The Bacteria

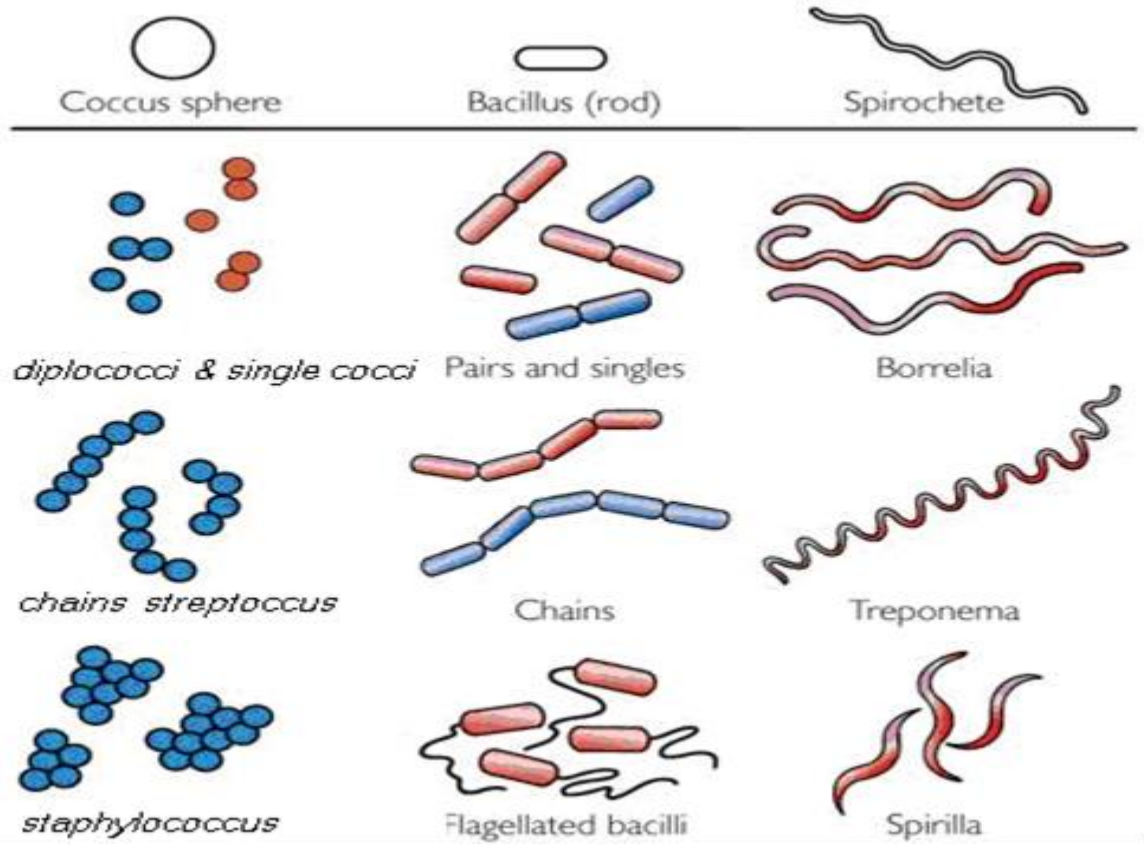
These organisms have a prokaryotic cell structure, they lack organelles such as mitochondria, and most organisms are enclosed in cell wall composed of peptidoglycan.
Some Bacteria have many benefits to human and other considered as pathogenic bacteria that cause diseases to human.

Bacterial morphology:

The shape of a bacterium is determined by its rigid cell wall. Bacteria are classified by shape into three basic groups:

1. cocci (spherical)
2. bacilli (rod-shaped)
3. spirochetes (helical)

Some bacteria with variable shapes, appearing both as coccus and bacillary forms, are called pleomorphic (pleo: many; morphic: shaped) in appearance.
The size of bacteria ranges from about 0.2 to 5 μm. The smallest bacteria approximate the size of the largest viruses (poxviruses), whereas the longest bacilli attain the same length as some yeasts and human red blood



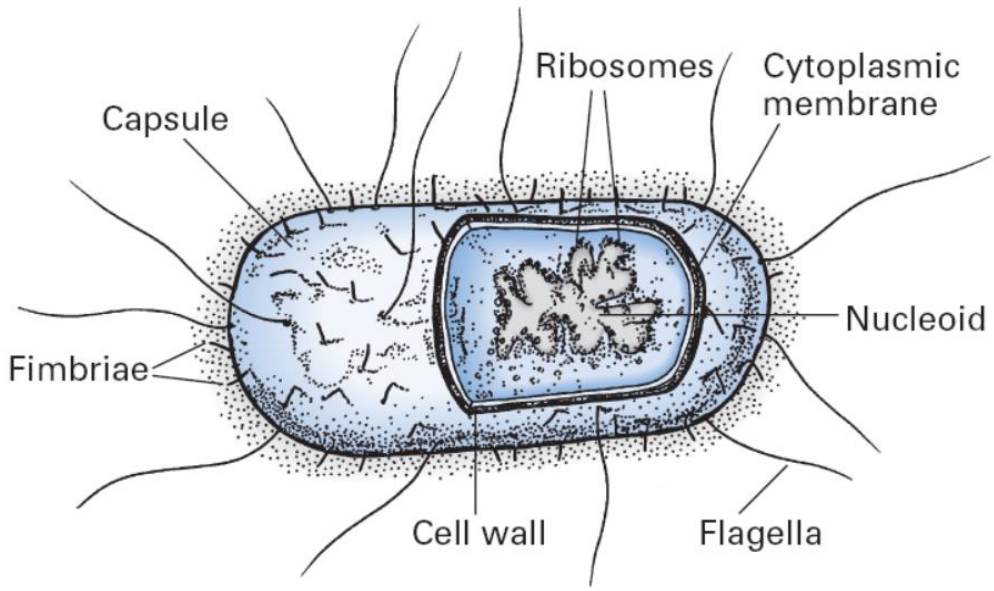
cells (7 μm).

Gram-staining characteristics:

In clinical microbiology, bacteria can be classified into two major subgroups according to the staining characteristics of their cell walls. The stain used, called the Gram stain (first developed by a Danish physician, Christian Gram), divides the bacteria into Gram-positive (purple) and Gram-negative (pink) groups. The Gram-staining property of bacteria is useful both for their identification and in the therapy of bacterial infections because, in general, Gram-positive bacteria are more susceptible to penicillins than Gram-negative bacteria

Bacterial structure:

The structure of a typical bacterium is shown in Figure below Bacteria have a rigid cell wall protecting a fluid protoplast comprising a cytoplasmic membrane and a variety of other components.



Structures external to the cell wall:

1. Flagella

Flagella are whip-like filaments that act as propellers and guide the bacteria towards nutritional and other sources. The filaments are composed of many subunits of a single protein, flagellin.

1. monotrichous: if only one flagellum located from one end of the bacteria.
2. lophotrichous: if several flagella located from one end.
3. Amphitrichous: if at least one flagellum is at each end.

4. Peritrichous: if the flagella located at all portions of the bacterial surface.

Peritrichous Lophotrichous Amphitrichous monotrichous

Many bacilli (rods) have flagella, but most cocci do not and are therefore non-motile. Spirochaetes move by using a flagellum-like structure called the axial filament, which wraps around the cell to produce an undulating motion.

2. Fimbriae and pili

Fimbriae and pili are fine, hair-like filaments, shorter than flagella, that extend from the cell surface. Pili, found mainly on Gram-negative organisms, are composed of subunits of a protein, pilin, and mediate the adhesion of bacteria to receptors on the human cell surface – a necessary first step in the initiation of infection. A specialized type of pilus, **the sex pilus (F or fertility pilus)**, forms the attachment between the male (donor) and the female (recipient) bacteria during conjugation, when genes are transferred from one bacterium to another.

3. Glycocalyx (slime layer)

The glycocalyx is a polysaccharide coating that covers the outer surfaces of many bacteria and allows the bacteria to adhere firmly to various structures, e.g., oral mucosa, teeth, heart valves and catheters, and contribute to the formation of biofilms. One common example of a biofilm dental plaque, a slimy buildup of bacteria that forms on the surfaces of teeth.

4. Capsule

An amorphous, gelatinous layer (usually more substantial than the glycocalyx) surrounds the entire bacterium; it is composed of polysaccharide, and sometimes protein (e.g., Anthrax bacillus). The sugar components of the polysaccharide vary in different bacterial species and

frequently determine the serological type within a species (e.g., 84 different serological types of *Streptococcus pneumoniae* can be distinguished by the antigenic differences of the sugars in the polysaccharide capsule). The capsule is important because:

• It mediates the adhesion of bacteria to human tissues or prosthesis such as dentures or implants – a prerequisite for colonization and infection.

• It hinders or inhibits phagocytosis; hence, the presence of a capsule correlates with virulence.

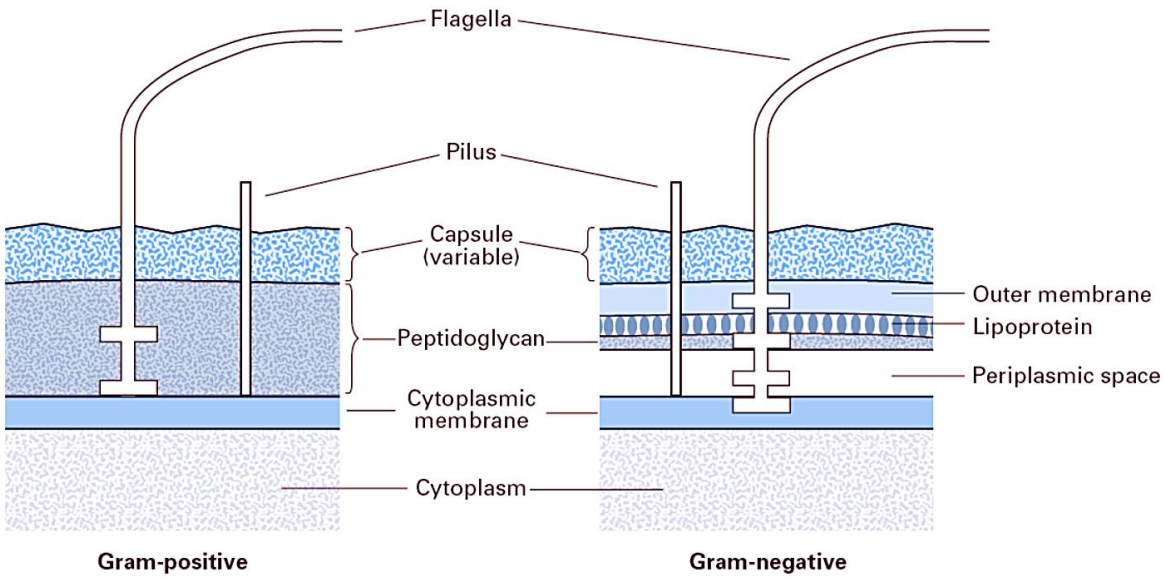
• It helps in laboratory identification of organisms.

• Its polysaccharides are used as antigens in certain vaccines because they elicit protective antibodies (e.g., polysaccharide vaccine of *S. pneumoniae*).

5. Cell wall

The cell wall confers rigidity upon the bacterial cell. It is a **multilayered** structure outside the cytoplasmic membrane. It is porous and permeable to substances of low molecular weight. The inner layer of the cell wall is made of peptidoglycan and is covered by an outer membrane that varies in thickness and chemical composition, depending upon the Gram staining property of the bacteria. The term 'peptidoglycan' is derived from the peptides and the sugars (glycan) that make up the molecule.

The cell walls of Gram-positive and Gram-negative bacteria have important structural and chemical differences



- The **peptidoglycan layer** is common to both Gram-positive and Gram-negative bacteria but is much **thicker** in the Gram-positive bacteria.
- In contrast, the Gram-negative organisms have a complex outer membrane composed of **lipopolysaccharide (LPS)**, lipoprotein and phospholipid. The O antigen of the LPS and the lipid A component are also embedded in the outer membrane. Lying between the outer membrane and the cytoplasmic membrane of Gram-negative bacteria is the periplasmic space. It is in this space that some bacterial species produce enzymes that destroy drugs such as penicillins (e.g. β-lactamases).
- The LPS of Gram-negative bacteria, which is extremely toxic, has been called the **endotoxin**. (Hence, by definition, endotoxins cannot be produced by Gram positive bacteria as they do not have LPS in their cell walls.) LPS is bound to the cell surface and is only released when it is lysed. It is responsible for many of the features of disease, such as fever and shock.
- The cell walls of some bacteria (e.g. *Mycobacterium tuberculosis*) contain lipids called **mycolic acids**, which cannot be Gram-stained, and hence are called **acid-fast** (i.e. they resist decolorization with acid alcohol after being stained).

6. Cytoplasmic membrane

The cytoplasmic membrane lies just inside the peptidoglycan layer of the cell wall and is a 'unit membrane' composed of a phospholipid bilayer similar in appearance to that of eukaryotic cells. However, eukaryotic membranes contain sterols, whereas prokaryotes generally do not. The membrane has the following major functions:

- active transport and selective diffusion of molecules and solutes in and out of the cell
- electron transport and oxidative phosphorylation, in aerobic species
- synthesis of cell wall precursors
- secretion of enzymes and toxins.

➢ there are one or more invaginations in the cell membrane called (**mesosmes**) that functions as the origin of the transverse septum that divides the cell in half during cell division. It is also the binding site of the DNA that will become the genetic material of each daughter cell.

7. Cytoplasm

The cytoplasm comprises an inner, nucleoid region (composed of DNA), which is surrounded by an amorphous matrix that contains ribosomes, nutrient granules, metabolites and various ions

A. **Nuclear material or nucleoid:** Bacterial DNA comprises a single, supercoiled, circular chromosome that contains about 2000 genes, approximately 1 mm long in the unfolded state.

B. **Ribosomes:** Ribosomes are the sites of protein synthesis. Bacterial ribosomes differ from those of eukaryotic cells in both size and chemical composition. They are organized in units of *70S*, compared with eukaryotic ribosomes of *80S*.

C. **Cytoplasmic inclusions:** The cytoplasm contains different types of inclusions, which serve as sources of stored energy.

8. Spores

Spores are highly resistant structure for dehydration, heating, radiation, and chemical agent. It's formed by certain gram-positive rods bacteria (*Bacillus* and *Clostridium)* under conditions of limitation in supply of carbon and nitrogen.
All bacterial spores contain large amount of **calcium dipicolinate acid complex** (CaDPA) and that cause the resistant of spore to dehydration, heating, radiation, and chemical agent.
The spore has no metabolic activity and can remain dormant for many years. Up on exposure to water and the nutrient, spore can produce bacterial cell.
The medical importance of spores is their extraordinary resistance to heat and chemicals so sterilization cannot be useful by boiling, steam–heating under pressure (autoclaving) at 121C° for 30 minutes is used to ensure sterility.

- Taxonomy (systematic classification of organisms into groups) can be performed according to morphology, staining reactions, cultural requirements, biochemical reactions, antigenic structure and DNA composition.