Dr. Sushil. K. Singh

Structure of Bacteria

Characteristics of bacteria

- Bacteria are prokaryotic cell belongs to kingdom Monera. Bacteria are usually single celled organism that lack nucleus.
- DNA is naked. This means the genetic material (DNA) in bacteria is not bound within the nucleus.
- The bacterial chromosome is located in irregular shaped region called nucleoid.
- Bacteria may contain extra chromosomal small circular DNA known as plasmid.
- They lack membrane bound organelles. Bacterial cell consist of cytoplasm, small 70S ribosome, nucleoid and plasma membrane surrounded by a cell wall.
- The cell wall of bacteria is made up of peptidoglycon also known as murein.
- Some bacteria have flagella and mostly they are reproduced by binary fission.

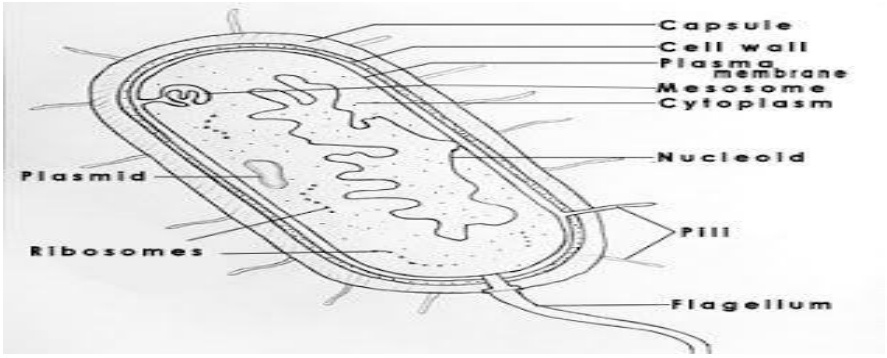


Fig- Bacterial cell

Size and Shape of Bacteria

Bacteria are so small that they can only be seen with microscope. The size of bacteria ranges from 0.2-1µm in diameter to 3.0-5.0µm in length. Typical bacterial cell may be of five basic shapes.

1. **Spherical**- The spherical bacteria is also known as cocci. They are available in following arrangements.

a) **Coccus or monococcus**- single spherical cell.
b) **Diplococcus**- coccus bacteria arranged in pair.
c) **Streptococcus or Enterococcus**- Cocci arranged in chain
d) **Tetrad**- Cocci arranged in square (4 cells)
e) **Sarcina**- Cocci arranged in club of Eight (4+4 cells)
f) **Staphylococcus**- Cocci arranged in a grape like cluster.

2. **Rods** - Rods are rectangular bacterial cells called as bacilli. They are arranged in following ways.

a) **Bacillus**- Single cell
b) **Diplobacilli**- Chain of two bacilli.
c) **Streptobacilli**- Chain or string of bacilli.

3. **Vibrio**- A comma shaped bacteria.
4. **Spirillum**- A rigid helical or spiral shape.
5. **Spirochetes**- A flexible helical shape.

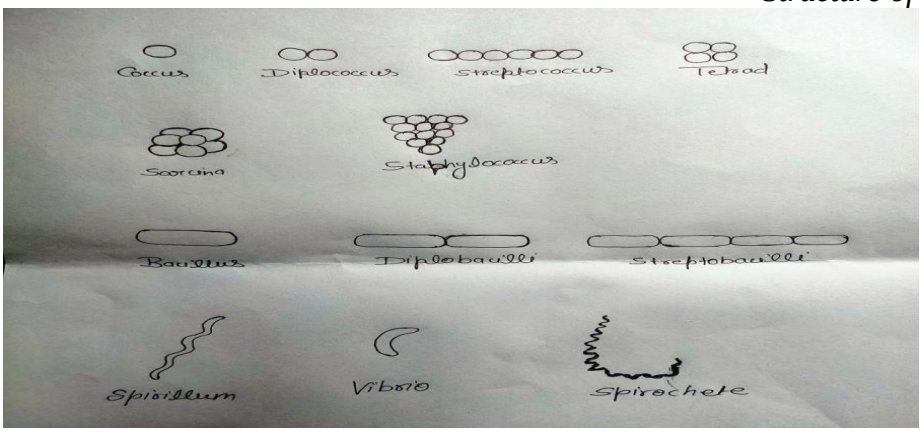


Fig- Shape and arrangement of bacterial cell

Structure of bacterial cell -

1. **FLAGELLA**

Flagella are hair like structures protruding from the bacterial cell wall and are responsible for bacterial motility (i.e. movement). It is made up of protein flagellin. Flagellum is morphologically differentiated in to three parts.

Filament- The outer most region of flagellum is known as filament. This is helical and longer than the bacterial cell. It is composed of flagellin protein and end with a capping portion.

Hook- It connects filament with basal body and is slightly wider than the filament. Hook of gram positive bacteria is longer than gram negative bacteria.

Basal body- The basal body consists of a small rod which is inserted in to a system of ring. Gram positive bacteria have only two rings i. e. S ring (Stator ring) in periplasmic space and M ring (motor) embedded in cytoplasmic membrane. In addition with S and M ring gram negative bacteria have two more rings- L ring in lipopolysaccharide layer and P ring in peptidoglycon layer.

The bacterium flagellum is driven by motor engine made up of protein located at flagella anchor point of the inner cell membrane. The engine is powered by proton motive force. Flagella rotation can move bacteria through liquid media at speed of up to 60 cell length/sec.

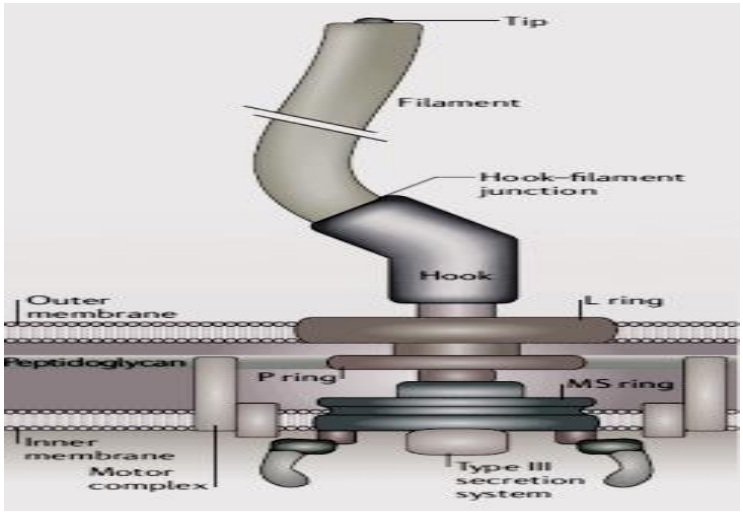


Fig- Structure of Flagella

Arrangement of flagella-

- Atrichous- No flagella
- Monotrichous- One flagella at end of bacterial cell
- Amphitrichous- Several flagella at both end of the cell
- Lophotrichous- Bunch of flagella at one end of bacterial cell
- Peritrichous- Flagella are present on all side of the cell

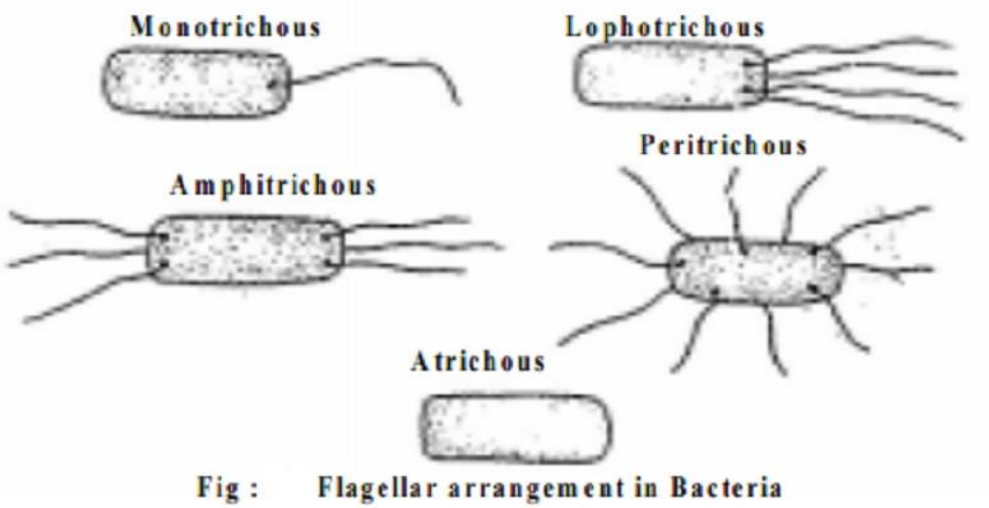


Fig : Flagellar arrangement in Bacteria

2. PILUS (Fimbriae)-

A pilus is hair like appendages found on the surface of many bacteria. They are shorter than the flagella and thicker. Pili are composed of oligomeric protein called pilin. They are involved in conjugation; it forms a bridge that enables transfer of plasmid between two bacterial cells. The term fimbriae are used for common pili that are involved in attachment.

3. CAPSULE Or SLIME LAYER

Many bacterial cells are known to secrete a layer of polymers of simple sugar or polysaccharide outside the cell wall. When this layer is well organised and not easily washed off it is called capsule. When the polysaccharide outside the cell is loosely attached and removed easily it is called slime layer. A slime is loosely attached with bacteria where as a capsule is attached tightly with a bacterium and have definite boundaries.

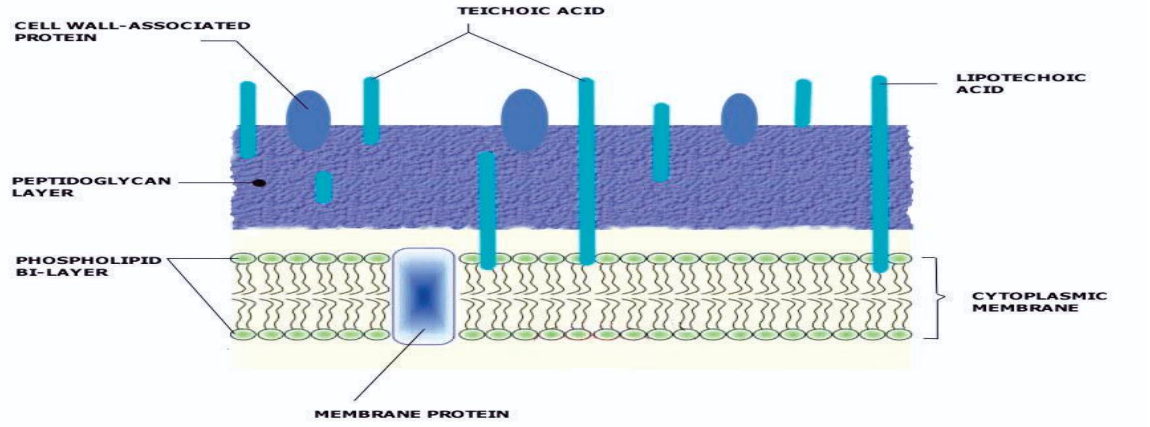
The capsule of *Bacillus anthracis* is made up of polyglutonic acid. Most of capsule are hydrophilic and may help the bacterium to avoid desiccation by preventing water loss. The presence of a capsule in *Streptococcus pneumonae* is the most important factor in its ability to cause pneumonia.

4. CELL WALL-

Cell wall is a rigid structure which gives shape to the bacterial cell and constitutes about 20-35% of the cell weight. The primary function of the cell wall is to protect the cell from internal turgor pressure caused by the much higher concentrations of proteins, and other molecules inside the cell compared to its external environment. The bacterial cell wall differs from that of all other organisms by the presence of peptidoglycan (Murein) which surrounds the cell membrane. Mureins are heteropolymers and are composed of polysaccharide back bone and a small peptide chain. These polymers are N-acetylglucosamine acid (NAG), N- acetylmuramic acid (NAM), L-alanine, D-alanine, D-glutamic acid and L-diaminoacid. Peptidoglycan is responsible for the rigidity of the bacterial cell wall and determination of cell shape. If the bacterial cell wall is entirely removed, it is called a protoplast while if it is partially removed, it is called as spheroplast. Lysozyme and beta-lactam antibiotics such as penicillin inhibit the formation of peptidoglycan cross-links in the bacterial cell wall.

Cell wall of Gram positive bacteria-

Gram-positive cell walls are thick and the peptidoglycan layer constitutes almost 95% of the cell wall in some gram-positive bacteria. The gram-positive bacteria take up the crystal violet dye and are stained purple in gram staining. In addition to Peptidoglycon some bacteria have polysaccharide or teichoic acids. Teichoic acids are found only in gram positive bacteria but not all gram positive bacteria. Teichoic acids are polymer of ribitol phosphate and glycerol phosphate and located in the membrane and the wall. The teichoic acids linked to the peptidoglycon function as antigenic determinants. The cell wall of some gram positive bacteria ex. *Mycobacterium* and *Corynebacterium* are rich in lipid



Cell wall of gram negative bacteria-

The peptidoglycan layer is thinner in gram negative bacteria constitutes about 5-12% of cell wall. They contain an outer membrane that surrounds thin layer of peptidoglycon. The outer membrane of gram negative bacteria is a bilayered structure contains lipopolysaccharides, lipoproteins and proteins. Due to presence of an outer membrane gram negative bacteria are rich in lipid.

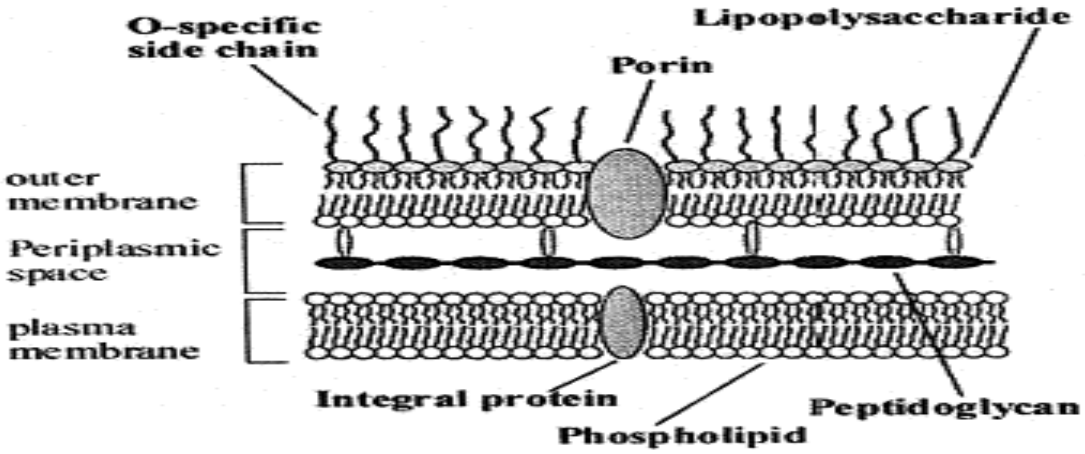


Fig- Gram Negative Cell wall

5. CYTOPLASMIC MEMBRANE

Cytoplasmic membrane is a semi permeable membrane composed of phospholipid (20-30%) bilayer in which most of the proteins (60%) are held. The cytoplasmic membrane also contain various enzyme involved in respiratory metabolism and in the synthesis of cell wall and capsular components.

Cytoplasmic membrane is the site of generation of proton motive force that drive ATP synthesis in many organisms. The membrane contains mechanisms for secreting toxins and certain enzymes into the extracellular medium.

It provides specific site of attachment for genophore and plasmid and plays important role in replication as well as segregation of daughter genophore.

6. MESOSOMES

Many bacteria especially gram positive bacteria possess membrane invaginations in form of a convoluted tubes and vesicles termed as mesosomes. They may appear in the nuclear area, cytoplasm or periphery of the cell. They are surrounded by single membrane. The roles of mesosomes are-

i. They form a site for cellular respiration and respiratory enzymes are also associated with it.
ii. Play a specific role in cross wall or septum formation.
iii. Act as a control centre for cell division.
iv. Serve as organ of attachment for bacterial nucleoid during replication.
v. May also function as an intracellular transport system.

7. CYTOPLASM

The cytoplasmic area appears like a delicate mosaic of ribosome in an aqueous background. Besides ribosomes it also contains protein, water soluble components and reserve materials.

8. RIBOSOMES

In bacteria the most numerous intracellular structure is the ribosome. It is the site of protein synthesis in all living organisms. Bacteria have 70S ribosomes which consist of 60% RNA and 40% protein. The 70S ribosome is made up of 50S and 30S subunits. The 50S subunit contains the 23S and 5S rRNA while the 30S subunit contains the 16S rRNA.

9. GENOPHORE

Rish in 1961 proposed the term genophore to represent bacterial nucleus or chromosome. Bacterial chromosome is located in the irregularly shaped region known as the nucleoid. Usually bacteria carry a single chromosome which has circular DNA. Along with chromosomal DNA, most bacteria also contain small independent pieces of DNA called plasmids that often encode for traits that are advantageous but not essential to their bacterial host. Plasmid can be transferred between bacteria through conjugation process.

9. ENDOSPORES

The spores produced within the bacterial cell are known as endospores. They are thick walled bodies produced by *Bacillus, Clostridium* and other genera. They are very resistant to drying, heat and chemicals. All endospores contain Dipicolinic acid. Unlike other cells, many bacterial spores can survive boiling and must be heated to at least 121°C (steam under pressure) to be killed.

Cellular reserve food material

A large number of water soluble granular inclusions are found in cytoplasm which could serve as cellular reserve materials. These can be divided in to three major categories on the basis of chemical composition and function namely **organic polymer, polymerized inorganic metaphosphate** and **elementary sulphur.**

- The organic polymer can serve as source of carbon energy. The Poly-hydroxy Butyric (PHB) acid is a character of prokaryote. These are fat equivalent and can be stained by sudan black.
- Polymerized inorganic metaphosphate also known as volutin granules are highly refractile and visible in light microscope. They may serve as phosphate reserve material. They are associated with energy metabolism and may have involvement in nucleic acid synthesis.
- Elementary sulphur occurs as reserve in sulphur oxidizing bacteria, They occur in the form of spherical and highly refractile droplets. example- Purple sulphur bacteria