energy and carbon from other organisms. Prokaryotes, though small and inconspicuous, play extremely important roles in our lives and in the greater ecosystem!

Key Terms

Bacteria: One of two domains for prokaryotes, includes some organisms that cause human diseases.

Cyanobacteria: A phylum of bacteria that obtain energy through photosynthesis.

Gram Staining: A way to classify bacteria based on the ability to retain a purple dye.

Gram-Positive Bacteria: Bacteria able to retain the dye.

Gram-Negative Bacteria: Bacteria do not retain the dye.

Archaea: One of two domains for prokaryotes that includes organisms living in extreme environments.

Extremophile: Any type of Archaea that lives in an extreme environment, such as a very salty, hot, or acidic environment.

Plasmid: Small, circular piece of DNA in prokaryotic cell.

Flagella: Tail-like structures that protrude from the plasma membrane of some prokaryotes.

Endospore: A spore that forms inside prokaryotic cells when under stress.

Genetic Transfer: How prokaryotic cells acquire new genetic material and thus increase the genetic variation in the population.

Bacteria

Bacteria is a domain of single-celled prokaryotes.

- Inhabit many diverse habitats, from the human intestine to acidic hot springs
- The most abundant organisms on Earth
- Did you know there are more bacteria in your body than actual cells?

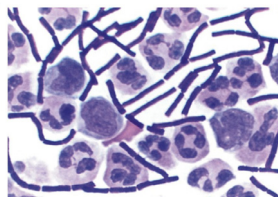
Cyanobacteria are very important bacteria that undergo photosynthesis and release oxygen into the atmosphere

- Thought to be responsible for changing the atmosphere of early Earth by adding oxygen
- Photosynthesis in these species occurs within a system of internal membranes
- Called *cyanobacteria* because the chlorophyll make the bacteria bluish green (*cyan*) in color



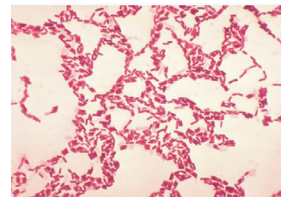
Gram Staining

Gram staining is one method used to classify bacteria. Bacteria are differentiated into **Gram-positive** and **Gram-negative** based on the ability to retain a purple dye. The ability to retain the dye depends on the type of cell wall and outer membrane the bacterium has.



Gram-positive bacteria stains purple with Gram stain. This is because they have a thick cell wall without an outer membrane. Example: Cyanobacteria

Image credit: JA Jernigan *et al.*/Centers for Disease Control and Prevention, Public Domain



Gram-negative bacteria stains red with Gram stain. This is because they have a thin cell wall with an outer membrane. Example: *Salmonella*

Image credit: William A. Clark/Centers for Disease Control and Prevention, Public Domain

Archaea

Archaea is the second domain of single-celled prokaryotes.

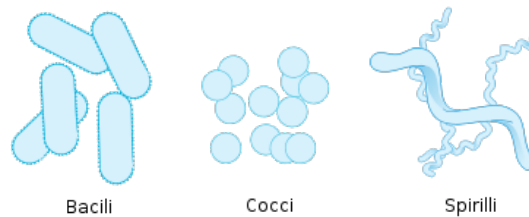
- Differ from bacteria in the evolutionary history, possessing traits unique from both domains Bacteria and Eukaryota
- Can be found in bodies of humans, although none are known with certainty to cause diseases
- Many Archaea are **extremophiles** (lovers of extremes)
- Can be found in unusually hot, acidic, or very salty environments

PROKARYOTES CONT.

Prokaryotic Structure

Prokaryotic cells can be distinguished by shape. The three most common shapes are helical (Spirilli), spherical (Cocci), and rod-shaped (Bacilli).

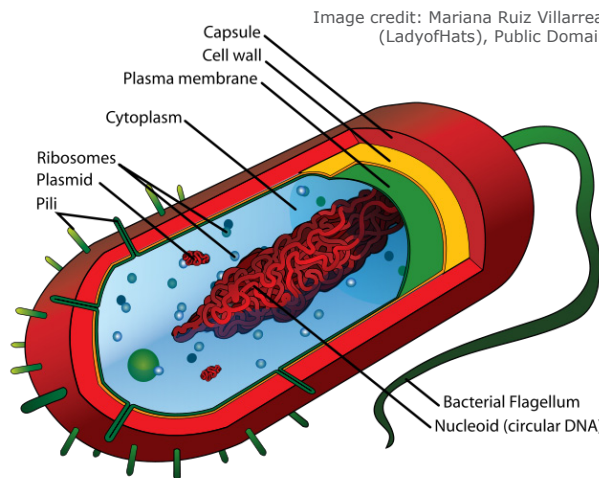
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Prokaryotic structures include:

- **Plasma membrane:** Like all other cells, prokaryotic cells have a selectively-permeable plasma membrane. It controls the movement of solutes into and out of the cell.
- **Cell wall:** The cell wall surrounds the plasma membrane and, like in plant cells, affords the prokaryotic cell more protection.
- **Cytoplasm:** The fluid inside the cell where cellular structures are found and where metabolic reactions take place.
- **Cellular structures:** Although prokaryotic cells lack organelles, the cells still have several cellular structures, such as ribosomes, a cytoskeleton, and a **plasmid**.
 - Many prokaryotic cells have small, circular accessory molecules of DNA known as plasmids. Plasmids usually contain helpful if not crucial genes.
- **Capsule:** An extra layer outside of the cell wall, which affords the cell greater protection and the ability to adhere to other surfaces.
 - The capsule allows a colony of prokaryotic cells to stick to each other on a given surface, such as shower walls and pebbles, and form a biofilm.
- **Flagella:** Used for movement; they are made up of protein.

Image credit: Mariana Ruiz Villarreal (LadyofHats), Public Domain



Endospores

Endospores are special structures that form when a prokaryote is under stress. These spores are tough structures that enclose the DNA and protect it. The prokaryote enters a dormant state that help the cell survive for long periods of time.

Prokaryotic Reproduction

Prokaryotes reproduce by binary fission, a type of asexual reproduction in which a parent divides into two genetically identical daughter cells. Binary fission begins with the duplication of the genetic material (chromosome and plasmids) and is followed by cytokinesis, the division of the cytoplasm.

Since the parent and offspring are exactly the same in binary fission, there is no genetic variation. This would increase the risk of extinction.

Prokaryotes increase genetic variation by **genetic transfer**. The cells can take up foreign DNA in the environment or directly exchange plasmid with other prokaryotic cells.

Notes

Role in the World

One really important role bacteria play in the ecosystem is as decomposers. They recycle organic compounds back into inorganic compounds and basic nutrients.

Bacteria also produce important products that have significant implications for human health. For example, bacteria make antibiotics and vaccines along with ethanol and certain enzymes.

Bacteria also lay at the root of many familiar diseases, for example, tetanus and food poisoning. One way people try to fight off bacterial infections is through the use of *antibiotics*. However, the overuse and misuse of antibiotic drugs has also led to *antibiotic resistance*, or the evolution of antibiotic-resistant bacteria.