Bacterial Cell Structure

Although the bacterial cell is extremely small, with the advancement and development of laboratory equipment such as light, electron, and fluorescence microscopes and biochemical methods, it has become possible to study its different parts. The bacterial cell consists of the surface layer and the protoplast. The surface layer includes flagella, cilia, capsule, and cell wall. As for the protoplast, it is located inside the cell wall and consists of the cytoplasmic membrane, cytoplasm, nuclear material, storage materials, ribosomes, and vacuoles. Figure (1). As well as the internal spores in sporulated bacteria. The water content of the cell reaches between (70-85%) of its weight, while the solid materials range from (15-30%) of the cell weight, and this percentage increases with the increase in the materials stored in the cell, such as poly-beta-hydroxybutyrate, polysaccharides, phosphates, and sulfur. The solid material in the cell consists mainly of protein 50%, lipids 10%, cell wall 10-20%, DNA 3-4%, and RNA 10-20%. We can divide the composition of the bacterial cell into two parts:

1- **Surface structures (external):** They include the cell wall, capsule, flagella and pili or cilia. It is noted that although the flagella have a body or basal part connected to the cytoplasmic membrane of the cell, some consider them to be external structures as they are located outside the cell (the flagellum consists of 3 regions: a basal body connected to the cytoplasmic membrane, a hook, and a thread. It is located outside the cell and is the part that affects the creation of kinetic waves).
2- **Internal structures:** They include everything that is located inside the cell wall, especially the protoplasm, and it is surrounded from the outside by the plasma membrane and is separated from the wall by a space known as the **plasma space**. It also includes the cytoplasm and what it contains of cytoplasmic structures and non-living contents, as well as the nuclear apparatus and endospores.

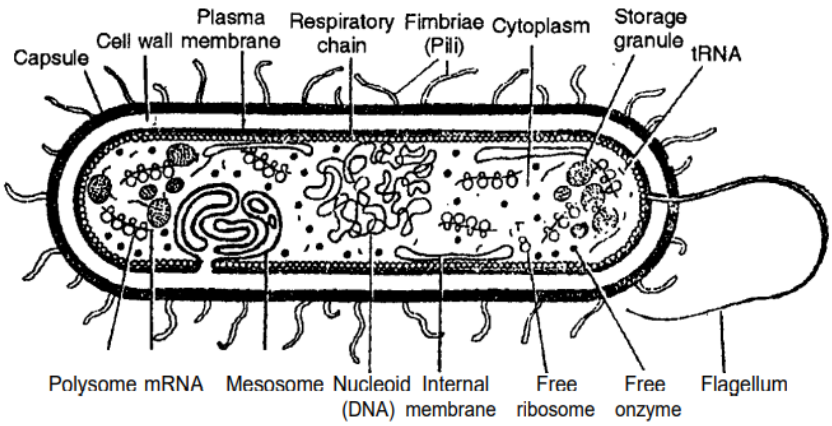


Figure (1): bacterial cell structure

First: External structures:

1- **Cell Wall:** All bacterial groups except Mycoplasma have a cell wall. This wall has a degree of rigidity and performs a purely mechanical function in maintaining the shape of the cell and protecting it from the effects of osmotic pressure between the cell and the surrounding external solutions. It has the property of selective permeability. Its thickness varies according to the type of bacteria (10-80 nm). As a result of the rigidity of the wall, the bacterial cell can withstand high osmotic pressures. It has been possible to separate it from the rest of the cell contents by lysozymes or by mechanical methods. After that, we can analyze the wall to study its various components. The bacterial wall has a taxonomic and medical importance. From a taxonomic point of view, we find that the wall contains components that are not found anywhere in nature. Also, the difference in the chemical composition of the wall is based on which bacteria are divided into positive and negative for Gram stain. From a medical perspective, we find that pure preparations of the cell wall of some types of bacteria produce pathological symptoms, and the effect of antibiotics on the bacterial cell appears through their effect on the structure of the cell wall.

The bacterial cell wall consists of structural units that differ according to the type of cell. The cell wall of Gram-negative bacteria differs from the wall of Gram-positive bacteria. The cell wall of Gram-negative or Gram-positive bacteria is generally composed of:

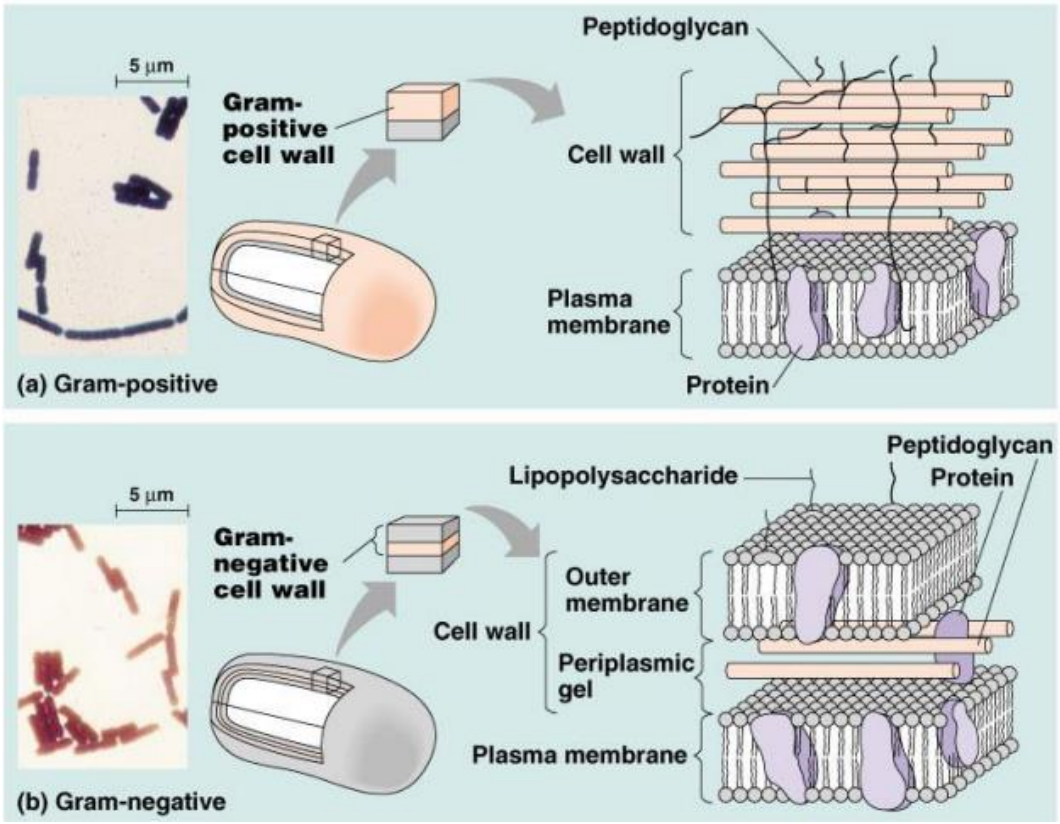
1- **Peptides:** It consists of 3-8 amino acids, including D-glutamate, L-alanine ,Meso-amino Diaminino pimelic acid or L-lysin, D-alanine.

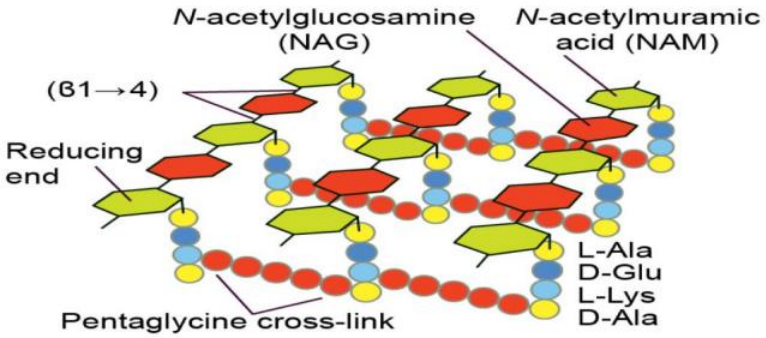
2- **Amino sugars:** It consists of two types, N-acetyl glucosamine and N-acetyl muramic acid, and they are found together alternately to form a polymer called peptidoglycan or murin, which is the basic structure of the bacterial cell wall and is responsible for the hardness of the wall. It is made up of strong fibers that form a perforated structure with three dimensions that resemble a perforated network. This structure allows water and nutrients to pass from outside the cell and also allows cell waste to exit from inside to outside. Connected to muramic acid, which is involved in the composition of murin, is a short cross peptide chain consisting of at least 3 amino acids, which is the reason for the rigidity of peptidoglycan. These cross peptide chains are found in abundance in the wall of Gram-positive bacteria, which helps each layer of peptidoglycan to bind to the next layer, so the wall appears more homogeneous in its composition. As for the wall of Gram-negative bacteria, it appears less homogeneous because it contains fewer layers of peptidoglycan, so it appears less thick.

3- **Teichoic acid**: is a group of glycerol units linked to D-alanine and phosphate or a group of ribitol units with D-alanine and glucose (and is found only in the wall of Gram-positive bacteria, which leads to the rigidity of the cell wall as it is not found in a separate layer but is found within the structure of the murin layers as a result of its connection to them via covalent bonds.

4- Lipopolysaccharide is found only in the wall of Gram-negative cells and has a high degree of toxicity, increasing the ability of cells to cause diseases.

5- Lipoproteins are found only in the walls of Gram-negative cells linked to the murin layer by weak hydrogen bonds.





2- The Flagella:

They are long thread-like structures made up of a special type of protein called **flagellin**. The flagella arise from a basal body embedded in the cell wall and cytoplasmic membrane and pass through the wall, so that the thread-like flagellum extends long outside the cell.

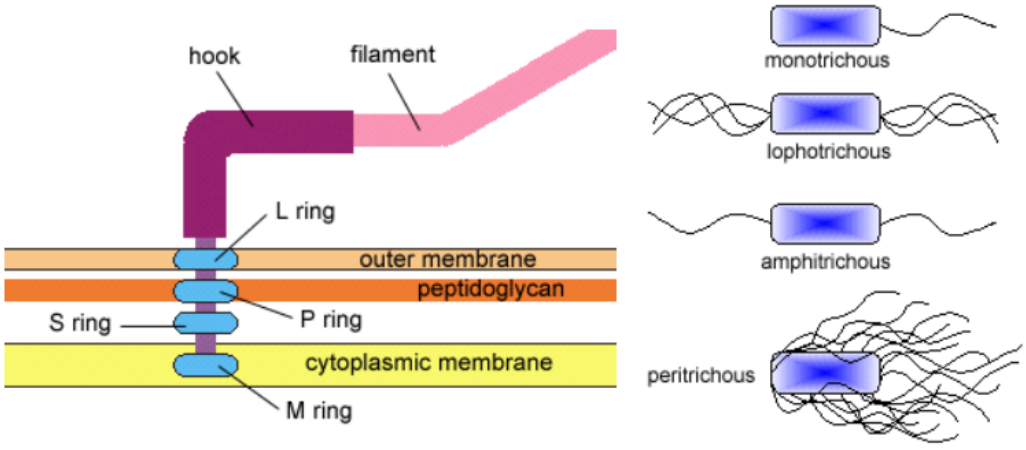
In general, cocci do not have flagella, while more than half of rod-shaped bacteria have flagella, and most spiral bacteria move by flagella. **The flagellum consists of 3 parts:**

1- Filament which is connected to the next part.
2- Hock is connected to the next part.
3- Basal granules or basal body which fixes the flagellum to the cell wall and plasma membrane.

The basal granules in G ve+ bacteria consist of a stalk surrounded by a pair of rings on the cytoplasmic membrane, the M ring is important in fixing the flagellum to the cytoplasmic membrane and the S ring has a motor role for the flagellum. In G ve- bacteria, another pair is added above the ring pair, the P ring located on the lipoprotein layer and the L ring located on the lipid layer.

The flagella are responsible for movement, and bacteria can be divided according to the location of the flagella in the cell into 4 sections:

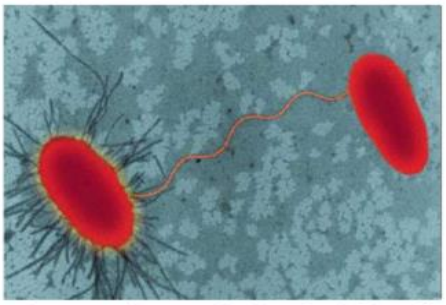
A- The flagellum is one polar at one end and is called Monotrichous
B- A tuft of flagella and is called Lophotrichous
C- One flagellum at both poles of the cell and is called Amphitrichous
D- A group of flagella surrounding the cell body and is called Peritrichous.



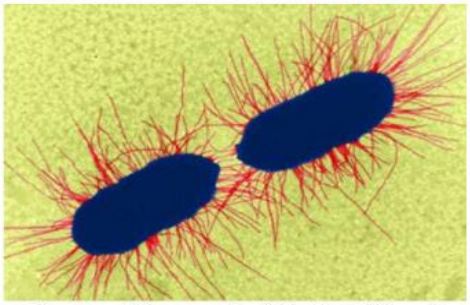
4- The Fimbriae and Pili:

Some bacterial cells contain fimbriae, which are shorter than flagella and are composed of **pilin** protein. They help the cell to adhere to surfaces, especially in pathological cases.

As for pili, they are found in abundance in Gram-negative bacteria. They are fine threads that are longer than cilia and range in length from (0 - 20) micrometers, and their width from (3 - 25) millimicrons, and their number is only one or two per cell. These appendages perform a number of functions in the bacterial cell, because they form the place where bacteriophages are fixed, and they fix the bacteria themselves in hemagglutination reactions and play an important role in conjugation, as they form the communication channel between the two mating bacterial cells, so they are sometimes called sexpilus, but their main role is still not precisely defined.



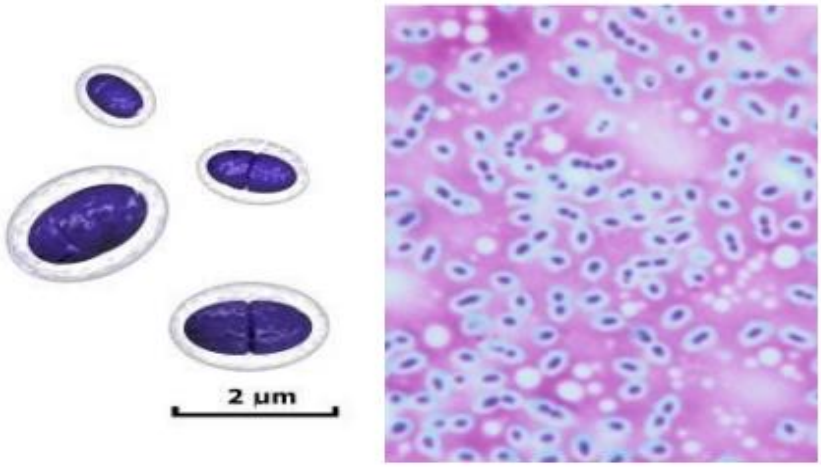
Electron Micrograph of *Escherichia coli* with a Conjugation Pilus



Electron Micrograph of *Escherichia coli* with Pili

5- The Capsule or Slime Layer:

The bacterial cell is surrounded by a viscous gelatinous layer whose thickness varies according to the species. It may be a thin membrane in some species and a thick membrane in others. It is called a capsule if its structure is cohesive, and its thickness may reach more than twice the cell. The capsule surrounds the single cell or the chain of cells if the group is in chains. If its structure is loose, it is called a gel or a viscous layer (Slime). If its structure is solid, it is called the sheath. The bacterial capsule is not stained in preparations stained by conventional methods, as the cell appears surrounded by an unstained area, which is the sheath. Therefore, special methods are used to stain the capsule. In most cases, the capsule material is composed of complex carbohydrates with many sugars, and in some species, amino acids enter into its composition. Examples of bacteria that form a capsule include Streptococcus pneumonia.



The importance of the capsule:

The capsule protects bacteria from bad environmental conditions, especially drought, and provides resistance against cellular phagocytosis, in addition to helping the cell adhere to surfaces. The presence of the envelope has a clear effect on the appearance of bacterial cultures, and thus it is useful in distinguishing between different species.