

Structure of Bacterial Cell

2.1 HISTORY OF THE CELL

1. The cell is the basic structural and functional unit of all known living organisms. It is the smallest unit of life that is classified as a living thing, and is often called the building block of life. Some organisms, such as most bacteria, are unicellular (consist of a single cell). Other organisms, such as humans are multicellular. (Humans have an estimated 100 trillion or 10^{14} cells, a typical cell size is $10\mu\text{m}$ and a typical cell mass is 1 nanogram.) The largest known cell is an unfertilized ostrich egg cell.
2. The word *cell* comes from the Latin *cellula*, meaning a small room. The descriptive term for the smallest living biological structure was coined by Robert Hooke in his book. He published in 1665 when he compared the cork cells he saw through his microscope to the small rooms monks lived in.
3. The cell theory, first given by Matthias Jakob Schleiden and Theodor Schwann in 1839, states that all organisms are composed of one or more cells, that all cells come from preexisting cells, that vital functions of an organism occur within cells, and that all cells contain the hereditary information necessary for regulating cell functions and for transmitting information to the next generation of cells.
4. Cells are mainly of two types: Prokaryotic cell (e.g. bacteria, virus) and eukaryotic cell (e.g. plant cell and animal cell).
5. All biological systems have the following characteristics:
 - (a) The ability to reproduce.
 - (b) The ability to ingest and metabolize them for energy and growth.
 - (c) The ability to excrete waste products.
 - (d) The ability to react to change in their environment.

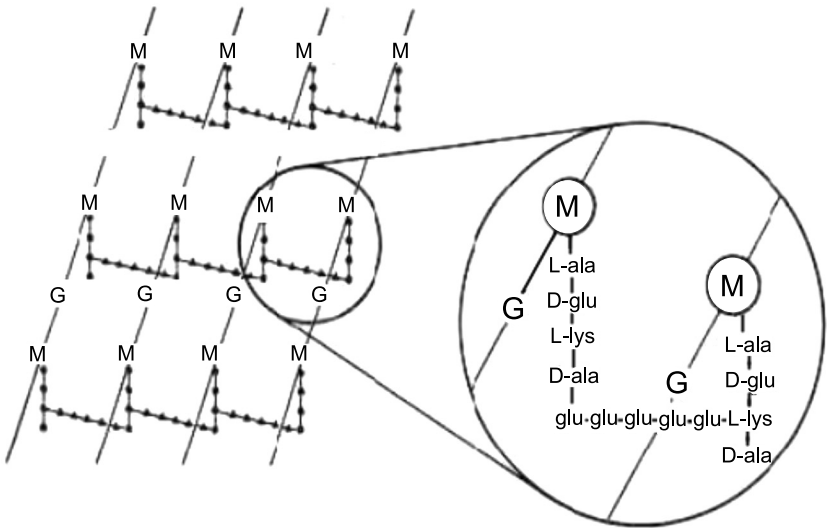


Fig. 2.2. Schematic diagram of the peptidoglycan sheet of *Staphylococcus aureus*.
 G = N-acetyl-glucosamine; M = N-acetyl-muramic acid; L-ala = L-alanine; D-ala = D-alanine;
 D-glu = D-glutamic acid; L-lys = L-lysine.

The gram-negative cell envelope (Fig. 2.3) is even more complicated; essentially, it contains lipoprotein molecules attached covalently to the oligosaccharide backbone and in addition, on its outer side, a layer of lipopolysaccharide (LPS) and protein attached by hydrophobic interactions and divalent metal cations, Ca^{2+} and Mg^{2+} . On the inner side is a layer of phospholipid (PL).

The lipopolysaccharide has toxic properties and is also known as **endotoxin**. (Endotoxins are the structural component of bacteria, which is released after bacterial cell lysed.)

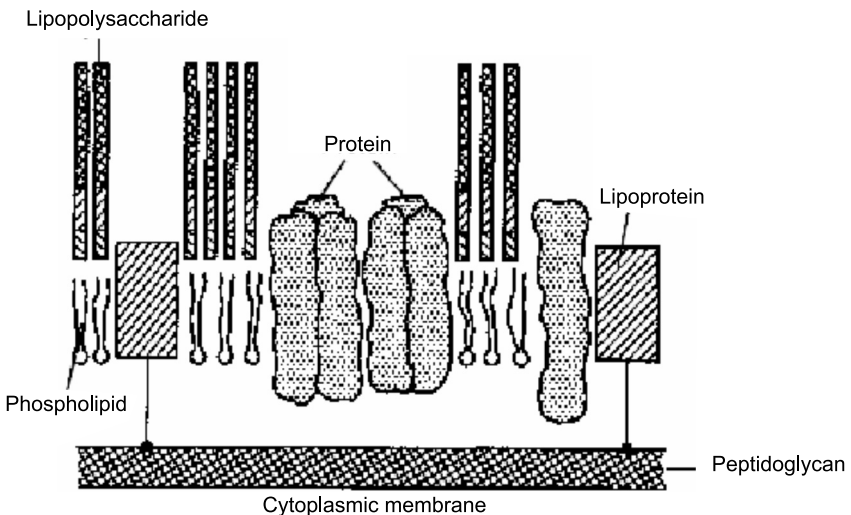


Fig. 2.3. Diagram showing detailed structure of the envelope of a gram-negative bacteria.

Cytoplasmic membrane: The bacterial cytoplasmic membrane is composed of a phospholipid bilayer which is 5 to 10 nm in thickness and has all the general functions of a cell membrane such as acting as a permeability barrier for most molecules and serving as the location for the transport of molecules into the cell.

It acts as a semipermeable membrane controlling the inflow and outflow of metabolites to and from the protoplasm. In this function, plasma membrane has selective permeability.

(**Note:** Staining of bacteria depends upon the chemical and physical nature of cytoplasmic membrane and cytoplasm.)

Mesosome: The outer membrane of cytoplasm forms much coiled invagination called mesosome. The surface of mesosome has many respiratory enzymes, which takes part in respiration. It is absent in eukaryotic cells.

Nucleus: In prokaryotes nuclear membrane and nucleolus are absent. It contains a single chromosome consisting of a circular DNA filament. The genetic material DNA is present in the cytoplasm without histon proteins.

Ribosomes: Bacteria contain a group of ribosomes called polyribosomes present in the cytoplasm of the cell. It is 70S type in bacterial cell having two subunits—the large unit is 50S and the smaller unit 30S. Ribosomes help in protein synthesis.

Flagellum: The bacterial flagella are a long, filaments and whip-like structures that produce through the cytoplasmic membrane and are responsible for motility. The flagella are nothing but surface appendages invariably found in **motile bacteria**, and appear generally as **filaments** having diameter ranging between 12–20 μm and length between 6–8 μm . It is only about 0.01 to 0.02 μm thick. A flagellum has three basic parts:

Basal body: It is embedded in the cell envelope.

Hook: The flagellar hook is a single peptide unit. It penetrates the cell wall and connects the main filaments to the hook at the surface.

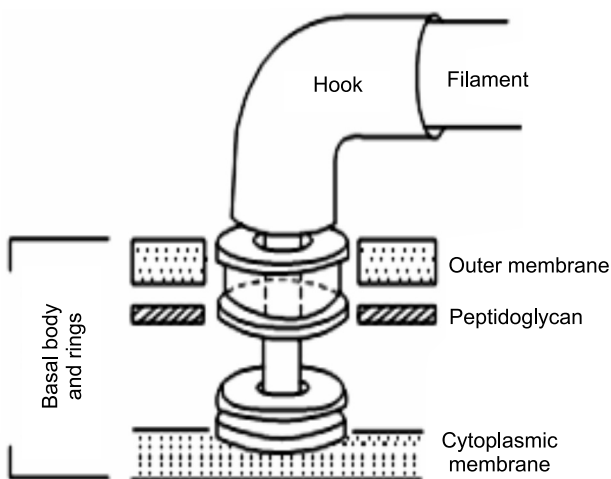


Fig. 2.4. Structure of bacterial flagella.

Filaments: The filaments lie external to the cell and remain connected to the hook at the surface. Filament is composed of a protein called flagellin which has a characteristic to connect just like myosin. It does not have any ATPase activity.

On the basis of the number and position of flagellum bacteria are divided into the following forms:

- (i) **Atrichous:** Bacteria without flagella. e.g., *Pasteurella*.
- (ii) **Monotrichous:** One flagellum is present at one end, e.g., *Vibrio*, *Pseudomonas thiobacillus*.
- (iii) **Lophotrichous:** Two or more flagella are present at one end, e.g., *Spirillum serpens*.
- (iv) **Amphitrichous:** Flagella are present at both the ends, e.g., *Nitrosomonas*.
- (v) **Peritrichous:** Flagella are found in whole body, e.g., *E. coli*, *Clostridium tetani*.

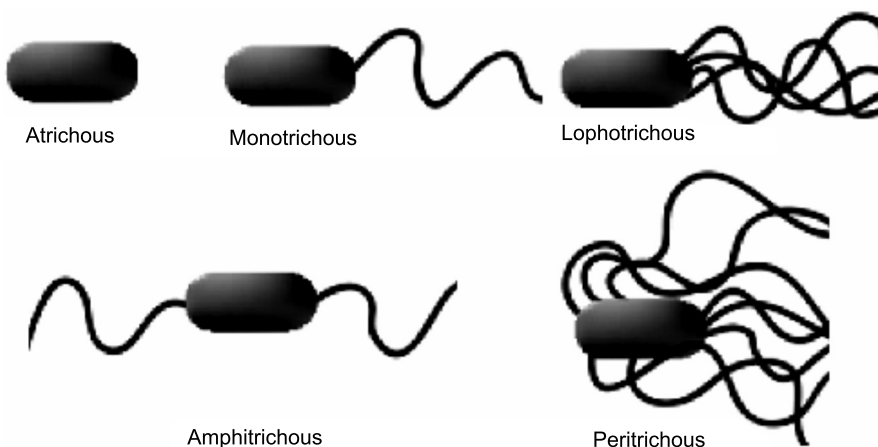


Fig. 2.5. Structure of different types of flagella.

Function of Flagella

1. Flagella are fully responsible for the bacterial motility.
2. Deflagellation by mechanical means renders the motile cells immotile.
3. The apparent movement of the bacterial cell usually takes place by the rotation of the flagella either in the clockwise or anticlockwise direction along its long axis.
4. Bacterial cell possesses the inherent capacity to alter both the direction of rotation and the speed; besides, the meticulous adjustment of frequency of 'stops' and 'starts' by the appropriate movement of the flagella.
5. Evidently, the flagellated peritrichal bacteria usually swim in a straight line over moderate distances. In actual practice, these swim-across straight line runs are interrupted frequently by abrupt alterations in the direction that ultimately leads to tumbling. Therefore, the movement of the bacteria is believed to be zig-zag.

6. It has been observed that the phenomenon of smooth swimming in a fixed direction is invariably mediated by the rotation of flagella in an anticlockwise direction; whereas, the process of tumbling in a zig-zag direction is usually caused by the rotation of flagella in a clockwise direction.
7. The presence of '**polar flagella**' in bacteria affords a distinct change in the direction that usually takes place by the reciprocal alteration in the direction of rotation.

Pili

Pili are hollow, non-helical, shorter and thinner than flagellum and are used for attachment and than for motility. On the basis of function at least 8 types of pili are present. A special type of pili is the F pili or sex pili helps in transfer of genetic material during bacterial mating.

2.3 SHAPE OF BACTERIAL CELL

Morphologically, three distinct forms of bacteria are recognized.

1. Spherical
2. Rod shaped or cylindrical
3. Spiral

2.3.1 Spherical (Cocci)

These are spherical in shape and commonly known as cocci. Majority of bacteria are cocci in their shape. They are of different types.

Cocci →

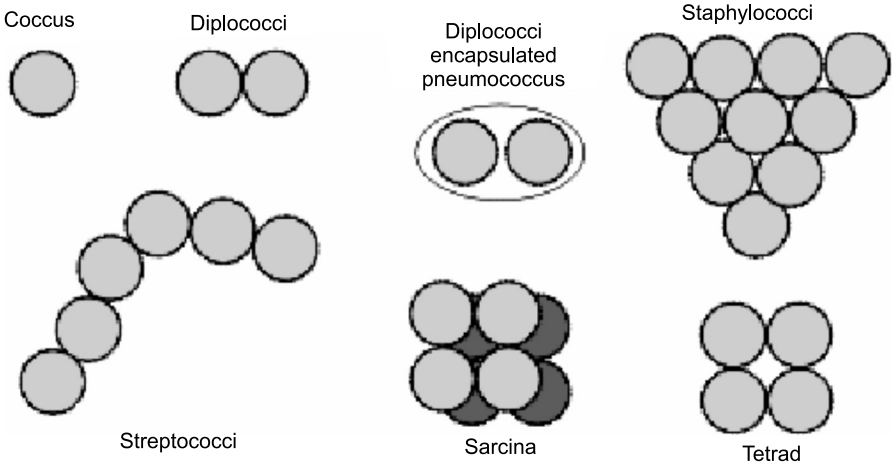


Fig. 2.6. Structure of different forms of cocci.

2.3.3 Spiral

Such type of bacteria have one or more twists, they are not straight.



Fig. 2.8. (A) Vibrio (B) Spirilla (C) Spirochete.

- a. **Vibrio:** These are small and comma-shaped bacteria, e.g., *Vibrio cholerae* which cause cholera.
- b. **Spirilla:** These are coiled and twisted like a screw, e.g., *Spirillum rubrum*.
- c. **Spirochetes:** These are highly coiled, e.g., *Spirochete stenostrepta*.

Structure of Eukaryotic cell

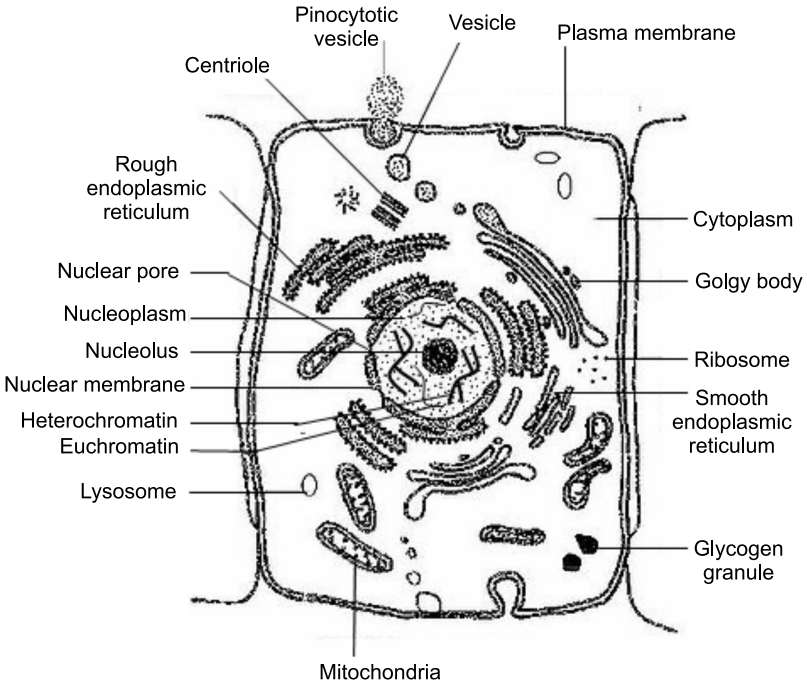


Fig. 2.9. Structure of animal cell.

