

Lecture: 2

Bacterial Cell

Bacteria: are small unicellular microorganisms, widely distributed in the nature either as free living, normal flora in human or animal body (like enteric bacteria in human intestine) or as a parasites infect human or animals causing important diseases.

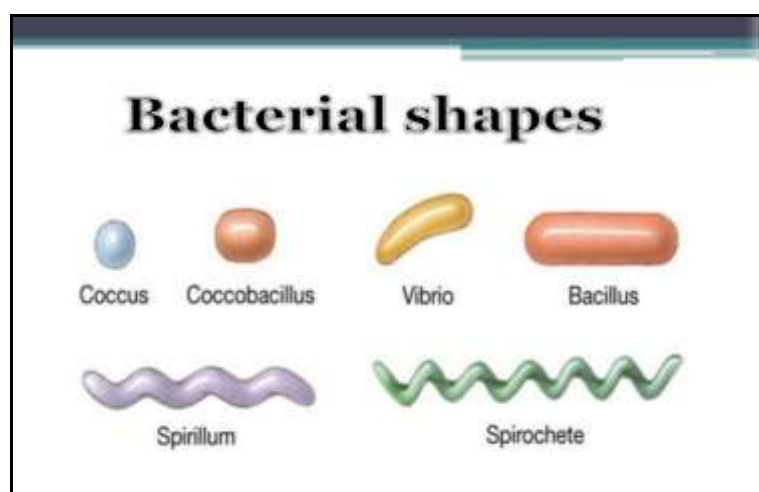
General property:

1. Typical prokaryotic cell
2. Contain both DNA and RNA
3. Most grow in artificial media
4. Replicate by binary fission
5. Almost all contain rigid cell wall
6. Sensitive to antimicrobial agent

Morphology of bacteria

When bacteria are visualized under light microscope, the following morphology are seen.

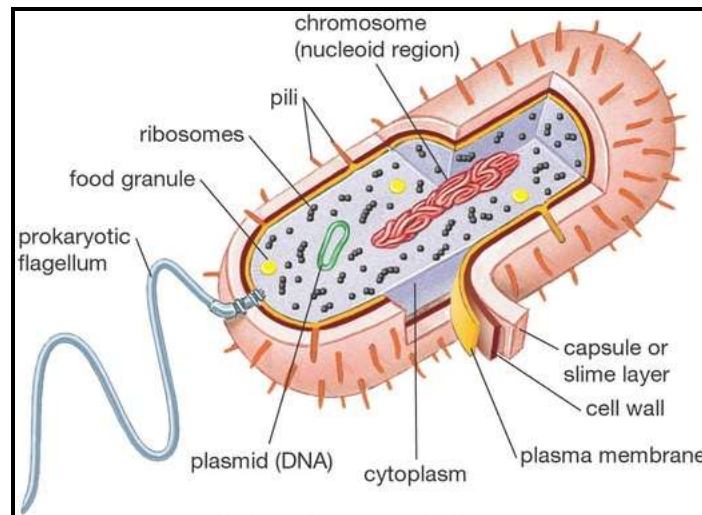
1. Cocci (singular coccus): Round or oval bacteria measuring about 0.5-1.0 μm in diameter. They are found in single, pairs, chains or clusters.
2. Bacilli (singular bacillus): Stick-like bacteria with rounded, tapered, square or swollen ends; with a size measuring 1-10 μm in length by 0.3-1.0 μm in width.
3. Coccobacilli (singular coccobacillus): Short rods.
4. Spiral: Spiral shaped bacteria with regular or irregular distance between twisting. Eg. *Spirilla* and *Spirochaetes*



Structure of Bacteria

Bacterial structure is considered at three levels.

1. Cell envelope proper: Cell wall and cell membrane.
2. Cellular element enclosed with in the cell envelope: Mesosomes, ribosomes, nuclear apparatus, polyamines and cytoplasmic granules.
3. Cellular element external to the cell envelope: Flagellum, Pilus and Glycocalyx.



Ultrastructure of Bacteria

A. Cell wall

Multi layered structure that constitutes about 20% of the bacterial dry weight. Average thickness is 0.15-0.5 μm . It is composed of Peptidoglycan(which is a polymer of N-acetyl Muramic acid and N-acetyl Glucosamine back bones cross linked with peptide chain and pentaglycine bridge).

Components of cell wall of Gram negative bacteria

1. Peptidoglycan.
2. Lipoprotein.
3. Phospholipid.
4. Lipopolysaccharide (LPS).

Components of cell wall of Gram positive bacteria

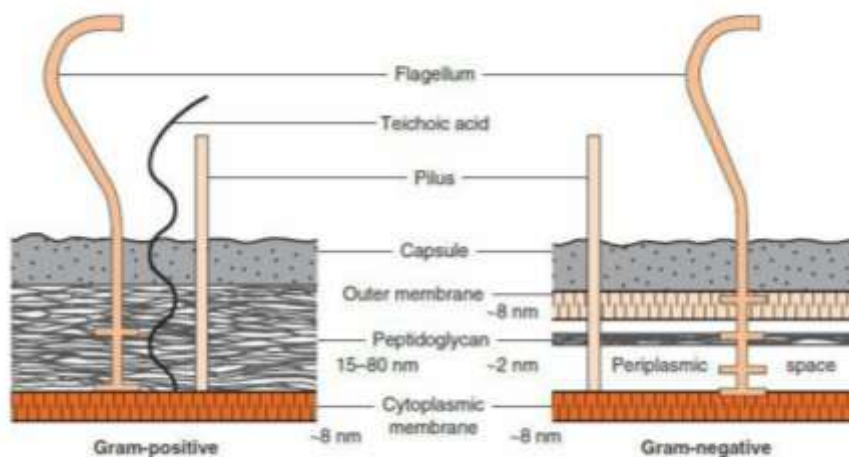
1. Peptidoglycan
2. Teichoic acid (Polymer of glycerol or ribitol phosphate).

Cell Walls of Gram-Positive and Gram-Negative Bacteria

The structure, chemical composition, and thickness of the cell wall differ in gram positive and gram-negative bacteria.

Comparison of Cell Walls of Gram-Positive and Gram-Negative Bacteria

Component	Gram-Positive Cells	Gram-Negative Cells
Peptidoglycan	Thicker; multilayer	Thinner; single layer
Teichoic acids	Yes	No
Lipopolysaccharide (endotoxin)	No	Yes



Cell walls of gram-positive and gram-negative bacteria. Note that the peptidoglycan in gram-positive bacteria is much thicker than in gram-negative bacteria. Note also that only gram-negative bacteria have an outer membrane containing endotoxin (lipopolysaccharide [LPS]) and have a periplasmic space where β -lactamases are found. Several important gram-positive bacteria, such as staphylococci and streptococci, have teichoic acids.

Functions of cell wall

1. Provides shape to the bacterium
2. Gives rigidity to the organism
3. Protects from environment
4. Provides staining characteristics to the bacterium
5. Contains receptor sites for phages/complements
6. Site of action of antibody and colicin
7. Contains toxic components to host (LPS).

B. Cell membrane

Also named as cytoplasmic membrane It is a delicate trilaminar unit membrane. It accounts for 30% of the dry weight of bacterial cell. It is composed of 60% protein, 20-30% lipids and 10-20% carbohydrate.

Function of cell membrane

1. Regulates the transport of nutrients and waste products into and out of the cell.
2. Synthesis of cell wall components
3. Assists DNA replication
4. Secretes proteins
5. Carries on electron transport system
6. Captures energy in the form of ATP

Cellular element enclosed with in the cell envelope

A. Mesosomees :

Convolute invagination of cytoplasmic membrane often at sites of septum formation. It is involved in DNA segregation during cell division and respiratory enzyme activity.

B. Ribosomes

Cytoplasmic particles which are the sites of protein synthesis. It is composed of RNA(70%) and proteins(30%) and constitutes 90% of the RNA and 40% of the total protein. The ribosome monomer is 70s with two subunits, 30s and 50s.

C. Cytoplasmic granules

Represent accumulated food reserves, according to their nature they are :

- ✓ Glycogen
- ✓ Poly-beta hydroxy butyrate
- ✓ Babes-ernst (Volutin)

D. Nuclear Apparatus

Bacterial genome consists of single molecule of double stranded DNA arranged in a circular form. Besides nuclear apparatus, bacteria may have extra chromosomal genetic material named as plasmids.

Plasmids do not play any role in the normal function of the bacterial cell but may confer certain additional properties (Eg. Virulence, drug resistance) which may facilitate survival and propagation of the microorganism.

3. Cellular element external to the cell envelope

A. Glycocalyx (Capsule and Slime layer)

Capsule is gel firmly adherent to cell envelope. Slime is gel easily washed off from cell envelope. All bacteria have at least a thin slime layer. Capsule is composed of polysaccharide and protein (D-Glutamate of *Bacillus anthracis*)

Features of Capsule

1. Usually weakly antigenic.
2. Not necessary for viability.

3. Endows virulence.
4. Protects from phagocytosis.
5. Capsulated strains are invariably non-motile.
6. Visualized by negative staining and capsule staining.
7. Detected by quellung phenomenon.

B. Flagellum

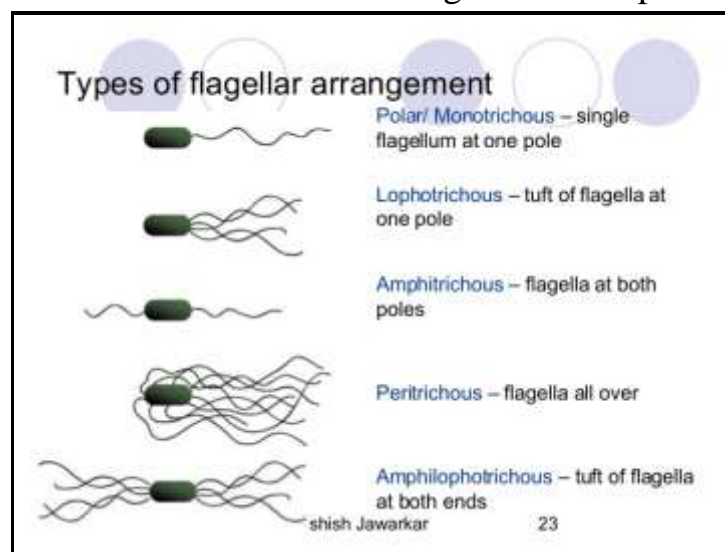
It is the organ of locomotion in bacterial cell and consists of three parts: The filament , The hook and The basal body. Their presence in bacterial cell is detected by

- ✓ Hanging drop preparation
- ✓ Swarming phenomenon on surface of plate agar
- ✓ Motility media
- ✓ Special staining methods
- ✓ Silver impregnation methods
- ✓ Dark –field microscopy
- ✓ Electron microscopy

Size: 3-20 μm in length and 0.01-0.013 μm in diameter. It is composed of protein named as flagellin. The flagellar antigen in motile bacterium is named as H (Hauch) antigen.

Flagellar arrangements

1. Atrichous: Bacteria with no flagellum.
2. Monotrichous: Bacteria with single polar flagellum.
3. Lophotrichous: Bacteria with bunch of flagella at one pole.
4. Amphitrichous: Bacteria with flagella at both poles.
5. Peritrichous: Bacteria with flagella all over their surface.
6. Amphiphotrichous: Bacteria with bunch of flagella at both poles.



C. Pili (fimbriae)

It is hair like structure composed of protein (pilin)

Two types (Based on function)

- Common pili: The structure for adherence to cell surface.
- Sex pili: The structure for transfer of genetic material from the donor to the recipient during the process of conjugation.

D. Spores

Bacterial spore is smooth walled and oval or spherical in shape. It does not take up ordinary stains. It looks like areas of high refractivity under light microscope. It is significant in spread of disease and indicator of sterility of materials. Spores are detected by

- . Simple staining methods
- . Special staining methods