Bacterial cell: structure and function

The fundamental structural and functional component of every known living thing is the cell. It's the smallest unit of life that can be called a living thing; it's often referred to as the building block of life. Humans are multicellular, with an estimated 100 trillion or 10 14 cells, a typical cell mass of 1 nanogram, and most bacteria are unicellular, or composed of a single cell.

Prokaryotic cells (such as bacteria and viruses) and eukaryotic cells (such as plant and animal cells) make up the majority of cells.

Bacteria are unicellular, prokaryotic organisms lacking chlorophyll.

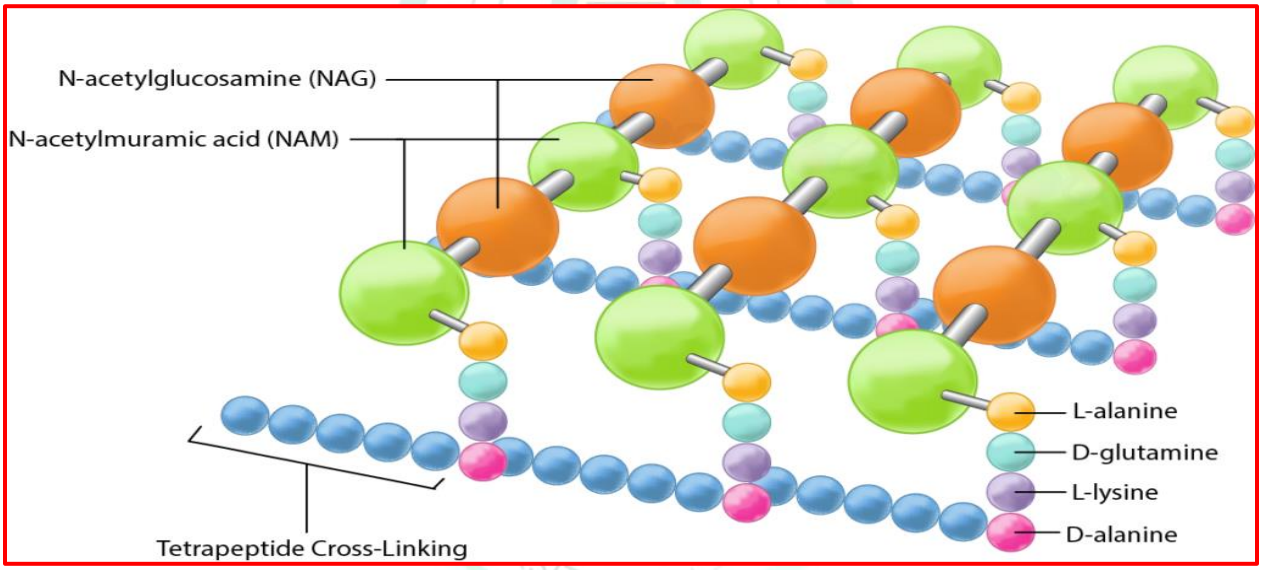
Bacteria can have diameters of 0.2–1.5 micrometers and lengths of 3-5 micrometer

Three categories exist for the organization of bacterial structure.

- Internal Structures: Cytoplasm, nucleoid, bacterial chromosome, plasmid ribosomes, endospores and storage granules
- Cell envelope: cell membrane, peptidoglycan cell wall or an outer lipid membrane (only found in Gram-negative cells)
- External structures (appendages & coverings): flagella, fimbriae, sex pilus and glycocalyx.

Cell wall structure

The peptidoglycan that makes up the rigid portion of the cell wall is called murein and is made up of N-acetyl glucosamine and N-acetylmuramic acid molecules that alternate in chains and are cross-connected by peptide subunits. Gram-positive bacteria have simpler chemical structures in their cell walls than Gram-negative bacteria.



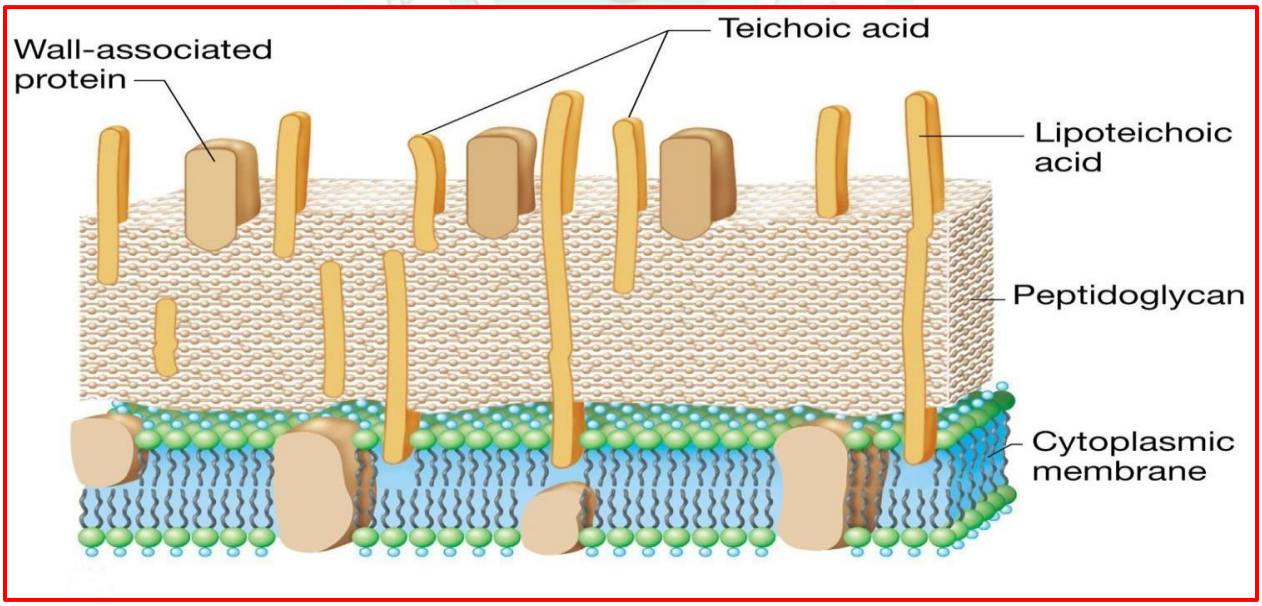
The rigid cell wall layer is located outside the plasma membrane. Its strong wall gives bacteria their shape and shields them from osmotic lysis, making it one of the most crucial components of bacterial cells. Many pathogens have components in their cell wall that contribute to their pathogenicity; additionally, several antibiotics act on the cell wall to protect it from toxic substances.

Peptidoglycan structure: a thin layer in gram-negative bacteria and a thick, homogenous layer in gram-positive bacteria. It contributes to the negative charge of the cell wall and, due to their chemical makeup, may be crucial in preserving the wall's structural integrity.

Teichoic Acids: Teichoic acids are polyol phosphate polymers bearing a strong negative charge. They are covalently linked to the peptidoglycan in some Gram-positive bacteria. They are strongly antigenic, but are generally absent in Gram-negative bacteria.

Lipoteichoic Acids: Anchored in the cytoplasmic membrane, lipophilic glycolipid polymers of amphiphitic glycophosphates are known as lipotecholic acids or membrane teichoic acids. They are antigenic, cytotoxic and adhesins (e.g., *Streptococcus pyogenes*)

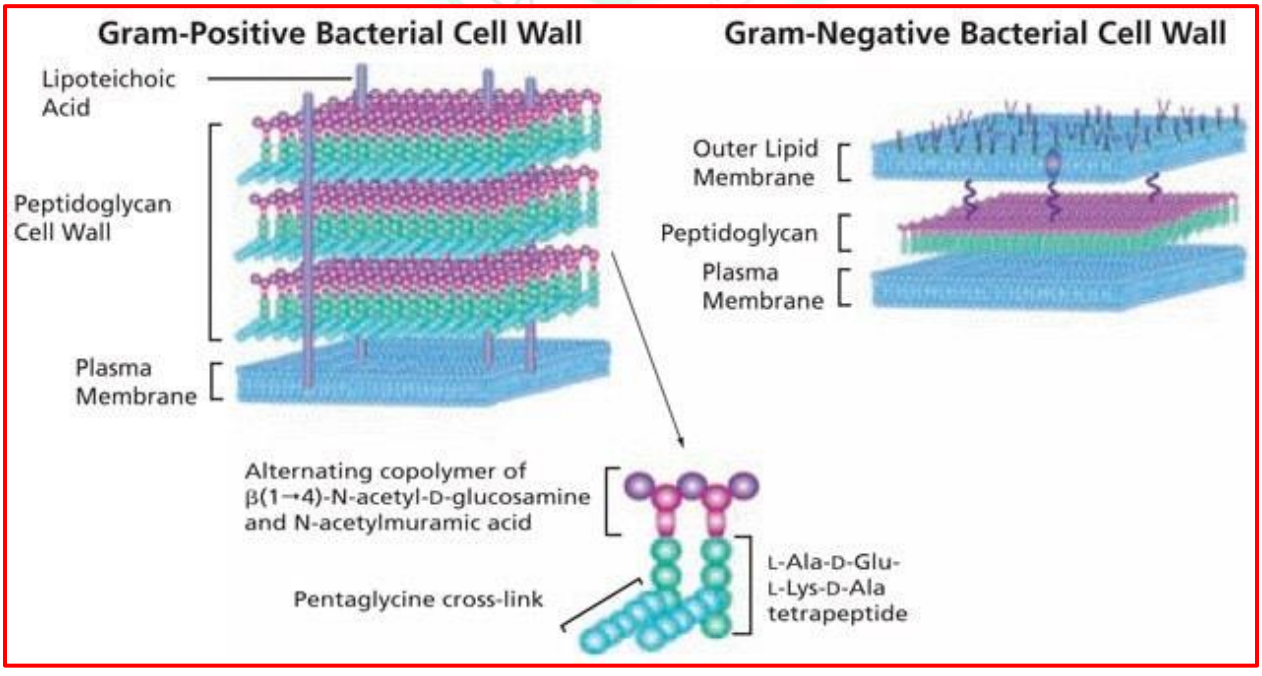
The outer membrane is located outside of peptidoglycan. Its most unusual constituents are lipopolysaccharide (LPS), which is made up of large, complex molecules that contain both lipid and carbohydrates. These molecules include lipid A, core polysaccharide, and the O-side chain.



LPS is significant for a number of reasons, including stabilizing membrane structure and adding to the negative charge on the bacterial surface.

Lipid A is toxic layer so it can act as endotoxin and cause some of the symptoms that arise in gram-negative bacterial infections. A most important outer membrane function is to serve as a protective barrier. It prevents or slow entry of bile salts, antibiotics, and other toxic substances that might kill or injure the bacterium. Outer membrane is more permeable than the plasma membrane and permits the passage of small molecules like glucose and other monosaccharides due to presence of special porin proteins

The Gram staining is one of the oldest and most important staining techniques used in microbiology first introduced in 1882 by Hans Christian Gram. The staining is the most crucial staining in microbiology and is the first step in differentiating bacteria. The gram-positive bacteria have thick cell wall because of thick layers of peptidoglycan, thus stain purple whereas gram-negative bacteria have thin layers of peptidoglycan and stains red/pink.



The Gram positive cell wall:

Gram-negative Cell Wall

The gram-negative cell wall has the following components:

- Thin peptidoglycan layer – Peptidoglycan is a polymer of sugar and amino acids and is often single-layered in the gram-negative cell wall.
- Outer membrane – It is a protein layer that acts as a target site for antibiotics and phages.
- Lipoprotein layer – Links the peptidoglycan to the outer cell membrane.
- Lipopolysaccharide – It constitutes the endotoxicity of gram-negative bacteria. The toxicity is associated with the lipid A molecule of the lipopolysaccharide.
- Periplasmic space – It is the space between the outer and inner membranes.

Gram-positive Cell Wall

The gram-positive cell wall has the following components:

- Thick or multilayered peptidoglycan. It provides structural strength and mechanical rigidity.
- Teichoic acid – It is a water-soluble polymer that constitutes the major surface antigens of gram-positive bacteria.

It lacks an outer membrane and lipopolysaccharide but has other components such as polysaccharides and proteins.

Structures external to Bacteria (Other bacterial surface structures):

Capsule:

Many bacteria secrete extracellular polymers outside of their cell walls. These polymers are usually composed of polysaccharides and sometimes protein.To visualize encapsulated bacteria using a microscope, a sample is treated with a dark stain, such as India ink.

hey are structures that help protect bacteria from phagocytosis and desiccation. Slime layer is involved in attachment of bacteria to other cells or inanimate surfaces to form biofilms. Slime layers can also be used as a food reserve for the cell.• Most bacterial capsules are composed of Polysaccharides eg: *Klebsiella pneumoniae*.• A few capsules are Polypeptides: e.g: *Bacillus anthracis*

Fimbriae:

Fimbriae are protein tubes that extend out from the outer membrane in many members of the **Proteobacteria**

- Filamentous protein structures
- Enable organisms to stick to surfaces or form pellicles

Pili

- Filamentous protein structures
- Typically longer than fimbriae
- Assist in surface attachment
- Facilitate genetic exchange between cells (conjugation)
- Type IV pili involved in twitching motility.

Sex pili:

short appendages, larger than fimbriae, they are genetically determined by sex factors or conjugative plasmids and required for bacterial transformation.

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Threadlike appendages extending outward from the plasma membrane and cell wall

- Locomotory organelles
- embedded in cell membrane
- project as strand
- Flagellin (protein) subunits
- move cell by propeller like action
- Some bacteria are motile
- Taste environment
- Respond to food/poison
- chemotaxis

Axial filaments

- spirochetes
- similar function to flagella
- run lengthwise along cell
- snake-like movement.

Bacterial endospore :

a number of gram-positive bacteria like Bacillus spp Clostridium can form a special resistant dormant structure called an endospore during a complex process called sporulation or sporogenesis (spore formation) which is begin when growth ceases due to lack of nutrients, spores are resistant to environmental stresses such as heat, ultraviolet and gamma radiation, chemical disinfectants and dessication so endospores are of big issue in food, industrial and medical microbiology.

Chemotaxis:

Is the movement of bacterial cells toward chemical attractants and away from repellents ,they attracted by such nutrients such as sugars and amino acids while repelled by many harmful substances. Bacterial cells response to other environmental condition such as temperature, light and gravity.