General Microbiology

Unit 3

Different between prokaryotes and Eukaryotes

	Prokaryotes	Eukaryotes
Type of Cell	Always unicellular	Unicellular and multi-cellular
Cell size	Ranges in size from 0.2 µm – 2.0 µm in diameter	Size ranges from 10 µm – 100 µm in diameter
Cell wall	Usually present; chemically complex in nature	When present, chemically simple in nature
Nucleus	Absent. Instead, they have a nucleoid region in the cell	Present
Ribosomes	Present. Smaller in size and spherical in shape	Present. Comparatively larger in size and linear in shape
DNA arrangement	Circular	Linear
Mitochondria	Absent	Present

Ultra structure of prokaryotic cell

- Structure of Prokaryotic cells- A prokaryotic cell is much simpler and smaller than eukaryotic cells. It lacks membrane bound organelles, including the nucleus.

Prokaryotic cell

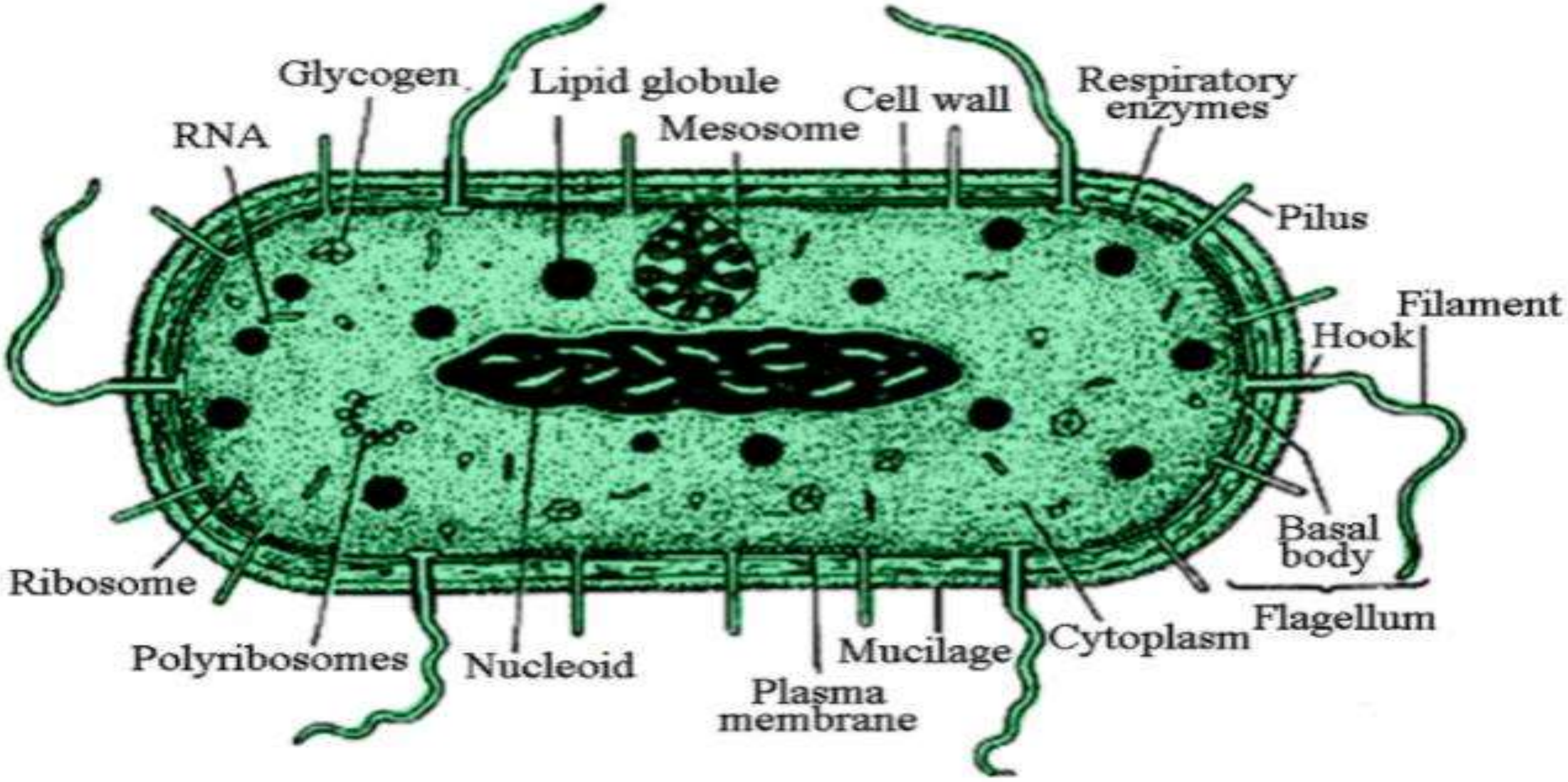


Fig: Ultrastructure of bacterial cell.

Structure

- 1. Outer Flagella: A flagellum attached to the bacterial capsule is a central feature of most of the prokaryotic cell especially motile bacteria. It provides motion or locomotion to the bacteria and be responsible for chemotaxsis of bacteria. Movement of bacteria towards a chemical gradient (such as glucose) is known as chemotaxsis. Flagellum is a part of cell wall and its motion is regulated by motor protein present inside the cell. Flagellar motion is an energy consuming process and governed by ATPase present at the bottom of the shaft. It is made up of protein flagellin and reduction or suppression of flagellar protein reduces bacterial infectivity (pathogenicity) and ability to grow.

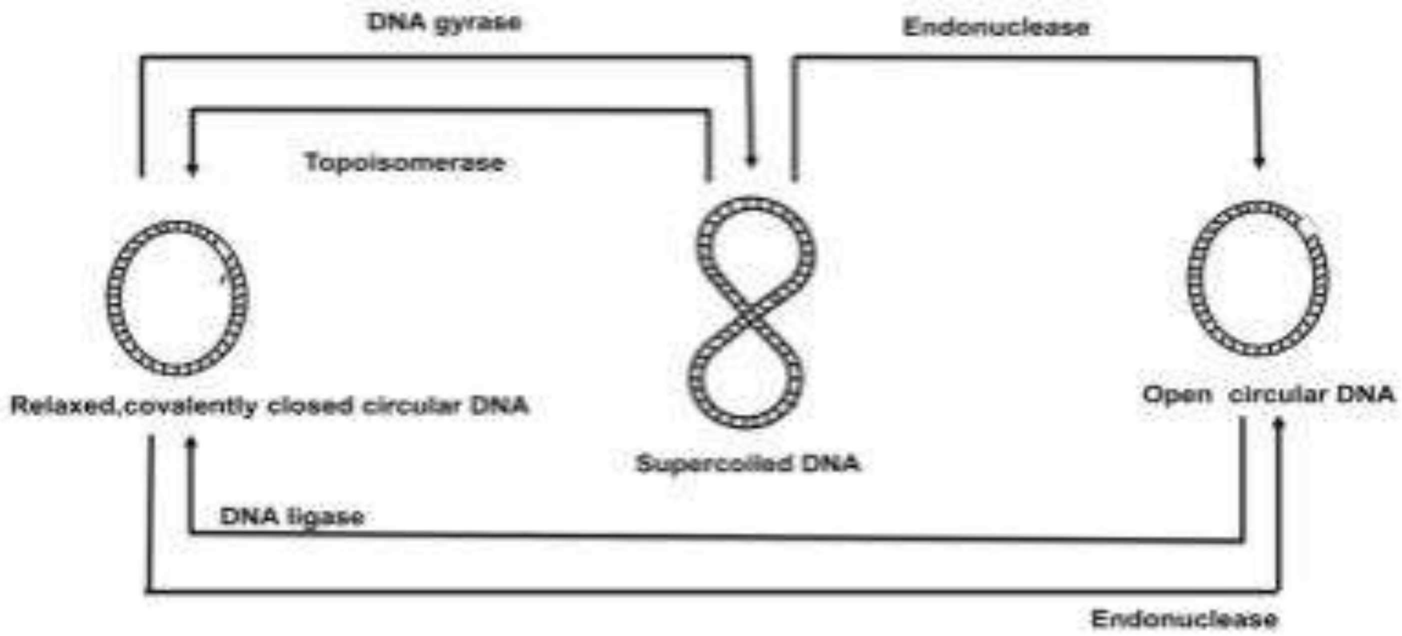
2. Bacterial surface layers:

- Bacteria posses 3 anatomical barriers to protect the cells from external damage.
- Bacterial capsule is the outer most layer and made up of high molecular weight polysaccharides. It is impermeable to the water or other aqueous solvent and it is responsible for antigenicity of bacterial cells.
- Cell wall in bacteria and its response to gram staining is the basis of classification of bacterial species.

- 3.Cell wall composition in gram-ve and gram +ve bacteria is different. Bacterial cell wall has different constituents and be responsible for their reactivity towards gram stain.
- A. Peptidoglycan layer: peptidoglycan layer is thick in gram +ve bacteria and thin in gram –ve bacteria.
- B. Lipoteichoic acids: Lipoteichoic acid (LTA) are only found in gram +ve bacteria cell wall and it is an important antigenic determinant.
- C. Lipopolysaccharides (LPS)- Lipopolysaccharides (LPS) are found only in gram –ve bacterial cell wall and it is an important antigenic determinant.

- Cytosol and other organelles-Prokaryotic cells do not contains any membrane bound organelle. The organelles are present in cytosol such as ribosome (70S), genetic material where as electron transport chain complexes are embedded within the plasma membrane.
- 4. Chromosome and extra chromosomal DNA-Prokaryote cell contains genetic material in the form of circular DNA, known as “bacterial chromosome”. It contains genetic elements for replication, transcription and translation. Bacterial chromosome follows a rolling circle mode of DNA replication. The genes present on chromosome does not contains non coding region (introns) and it is co-translated to protein. Besides main circle DNA, bacteria also contains extra circular DNA known as “plasmid”.

- Bacterial Plasmid: Plasmid are widely been used for cloning of foreign DNA into the bacteria as host strain. Before getting into the details of discussing bacterial plasmid we will discuss the basic properties of plasmids.



- Prokaryotic flagella are whip-like structures that extend from the cell surface and enable the cell to move through its environment.
- Prokaryotic flagella rotate like propellers, allowing the cell to move forward, backward, and even tumble. The direction of rotation is controlled by the cell and can be used to navigate towards or away from stimuli such as nutrients or toxins.
-
- Types of Flagellar Arrangements:
-
- Monotrichous: A single flagellum at one end of the cell.
- Lophotrichous: A tuft of flagella at one or both ends of the cell.
- Amphitrichous: A single flagellum at each end of the cell.
- Peritrichous: Flagella distributed over the entire surface of the cell.

- Pili are hair-like structures found on the surface of many prokaryotic cells, particularly bacteria. They are distinct from flagella, which are primarily involved in cell movement.
- Functions of Pili:
- Attachment: Pili help bacteria adhere to surfaces, including host cells, medical implants, and other bacteria. This attachment is crucial for colonization and the formation of biofilms.
- ….. Conjugation: Some types of pili, known as sex pili or F pili, play a role in bacterial conjugation, a process of horizontal gene transfer where genetic material is exchanged between bacteria.
- Motility: Certain types of pili, such as type IV pili, can also contribute to bacterial movement, although this function is less common than flagellar movement.

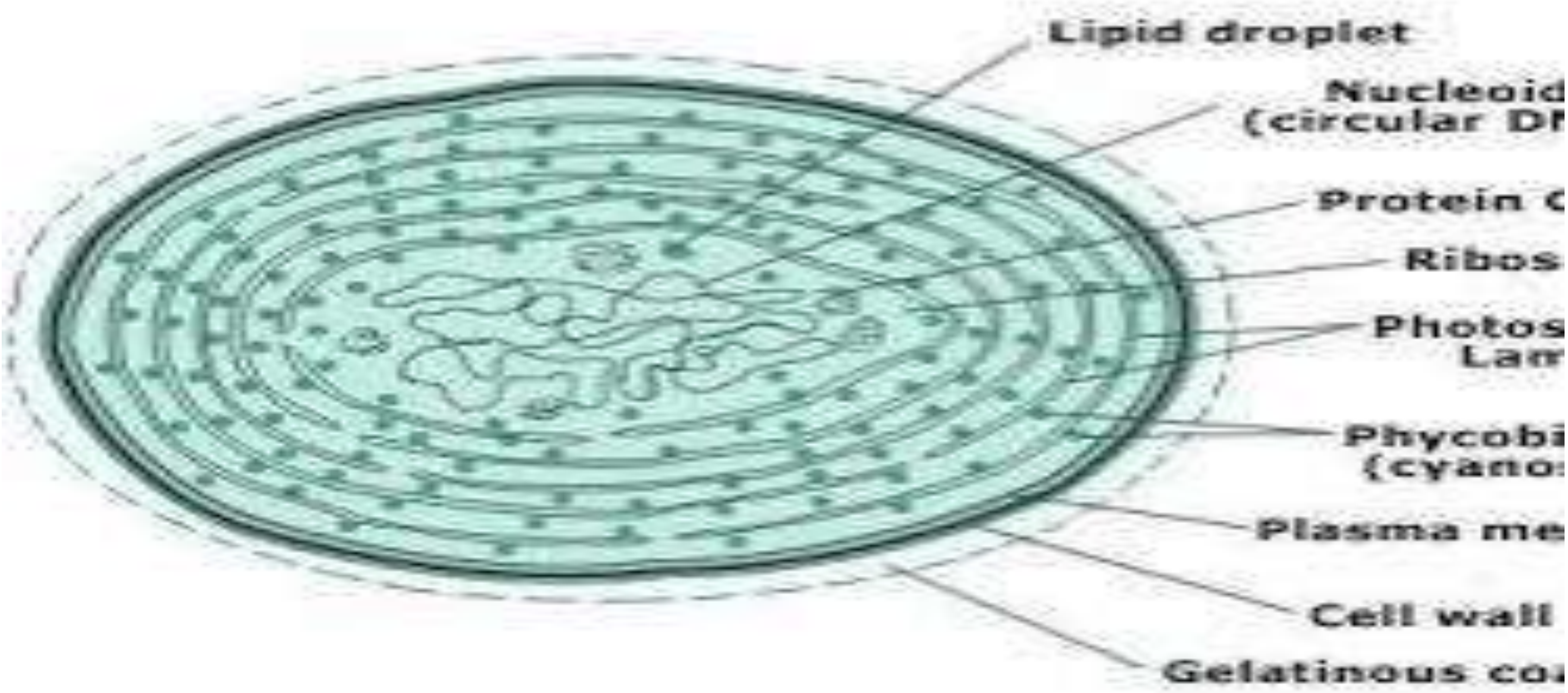
- Types of Pili:
- Type I pili: These are common in Gram-negative bacteria and are involved in adhesion to host cells.
- Type IV pili: These are more diverse in function and can be involved in attachment, motility, and DNA uptake.
- Sex pili (F pili): These are specialized pili involved in bacterial conjugation.

- Gas vesicles, also known as gas vacuoles, are unique, gas-filled structures found in certain prokaryotes, primarily aquatic bacteria and archaea. They provide buoyancy, allowing these microorganisms to control their vertical position in the water column.
- Structure and Function:
- Composition: Gas vesicles are composed entirely of protein; no lipids or carbohydrates have been detected. The protein shell is rigid and impermeable to water, but permeable to gases.
- Shape: They typically have a cylindrical shape with conical end caps.

- Buoyancy: The gas vesicles fill with gas (primarily air), making the cell less dense than the surrounding water. This reduced density allows the cell to float upwards.
- Light and Nutrient Acquisition: Many photosynthetic prokaryotes, like cyanobacteria, use gas vesicles to rise towards the water surface to maximize light exposure for photosynthesis. Similarly, some bacteria use gas vesicles to reach nutrient-rich zones at different depths.

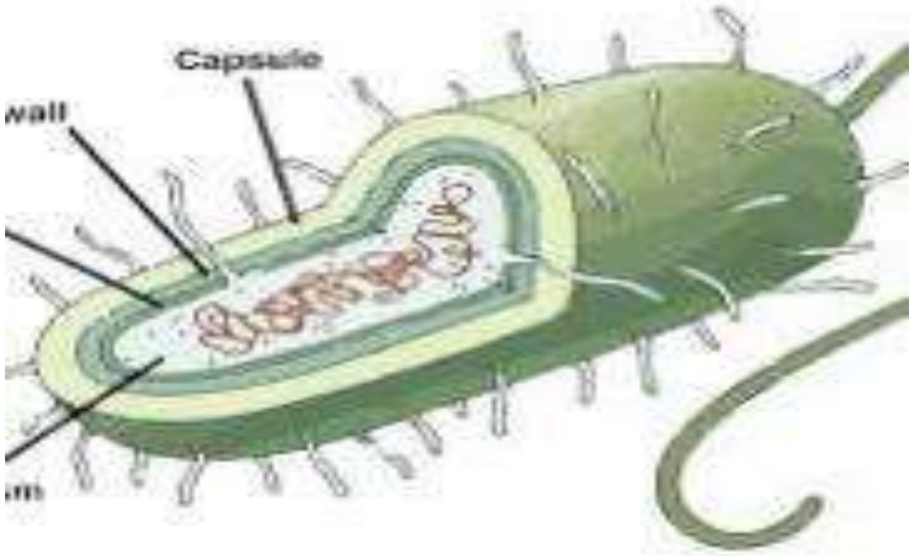
- Carboxysomes are remarkable protein-based structures found within prokaryotic cells, primarily in bacteria and archaea that perform carbon fixation. They are essentially microcompartments that encapsulate the key enzyme for carbon fixation, RuBisCO, along with other associated enzymes.
- Phycobilisomes are large, intricate protein complexes found in certain prokaryotes, particularly cyanobacteria and red algae. They function as light-harvesting antennae, efficiently capturing light energy and transferring it to the photosynthetic reaction centers.

Phycobilisomes



Capsule

- A capsule is a well-organized, distinct layer of material that surrounds the cell wall of many bacteria. It's essentially a protective covering that provides several key advantages to the bacterial cell.
- Composition:
- Primarily composed of polysaccharides .
- Can also contain proteins or other substances.



- Functions:
- Protection:
- Desiccation (drying out): The capsule helps retain moisture, preventing the cell from drying out.
- Phagocytosis: Capsules can hinder the engulfment of bacteria by immune cells (phagocytes), making it harder for the host’s immune system to eliminate the infection.
- Toxic chemicals: The capsule can shield the bacterium from harmful chemicals in the environment.

Property of capsule

- Adhesion: The capsule’s sticky nature allows bacteria to adhere to surfaces, including:
- Other bacteria, forming biofilms
- Host tissues, facilitating colonization and infection
- Inanimate objects
- Virulence: In many pathogenic bacteria, the capsule is a key virulence factor, contributing significantly to their ability to cause disease.

- Reserve Food Materials:
-
- Glycogen: A complex carbohydrate similar to starch in plants. It serves as a readily available energy source.
- Polyhydroxybutyrate (PHB): A type of lipid that can be broken down to provide both energy and carbon.
- Sulfur globules: Some sulfur-oxidizing bacteria store elemental sulfur as an energy reserve.
- Polyphosphate granules: These granules store inorganic phosphate, which can be used for various cellular processes, including energy production and nucleic acid synthesis.

- Inclusion bodies are distinct structures within the cytoplasm where reserve food materials are stored. They may be surrounded by a thin membrane or lack a membrane altogether.

. Significance:

Energy Storage: Reserve food materials provide a readily available energy source for the cell, allowing it to survive periods of nutrient scarcity.

Carbon Source: Some reserve materials, like PHB, can also serve as a source of carbon for cellular biosynthesis.

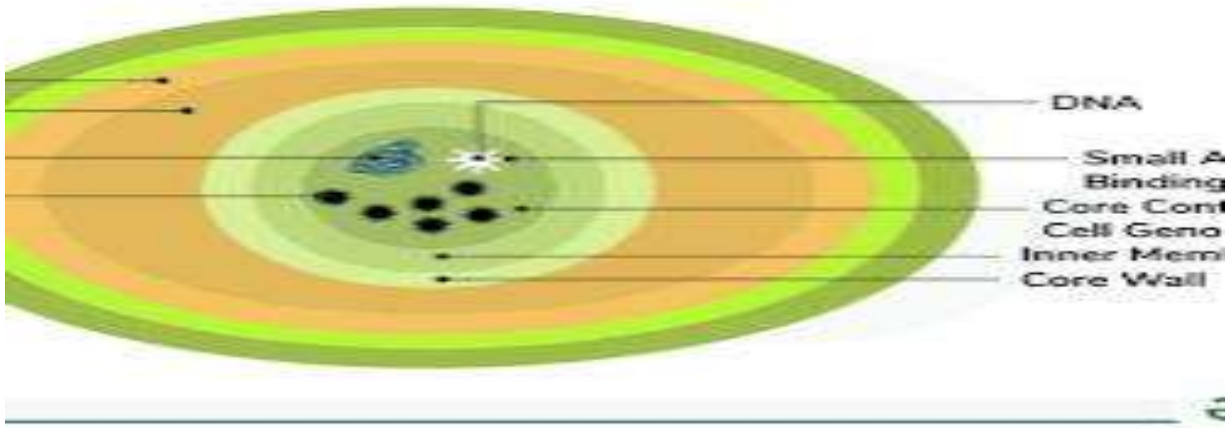
Metabolic Flexibility: The ability to store and utilize different types of reserve food materials provides prokaryotes with metabolic flexibility, enabling them to adapt to various environmental conditions.

Endospores structure and function

- Endospores are highly specialized structures formed by certain bacteria, primarily those belonging to the genera Bacillus and Clostridium. They are not present in all prokaryotic cells, but only in those that have the genetic capacity to produce them.
- . Structure:
- Core:
-
- The innermost part of the endospore, containing the bacterium’s essential genetic material (DNA) and a small amount of cytoplasm.
- Contains high levels of calcium dipicolinate, which plays a crucial role in heat resistance.
- Also contains small, acid-soluble proteins (SASPs) that bind to and protect the DNA.

- Core Wall:
- A thin layer of peptidoglycan that surrounds the core.
- Cortex:
- A thick layer of peptidoglycan located beneath the spore coat.
- Its unique structure contributes to the dehydration of the core, which is essential for heat resistance.
- Spore Coat:
- A thick, multilayered protein coat that provides significant resistance to chemicals and enzymes.
- It is the primary barrier against harsh environmental conditions.

- Exosporium:
-
- A thin, delicate outer covering made of protein.
- May play a role in spore germination or attachment to surfaces.
- .

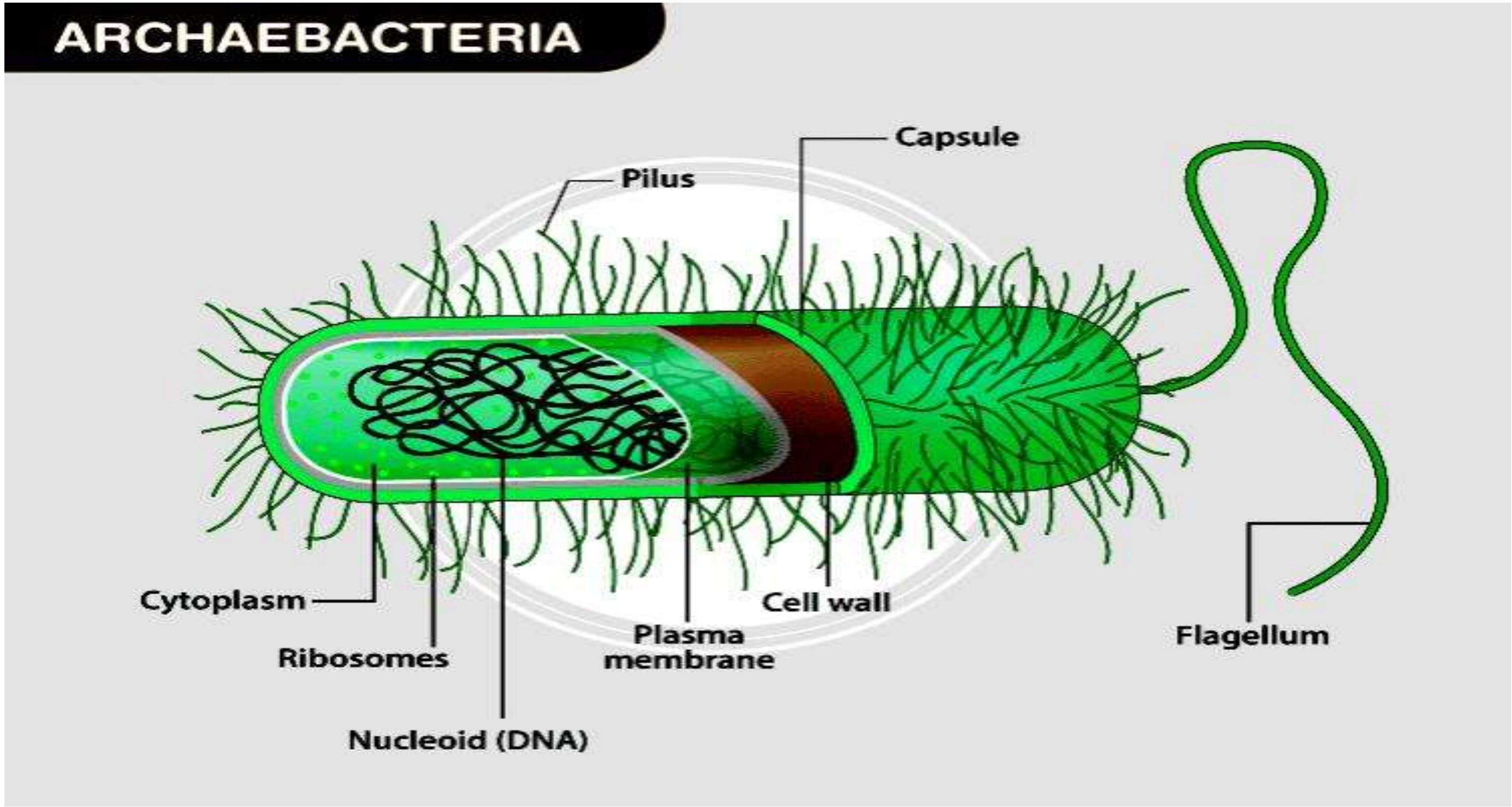


Archaebacteria

- Distinct Domain: Archaea are a unique domain of life, separate from Bacteria and Eukarya.
- Prokaryotes: They are single-celled organisms lacking a true nucleus.
- Extremophiles: Many archaea thrive in extreme environments like hot springs, deep-sea vents, and highly salty conditions.
- Unique Cell Wall: Their cell walls lack peptidoglycan, a key component of bacterial cell walls.

- Diverse Lipids: Their cell membranes contain unique lipids not found in other organisms.
- Methanogens: Some archaea produce methane as a byproduct of their metabolism.
- Halophiles: Some thrive in extremely salty environments.
- Thermophiles: Some thrive in high temperatures.
- Acidophiles: Some thrive in highly acidic environments.
- Ecological Importance: Play crucial roles in nutrient cycling and contribute to the global carbon cycle.

Structure of Archaebacteria



- Cell Wall:
- Unique Composition: Unlike bacteria, which have cell walls made of peptidoglycan, archaea have diverse cell wall compositions. Some lack a traditional cell wall altogether, while others have walls made of proteins or pseudomurein (a peptidoglycan-like substance).
- S-Layer: Many archaea possess an S-layer, a rigid outermost layer composed of interlocking protein subunits. This layer provides structural support and protection.

- Cell Membrane:
- Lipid Composition: Archaea have unique lipids in their cell membranes. These lipids have isoprene chains instead of fatty acids, and the linkage between the glycerol backbone and the lipid chains is an ether bond rather than an ester bond found in bacteria and eukaryotes. This unique lipid composition allows archaea to thrive in extreme environments.

- Cytoplasm:
-
- No Membrane-Bound Organelles: Like bacteria, archaea lack membrane-bound organelles such as a nucleus, mitochondria, chloroplasts, endoplasmic reticulum, and Golgi apparatus. Their genetic material (DNA) is typically a single circular chromosome located in the cytoplasm.
- Ribosomes: Archaea have ribosomes, but their structure and composition differ from those of bacteria and eukaryotes.

- Flagella:
-
- Unique Structure: Some archaea have flagella for motility, but their structure and mechanism of movement differ from bacterial flagella. Archaeal flagella are simpler and thinner.
- 5. Other Features:
- Pili and Fimbriae: Some archaea have pili and fimbriae, which are hair-like structures involved in attachment to surfaces and other cells.
- Capsules and Slime Layers: Some archaea may have a capsule or slime layer outside the cell wall, providing additional protection and aiding in attachment.