Structure and shape of bacteria

The cellular world is divided into two major groups, based on whether or not the cells have a nucleus (that is, an internal membrane-enclosed region that contains the genetic material). Cells that have a well-defined nucleus are called eukaryotic, whereas cells that lack a nucleus are called prokaryotic. All bacteria are prokaryotes. In addition, bacterial DNA is not organized into the elaborate multi-chromosomal structures of the eukaryotes, but typically is a single double-stranded molecule of DNA. Prokaryotes and eukaryotes employ very similar metabolic pathways to achieve cell growth and maintain viability. However, prokaryotes synthesize substances and structures that are unique to bacteria, for example, peptidoglycan. A generalized prokaryotic cell is shown in Figure 1.2.

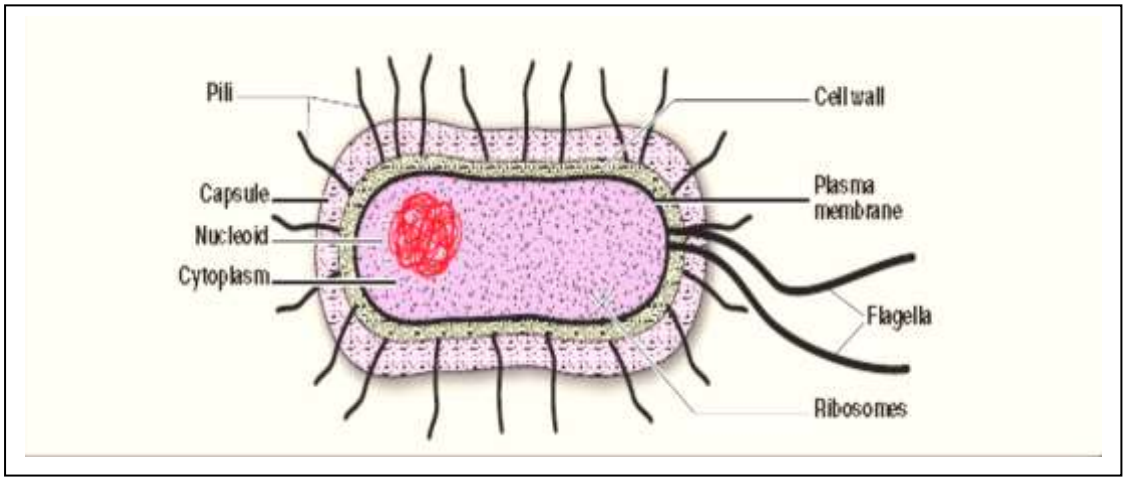

Figure 1.2 : generalized structure of a bacterial cell.

Chemical composition

The bacterial “cell envelope” is a term applied to all material external to and enclosing the cytoplasm. It consists of several chemically and functionally distinct layers, the most prominent of which are the cell wall and the cytoplasmic membrane. The cell envelope also includes the capsule or glycocalyx, if present

1-Cytoplasmic membrane

The cell membrane is composed of phospholipid, the molecules of which form two parallel surfaces (called a lipid bilayer) such that the polar phosphate groups are on the outside of the bilayer and the nonpolar lipid chains are on the inside. The membrane acts as a permeability barrier, restricting the kind and amount of molecules that enter and leave the cell.

2-Peptidoglycan

The peptidoglycan layer determines the shape of the cell. It is composed of a cross-linked polymeric mesh (Figure 1.3.) The glycan portion is a linear polymer of alternating monosaccharide subunits:

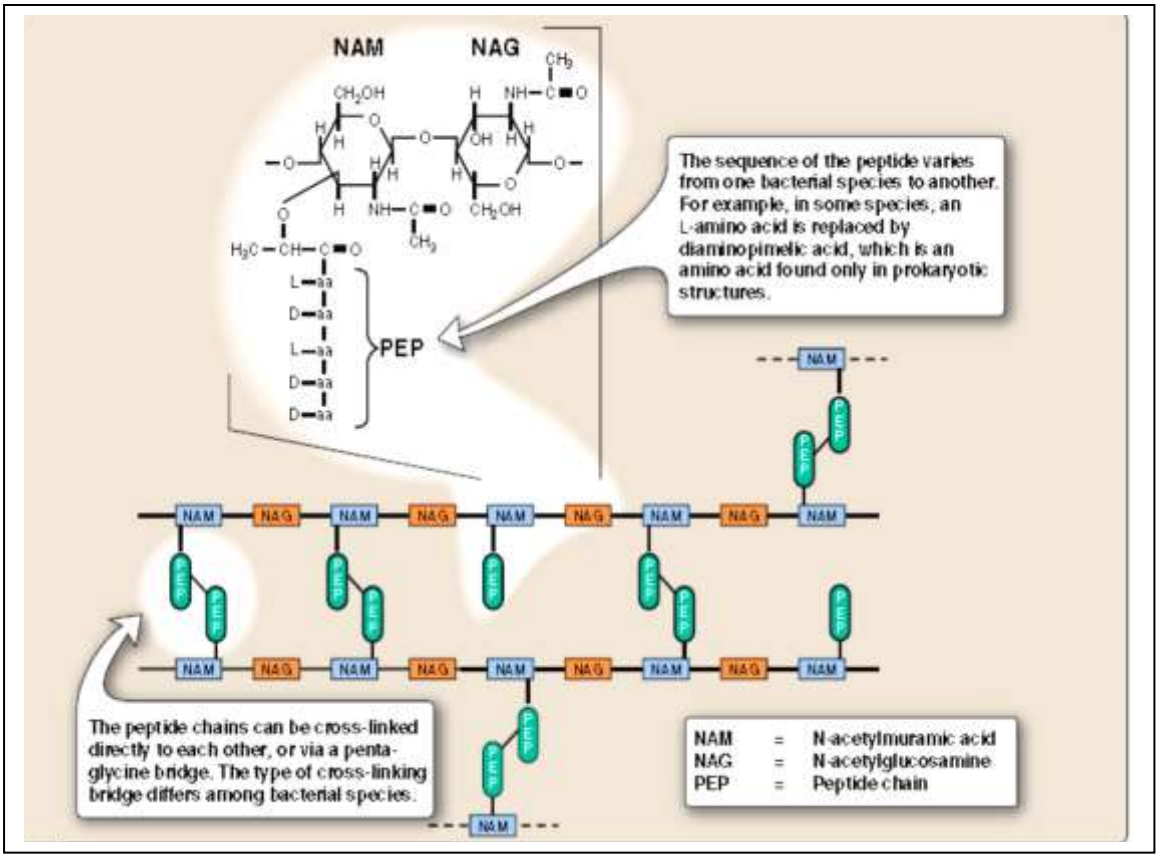

Figure 1.3: structure of peptidoglycan, the major polymer of bacterial cell walls.

N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM). This polymer is the carbohydrate "backbone" of the mesh. The "peptido" portion of the polymer is a short string of amino acids that serves to cross-link adjacent polysaccharide strands at the NAM subunits of the backbone, forming a network with high tensile strength .

Cell wall of gram negative and positive bacteria

The molecular details of the cell walls of gram-positive and gram negative bacteria are shown in Figure 1.4. Additional surface layers, such as a capsule or glycocalyx, can be found outside of the cell wall in some species of gram-positive and gram-negative bacteria

1- **Gram-positive bacteria:**
Gram-positive bacteria have thick, multilayered, peptidoglycan cell walls that are exterior to the cytoplasmic membrane. The peptidoglycan in most gram-positive species is covalently linked to teichoic acid, which is essentially a polymer of substituted glycerol units linked by phosphodiester bonds. The teichoic acids are major cell surface antigens. Teichoic acids are integrated into the peptidoglycan layers but not tethered to the cytoplasmic membrane. Lipoteichoic acids are lipid modified and integrated by this moiety into the outer leaflet of the cytoplasmic membrane.

2- **Gram-negative bacteria:** Gram-negative bacteria have a more complex cell wall structure composed of two membranes (an outer membrane and an inner, that is, cytoplasmic, membrane). The two membranes are separated by the periplasmic space, which contains the peptidoglycan layer. The periplasmic space also contains degradative enzymes and transport proteins. In contrastto gram-positive cells, the peptidoglycan layer of gram-negative cells is thin, and the cells are consequently more susceptible to physical damage. The outer membrane is distinguished by the presence of embedded lipopolysaccharide (LPS) that is the major constituent of the outer leaflet of the outer membrane. The polysaccharide portion of LPS (O-polysaccharide) is antigenic and can, therefore, be used to identify different strains and species. The lipid portion (called lipid A) is imbedded in the membrane and is toxic to humans and animals. Because lipid A is an integral part of the membrane, it is called endotoxin, as opposed to exotoxins, which are secreted substances. Do not confuse endotoxin or exotoxins with enterotoxins, which are exotoxins that are toxic for the mucosal membrane of the intestine. “Enterotoxin” denotes the site of action, rather than its

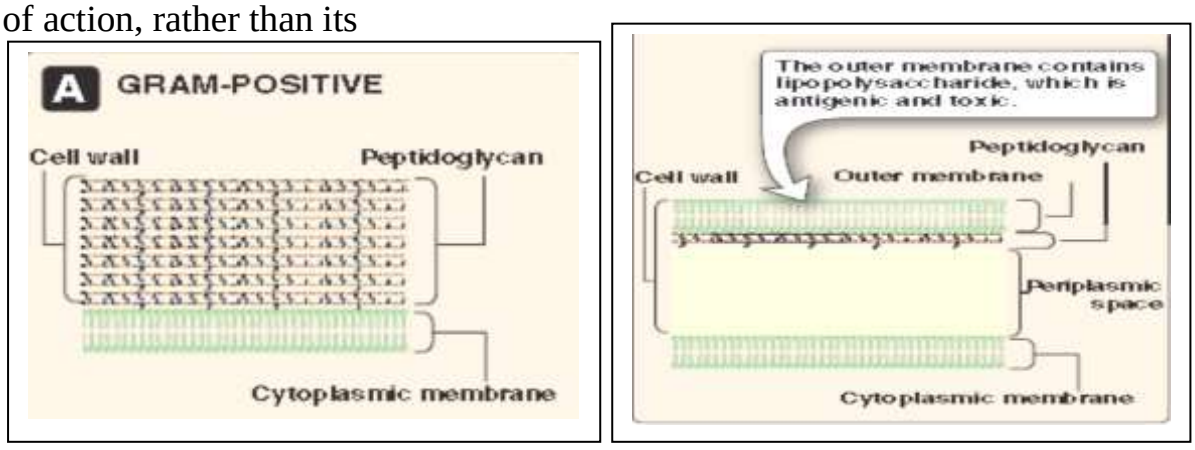

Figure 1.4 comparison of gram-positive and gram-negative bacterial cell walls.

Secondary structure of bacteria cell

Many bacteria secrete a sticky, viscous material that forms an extracellular coating around the cell. The material is usually a polysaccharide However, The **capsule** is composed of poly-D-glutamic acid. If the material is tightly bound to the cell and has an organized structure, it is called a cap If the material is loosely bound and amorphous, it is called a slime layer, or glycocalyx. The capsule or glycocalyx allow cells to adhere to surfaces, protect bacteria from antibodies and phagocytosis, and act as diffusion barriers against some antibiotics, thus contributing to the organisms' pathogenicity. Capsules can also protect bacteria against dessication, or drying, which facilitates transmission.

Appendages : Many bacteria have hairlike appendages that project from the cell wall. There are of two kinds of appendages:
flagella (singular,flagellum) and pili (singular, pilus).

A- Flagella: Prokaryotic flagella are long, semirigid, helical, hollow tubular structures composed of several thousand molecules of the protein flagellin. They enable bacteria to move in a directed fashion, for example, in response to a chemotactic stimulus. Flagella are anchored in the cell membranes by a basal body, which is a complex molecular machine that rotates the flagellum like the screw propeller of a ship (Figure 1.5). Cells may have one or many flagella. Flagella are highly antigenic. Bacteria that have flagella often do not form compact colonies on an agar surface, but instead swarm over the surface of the agar if it is sufficiently wet, producing a scumlike mat.

B-Pili: Pili (sometimes called fimbriae) are shorter and thinner than flagella and function as attachment structures that promote specific cell-to-cell contact . The attachment can be between the bacterial cell and the host eukaryotic cell or between one bacterial cell and another.

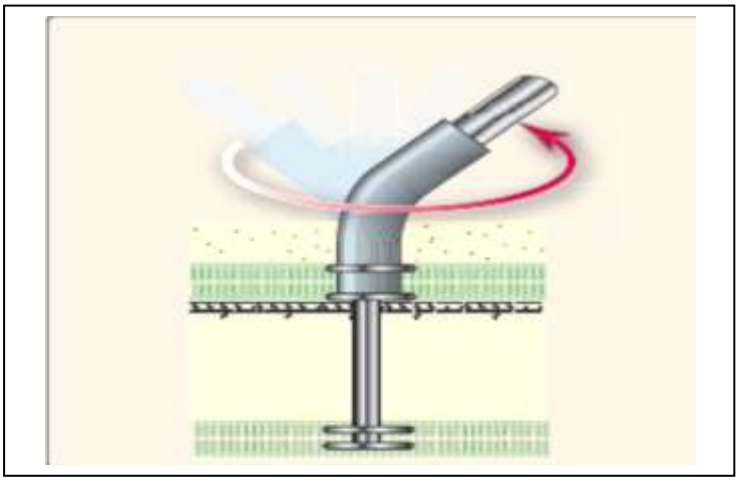

Figure 1.5 : The flagellum rotator machine.