# The outer membrane

The Gram-negative cell wall is composed of **an outer membrane, a peptidoglycan layer, and a periplasm.**

The outer membrane of Gram-negative bacteria is a bilayer membrane that acts as **a protective barrier and excludes many toxic compounds.**

**The outer membrane** is composed of **phospholipids, lipoproteins, lipopolysaccharides (LPS), and proteins.**

**Lipopolysaccharides (LPS)**, also known as **endotoxins** and **lipoglycans** act as **virulence factor and causes disease in animals.**

The LPS are large molecules consisting of three parts; two of them are **medically significant:-**

**1. Lipid A**: Embedded in the membrane, this portion is also called an **endotoxin** since it is toxic to a host.

**2. Core Oligosaccharide (glycoside part):** Located on the surface of the membrane. It is high-charged (negative charge).

**3. O antigen (or O polysaccharide)**: Short polysaccharides extended out from the core. This O-antigen portion is the primary site of gram-negative bacteria, recognized by antibodies. The variability of the O-antigen chain can cause problems with the immune response.

**Porins:** barrel proteins form channels (pores) through both sides of the outer membrane of gram-negative bacteria, through which molecules can diffuse.

**Periplasm:** The region between the cytoplasmic membrane and the outer membrane is filled with a gel-like fluid called periplasm**.** The periplasm consists of **peptidoglycan, proteins** (that are involved in various cellular activities, including nutrient degradation and transport), and metabolites found in the periplasmic space.

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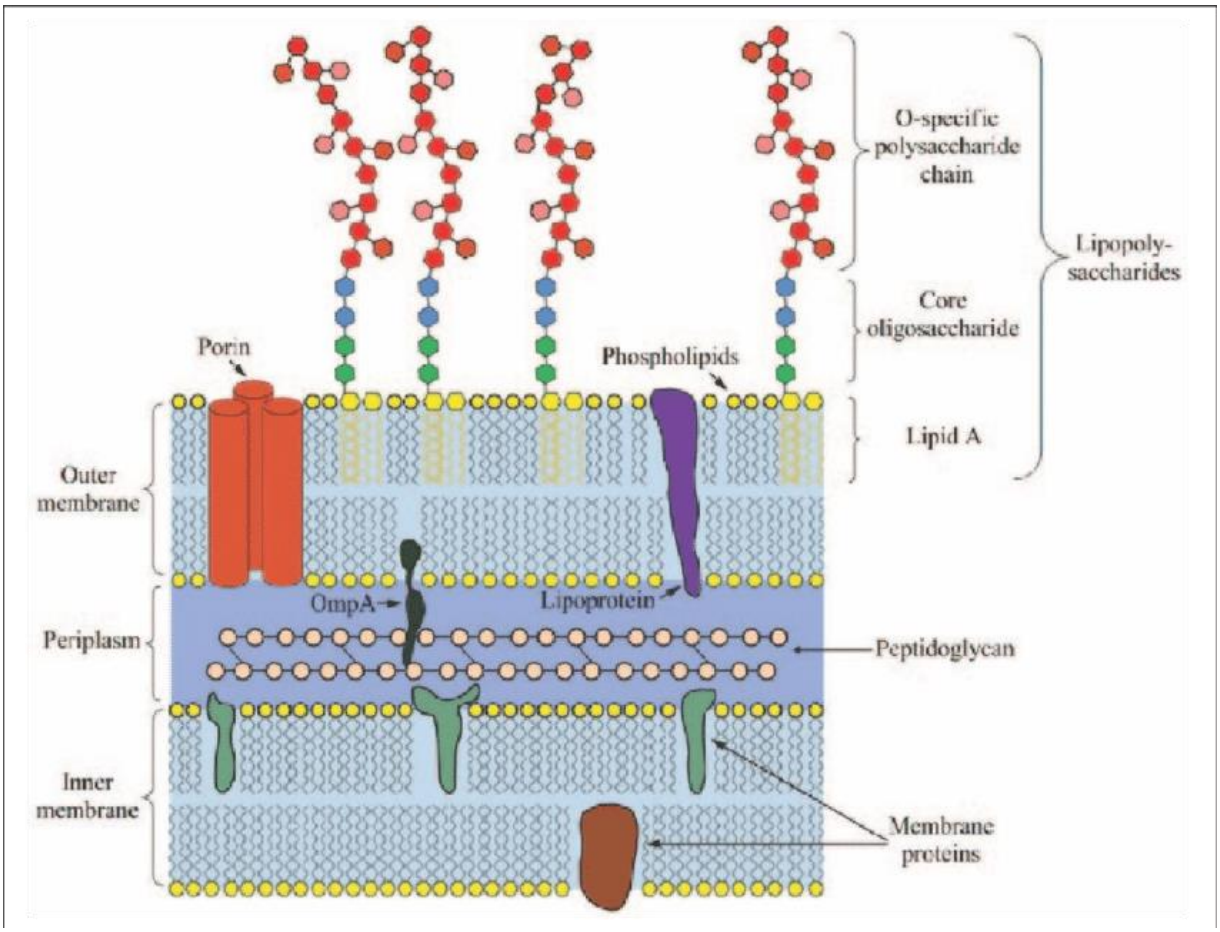
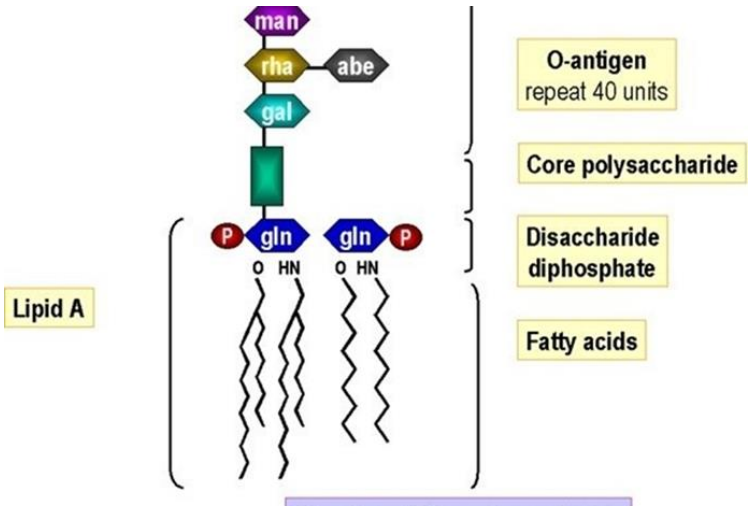



**The outer and inner membranes of Gram-negative bacteria**




**Chemical structure of lipopolysaccharides**

## Cell-Wall-Deficient Bacteria (Bacteria without cell wall)

Some bacteria lack a cell wall but retain their ability to survive by living inside another host cell like **Mycoplasma species.**

**Mycoplasma** is a genus of bacteria that lack a cell wall around their cell membranes. This characteristic makes them naturally resistant to antibiotics that target cell wall synthesis (like the beta-lactam antibiotics). They can be **parasitic or saprotrophic**. Several species are pathogenic in humans. Mycoplasma species are the smallest bacterial cells yet discovered, can survive without oxygen, and come in various shapes.

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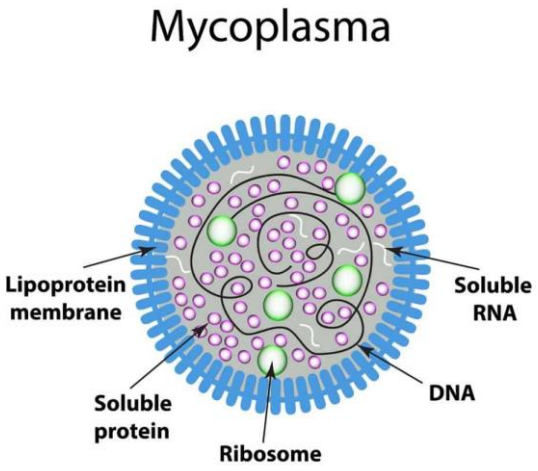


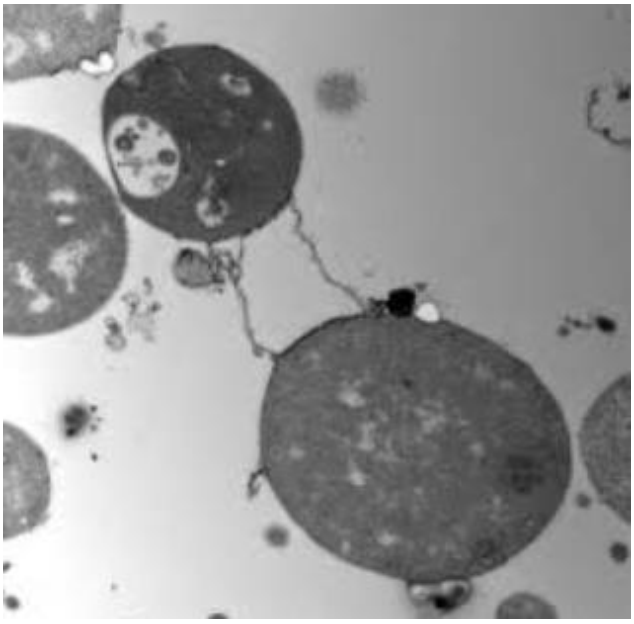

**L-form bacterial lack a cell wall structure**

Other bacterial species occasionally mutate or respond to extreme nutritional conditions by forming cells lacking walls, termed **L-forms (also known as Sam Cannon, L-phase variants, and cell wall-deficient (CWD) bacteria)**. This phenomenon is observed in both gram-positive and gram-negative species.

***Mycoplasma are not considered L-forms** since they are not derived from bacteria that normally have cell walls.

## The cell membrane

The cell membrane (also known as the plasma membrane (PM) or cytoplasmic membrane) is a biological membrane that separates the interior of all cells from the outside environment.

## Plasma Membrane Composed of:-

- **Phospholipid bilayer asymmetric** (the phosphate group called the **"head"** is negatively charged, making the head polar and hydrophilic, or **"water-loving"** and the lipid called the **"tails. "** nonpolar, and hydrophobic, or **"water fearing"**).
- **Protein molecules** (integral proteins & peripheral proteins).
- **Hopanoids** - embedded in the bilayer (Sterol-like (similar to cholesterol) which stabilizes the membrane.

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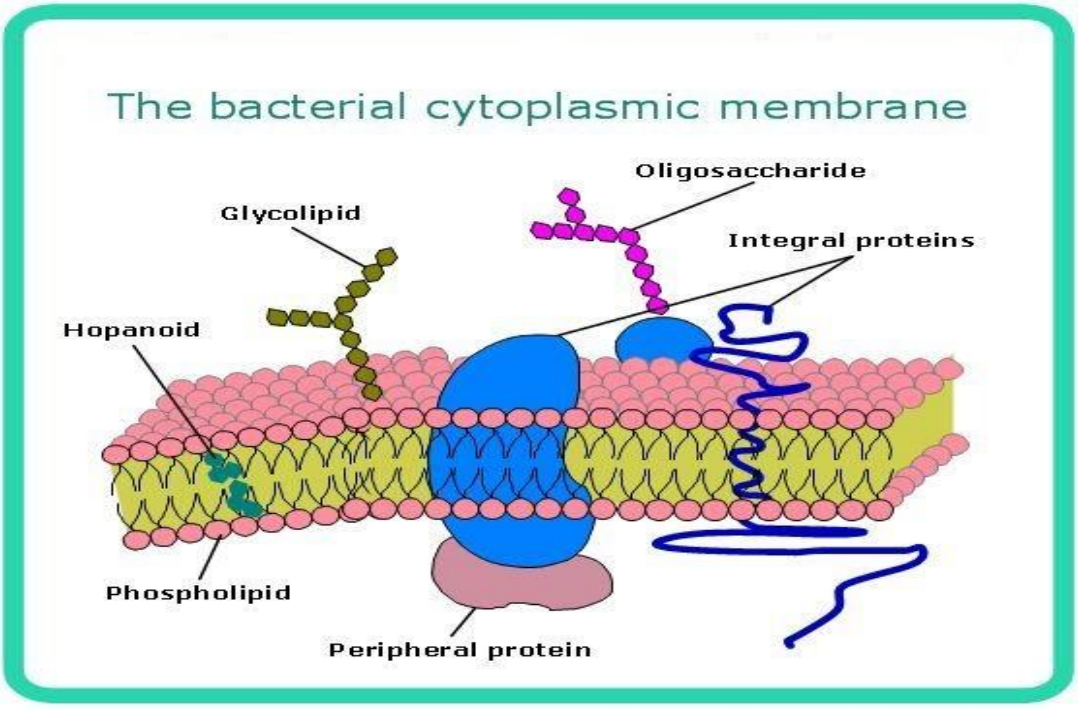
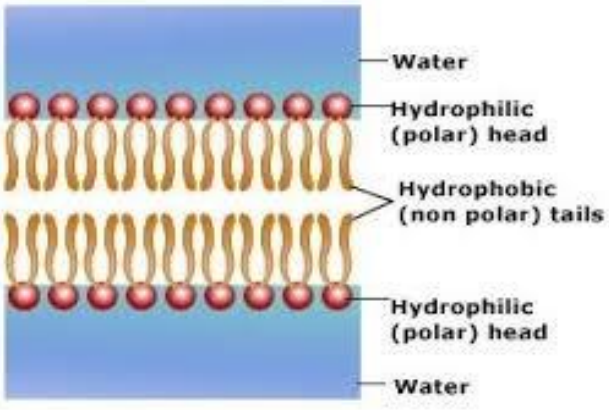





## Plasma membrane functions:-

1- Separates cells from the outside environment.

2- Selectively permeable barrier.

3- Captures energy as ATP.

4- Location of metabolic reactions.

5- Synthesizes cell wall components and DNA.

6- Responds to chemical substances in the environment (Chemotaxis).

## Internal Structure

### 1- Cytoplasm

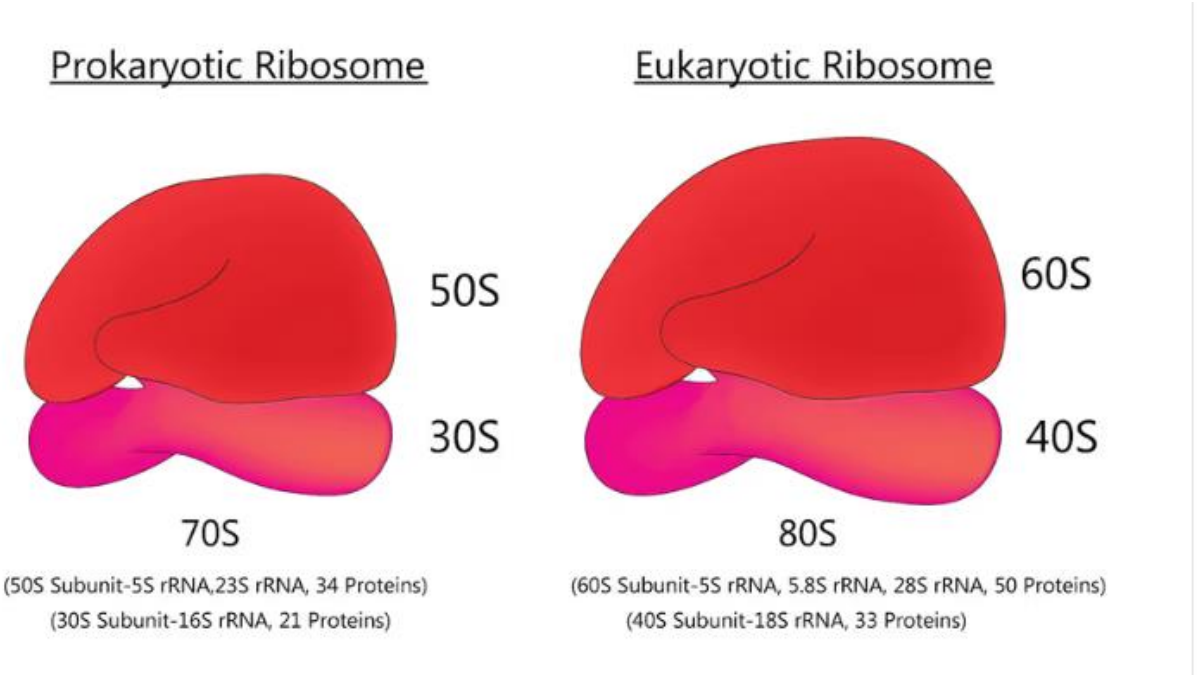
**The cytoplasm, or protoplasm, of bacterial cells, is where the functions for cell growth, metabolism, and replication are carried out.** It is a gel-like matrix composed of water, enzymes, nutrients, wastes, and gases and contains cell structures such as ribosomes, a chromosome, and plasmids. The cell envelope encases the cytoplasm and all its components.

### 2- Ribosomes

**Ribosomes are microscopic "factories" found in all cells, including bacteria.** They are composed of a complex of protein and RNA and are the site of protein synthesis in the cell. Bacterial ribosomes are similar to eukaryote ribosomes (the

**80S**), but are smaller **(70S)** and have a slightly different composition and molecular structure. They are never bound to other organelles as in eukaryotes but are free structures in the cytoplasm. There are sufficient differences between bacterial ribosomes and eukaryotic ribosomes. Some antibiotics will inhibit the functioning of bacterial ribosomes, but not a eukaryote's ribosomes, thus killing bacteria but not the eukaryotic organisms they infect.

**S = the Svedberg unit (Symbol S or Sv)**: a measure of the sedimentation rate of a particle when centrifuged.




## 3- Inclusions and granules

- Intracellular storage bodies within the cytoplasm of certain bacteria act as food reserves.
- Vary in size, number, and content
- Bacterial cells can use them when environmental sources are depleted.

## Examples:

- **Glycogen granules:** storage of glucose polymers (starch).
- **Gas vesicles:** provide buoyancy (floatation) in the aquatic environments.
- **Magnetosomes:** Particles of iron oxide (magnetite), that Provide orientation in a magnetic field.
- **Volutin granules (or metachromatic granules):** a storage form for inorganic phosphate and energy.
- **Poly *β*-hydroxybutyrate (PHB):** For lipid storage.

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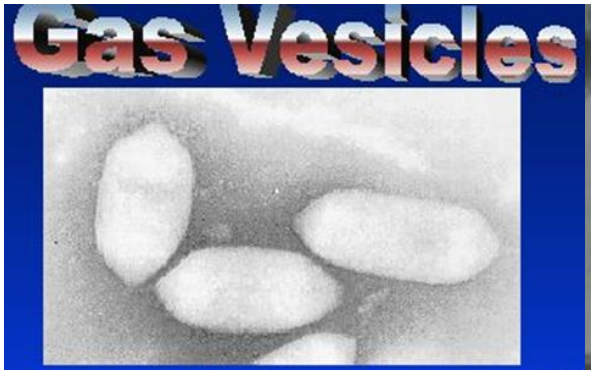


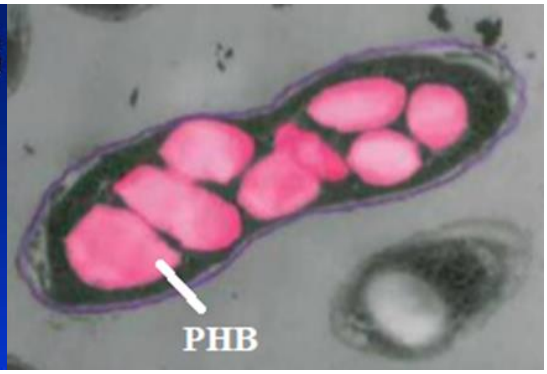


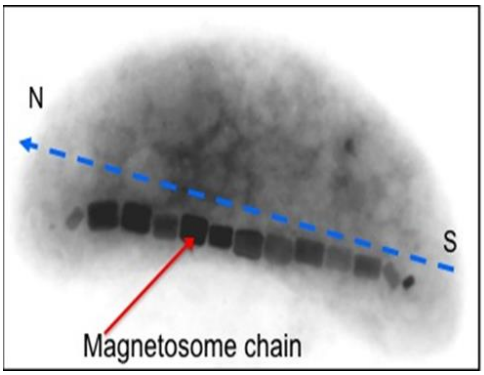


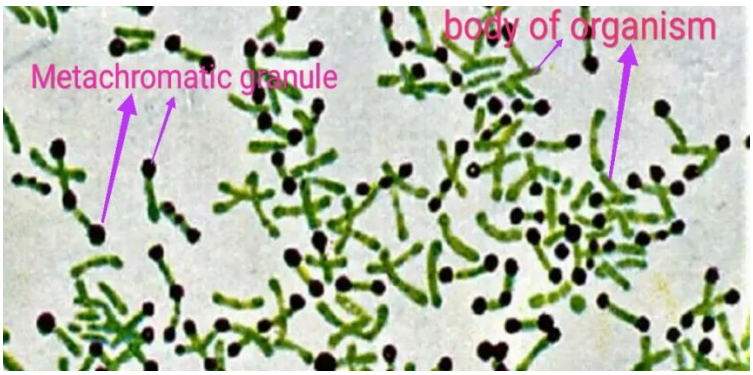

## 4- The Nucleoid

**The nucleoid (meaning nucleus-like)** is an irregularly shaped region within the cell of a prokaryote that contains all or most of the genetic material represented by DNA and is called the bacterial chromosome.

The nucleoid is mostly **composed of multiple compacted copies of DNA in a continuous thread, with the addition of some RNA and proteins.** The DNA in prokaryotes is double-stranded and generally takes a circular shape. But the DNA can sometimes also be found in other regions outside the nucleoid.

**The function of Nucleoid:** The nucleoid is essential for **controlling the activity of the cell and reproduction.** It is where the transcription and replication of DNA take place.

*Most bacteria have **one or two** circular chromosomes (nucleoids), the number of nucleoids, depends on the growth conditions. Rapidly growing bacteria have more nucleoids per cell than slowly growing ones.

### Plasmids

In addition to the bacterial chromosome, bacteria often contain small usually circular, double-stranded DNA molecules called **plasmids** that contain (usually) non-essential genes.

Plasmids are not connected to the main bacterial chromosome but have very important functions:

- **Antibiotic resistance**
- **Tolerance to toxic metals**
- **Production of toxins**
- **the synthesis of enzymes.**

*Plasmids can be transferred from one bacterium to another.

*In fact, plasmid DNA is used for gene manipulation in biotechnology.