L2:Structure and function of bacterial cell

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Structure and function of bacterial cell

Bacteria are single-celled prokaryotic microorganisms, and their DNA is not contained within a separate nucleus as in eukaryotic cells. and exist in various shapes, including spheres (cocci), curves, spirals and rods (bacilli). These characteristic shapes are used to classify and identify bacteria.

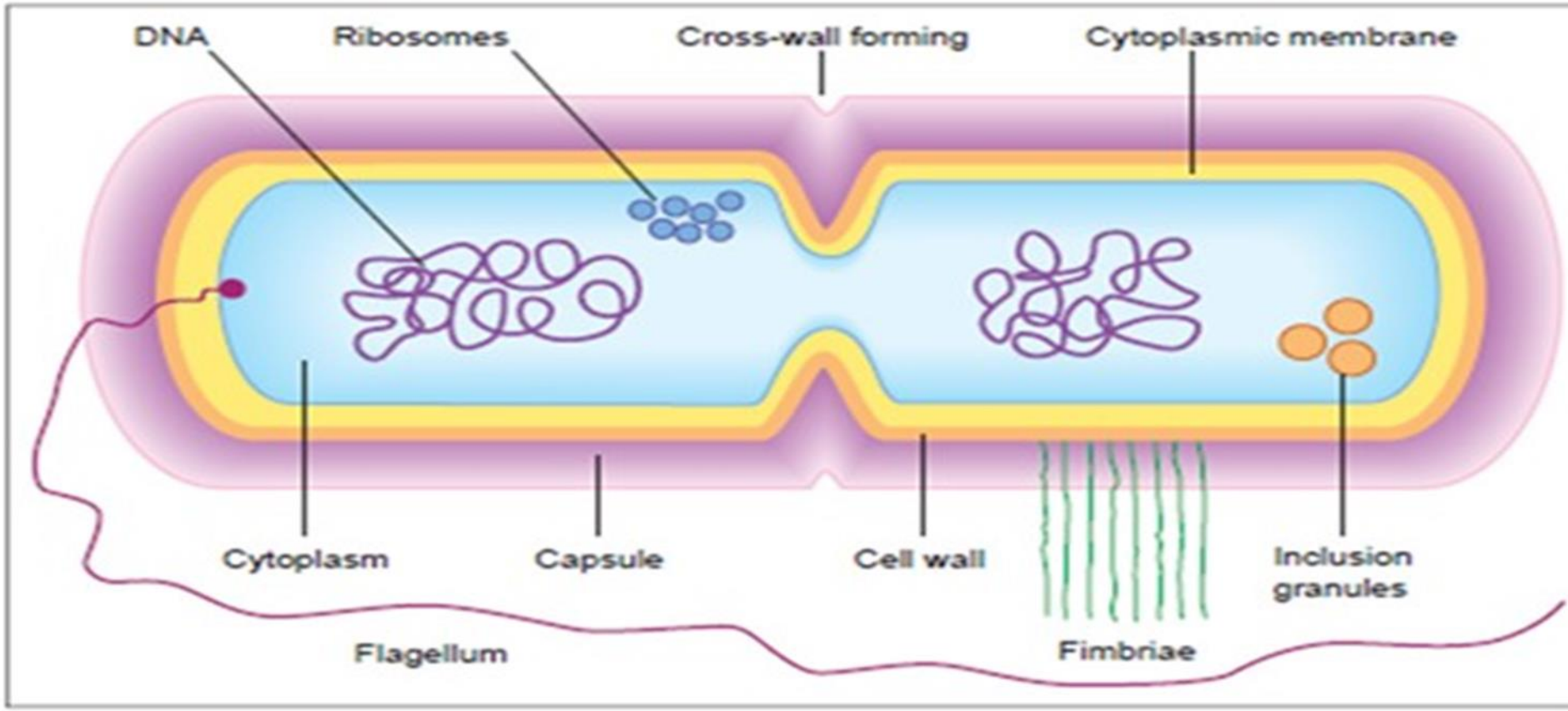
A bacterial cell have essential structural components : cell wall, cytoplasm membrane , intra cytoplasm structure and cell surface appendages (capsule , flagella , fimbriae , spore). The biochemical compositions of these structures are macromolecules are arranged or sequenced in primary – structure of molecule in which the subunits are put together such as:

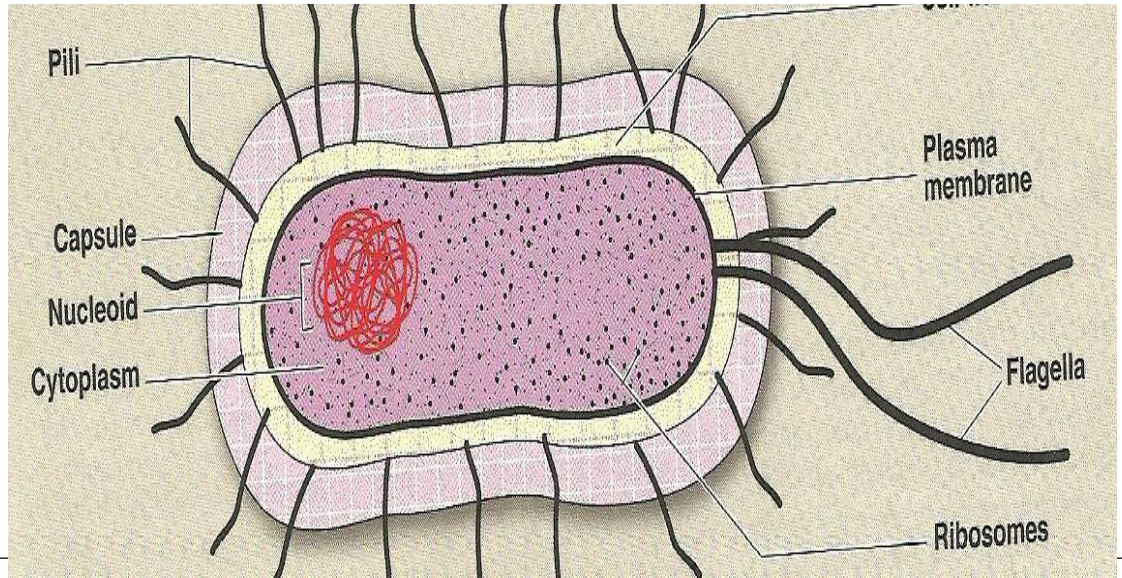
DNA, RNA ---------- Nucleotides

Protein ---------- amino acid

Phospholipid ------- fatty acid

Polysaccharide ------- sugars


DNA
Ribosomes
Cross-wall forming
Cytoplasmic membrane
Cytoplasm
Capsule
Cell wall
Inclusion granules
Flagellum
Fimbriae


Pili
Plasma membrane
Capsule
Nucleoid
Cytoplasm
Flagella
Ribosomes

Structure and function of bacterial cell

Cell wall

The bacteria are surrounding by rigid cell wall. The principle structural component of cell wall is peptidoglycan. **The cell wall consists of polymer of two sugar derivatives N- acetylglucosamine and N-acetylmuramic acid cross linked by short chains of amino acids (peptide), this molecule is a type of peptidoglycan called murein** Peptidoglycan (PG) is complex of polysaccharide and polypeptide. Most bacteria are classified according to reaction of Gram stain with components of cell wall into major groups; Gram positive & Gram negative bacteria based on staining properties. Gram stain developed in 1884 by Christian Gram ,the most widely employed in bacteriology lab.

A. Gram positive bacteria cell wall composed of :

This layer is very thick in G +ve bacteria constituting 50-80nm of cell wall and responsible for the rigidity of cell wall and retention of crystal violet dyes during the Gram stain procedure. The large amounts of PG make Gram positive bacteria susceptible to antibiotics (penicillin) that inhibit cell wall synthesis.

-**Teichoic acid** and thin layer of lipid .Other cell-wall polymers, including **teichuronic acids** and **proteins**, are also present(Figure 1.4 a).

B- Gram negative bacteria cell wall composed of :

-have Inner layer of peptidoglycan.This layer is thin constituting of (5-10) nm of cell wall which cannot retain the crystal violet stain.

-have **outer membrane or Lipopolysaccharides (LPS)** that differs in structure from the cytoplasmic membrane (Figure 1.4b).

-LPS containing of lipid A (endotoxin) and polysaccharide are characteristic feature of Gram-negative bacteria

The **LPS** on its outer face, **phospholipids** on its inner face, proteins and lipoproteins which anchor it to the peptidoglycan.

Porins are a group of proteins that form channels through which small hydrophilic molecules, including nutrients, can cross the outer membrane.

-Periplasmic space between the inner and outer layers

It is filled with gel and is crossed by lipoprotein molecules to link the peptidoglycan layer and LPS layer, and no teichoic acid.

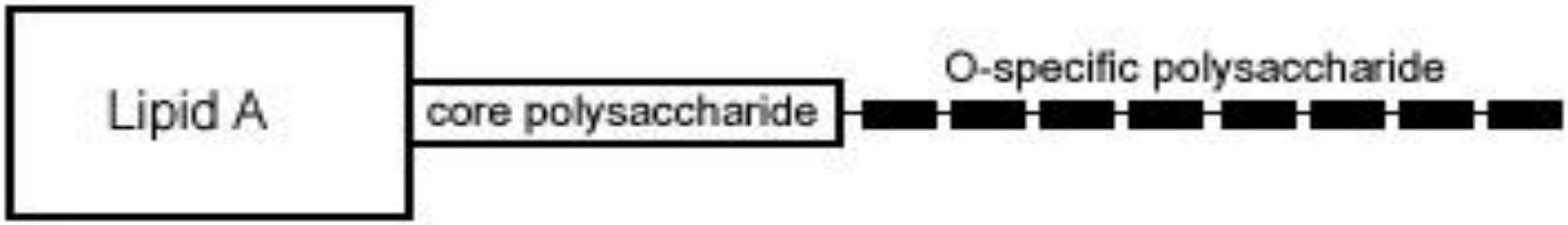


Fig. LPS in Gram negative bacteria

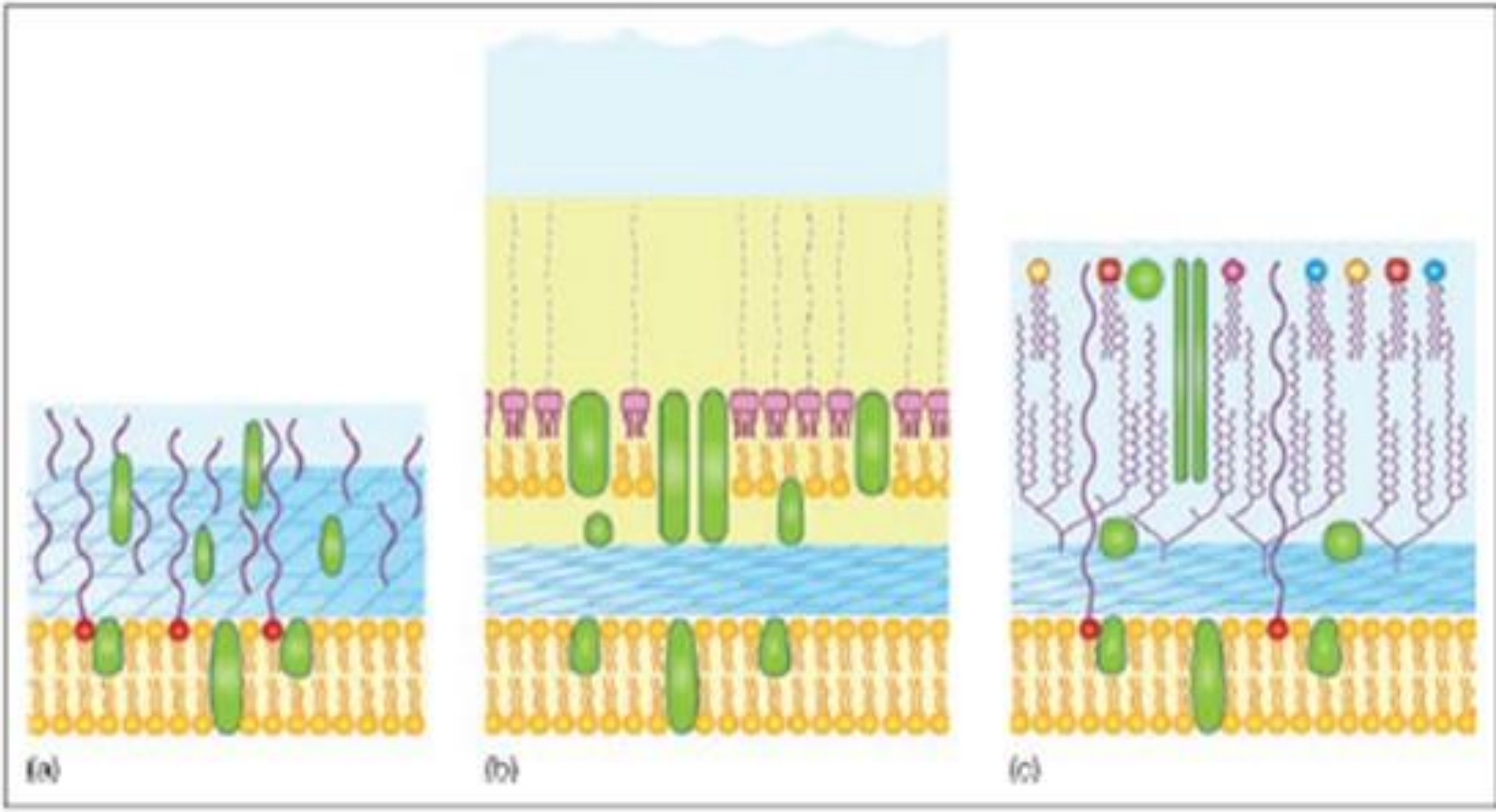
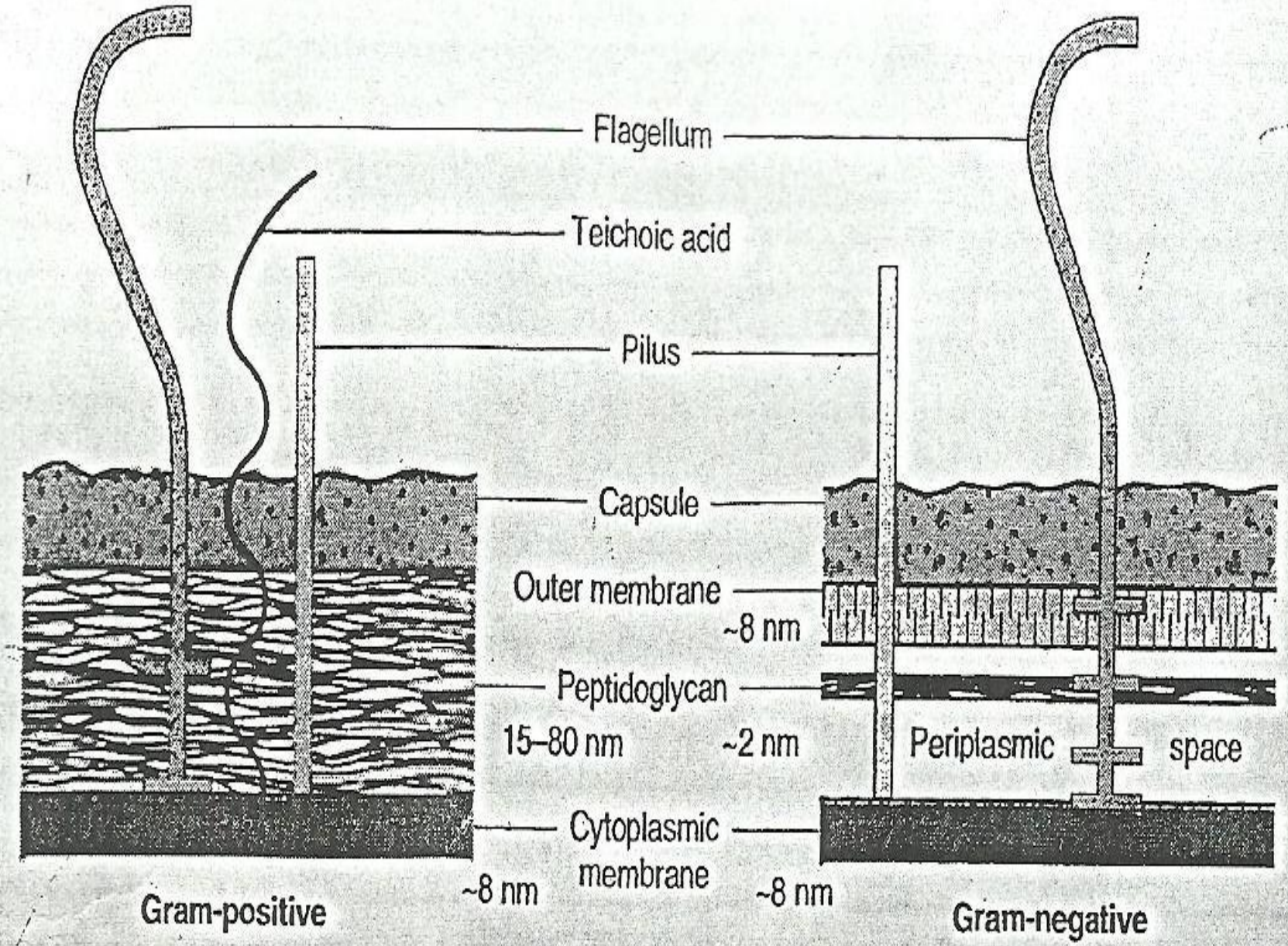


Figure 1.4 Cell wall and cytoplasmic membrane of (a) Gram-positive bacteria, (b) Gram-negative bacteria and (c) mycobacteria. The Gram-positive bacterial cell wall has a thick peptidoglycan layer with associated molecules (teichoic acids, teichuronic acids and proteins). The Gram-negative bacterial cell wall contains lipopolysaccharides, phospholipids and proteins in an outer membrane linked to a thin inner peptidoglycan layer. The mycobacterial cell wall contains long chain length fatty acids (mycolic acids).


Flagellum
Teichoic acid
Pilus
Capsule
Outer membrane
~8 nm
Peptidoglycan
15–80 nm
~2 nm
Periplasmic space
Cytoplasmic membrane
~8 nm
~8 nm
Gram-positive
Gram-negative

Mycobacteria have a distinctive cell wall structure and composition that differs from that of Gram-positive and Gram-negative bacteria. It contains peptidoglycan but has large amounts of high molecular weight lipids in the form of long chain length fatty acids (mycolic acids) attached to polysaccharides and proteins. This high lipid content gives the mycobacteria their acid fast properties (retaining a stain on heating in acid), which allows them to be distinguished from other bacteria (e.g. positive Ziehl-Neelsen stain).

Function of cell wall:

-Protection the internal structures.

-It maintains the shape of bacterial cell.

-Contain component which toxic to host cell.

- It plays a role in cell division

Example on cell wall deficient bacteria

a- *Mycoplasma*

This is naturally deficient in cell wall. ***Mycoplasma*** is pleomorphic shape and not affected by penicillin treatment

b- L- forms

Some of bacteria under certain condition are fail in synthesis of cell wall when the cells is subjected to penicillin drug or lysozymes.

Cell membrane (plasma membrane):

Cell membrane is composed of two layers of lipid (the lipids linked to proteins and to polysacchrides). It is located under cell wall.

Gram negative bacteria have inner and outer mem., whereas Gram positive bacteria have only inner cell membrane. The space between inner and outer membrane called periplasmic space. Outer cell membrane of Gram negative bacteria is composed of lipopolsaccharide (LPS) and lipoproteins. LPS acts as endotoxine.

Function of cell membrane

1. Control on inflow of metabolites from cell by control on active transport of molecules into cell because it has selective permeability.
2. Energy generation by oxidative phosphorylation.
3. Secretion of enzyme and toxin.
4. Synthesis of precursors of cell wall (have important role in synthesis of cell wall).

- **Nucleoid**

The bacterial genome consists of a single chromosome. It is not surrounded by nuclear membrane. Some bacteria have small, circular of DNA (plasmid) as free in cytoplasm.

- **Ribosome**

It is composed of several RNA and proteins. The 70s unit is composed of two small subunits (50s and 30s), while eukaryotic ribosome is consist of 80s (60s and 40s).

The important role of it:

1. The ribosome are site of protein synthesis.
2. The differences in rRNA and protein constitute of bacteria, the basis of selective action of several antibiotics (tetracycline) that inhibit bacterial protein synthesis.

External structures

- **External structures**
- **A – Capsule**
- Some bacteria have capsule. It is a gelatinous layer covering the entire bacterium, may be composed polysaccharide or poly peptide. Encapsulated bacteria grow as " smooth " colonies , where as colonies of bacteria that have lost their capsules appear “rough”. Some bacteria produce slime to help them to stick to surfaces , usually made up from polysaccharides, produced by streptococcus mutants enables stick to the surface of teeth, were helps to form plaque , leading to dental carries.

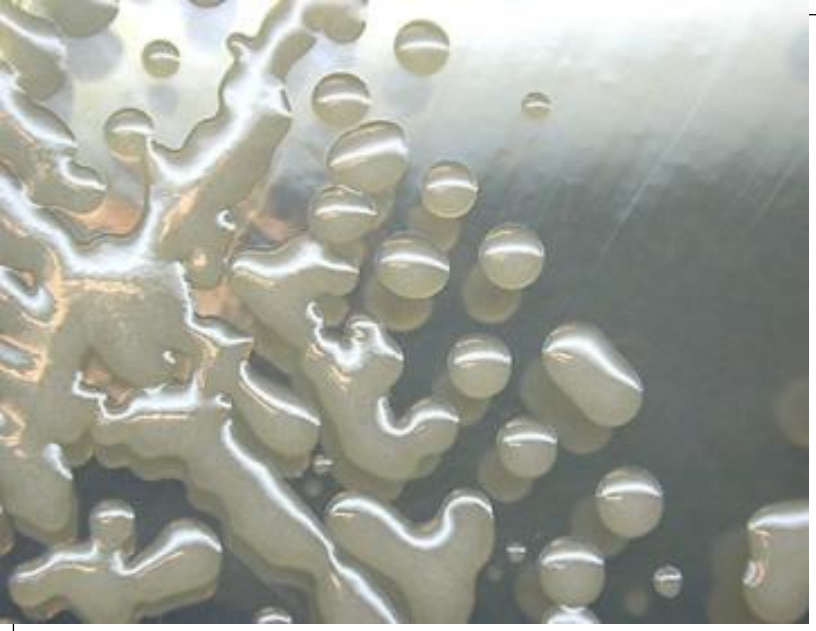


Fig. slime of bacteria

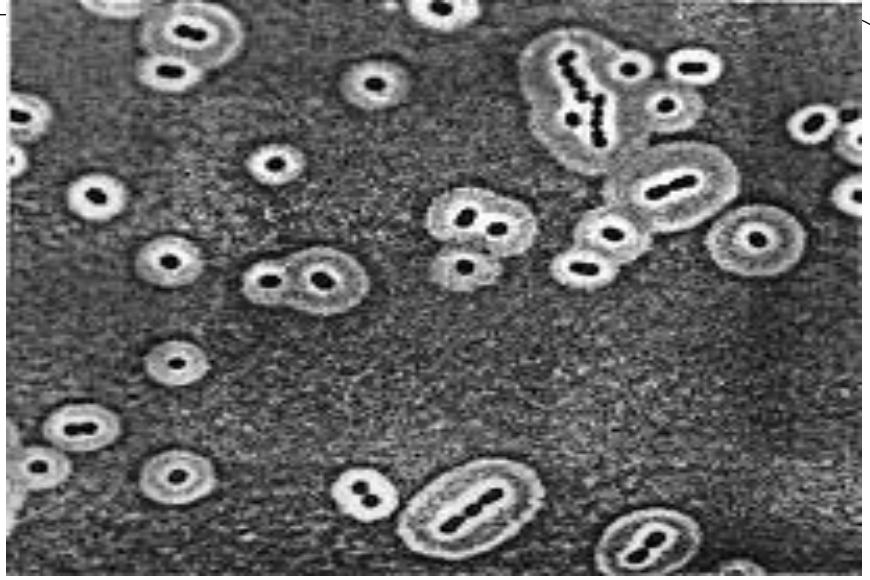


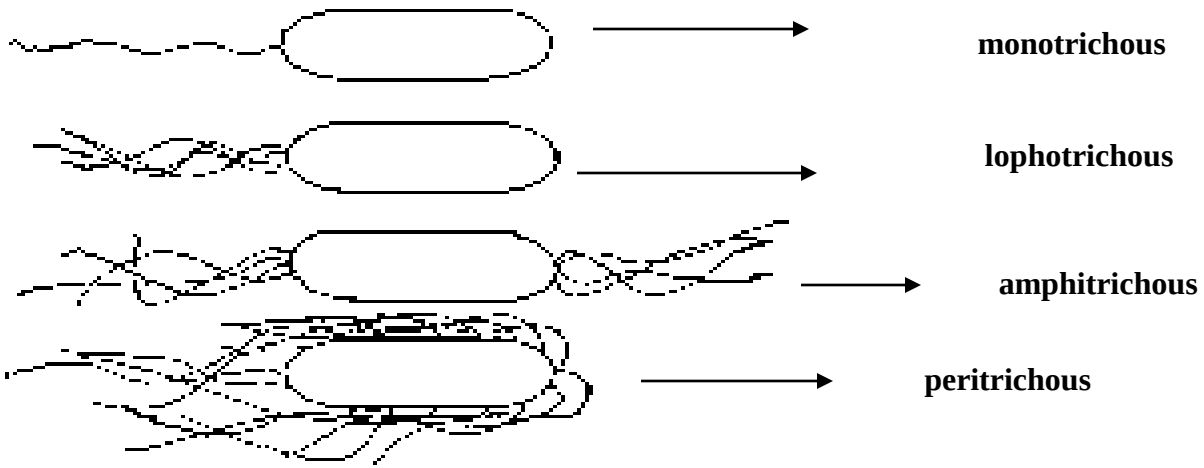
Fig. bacterial capsule

Capsule importance:

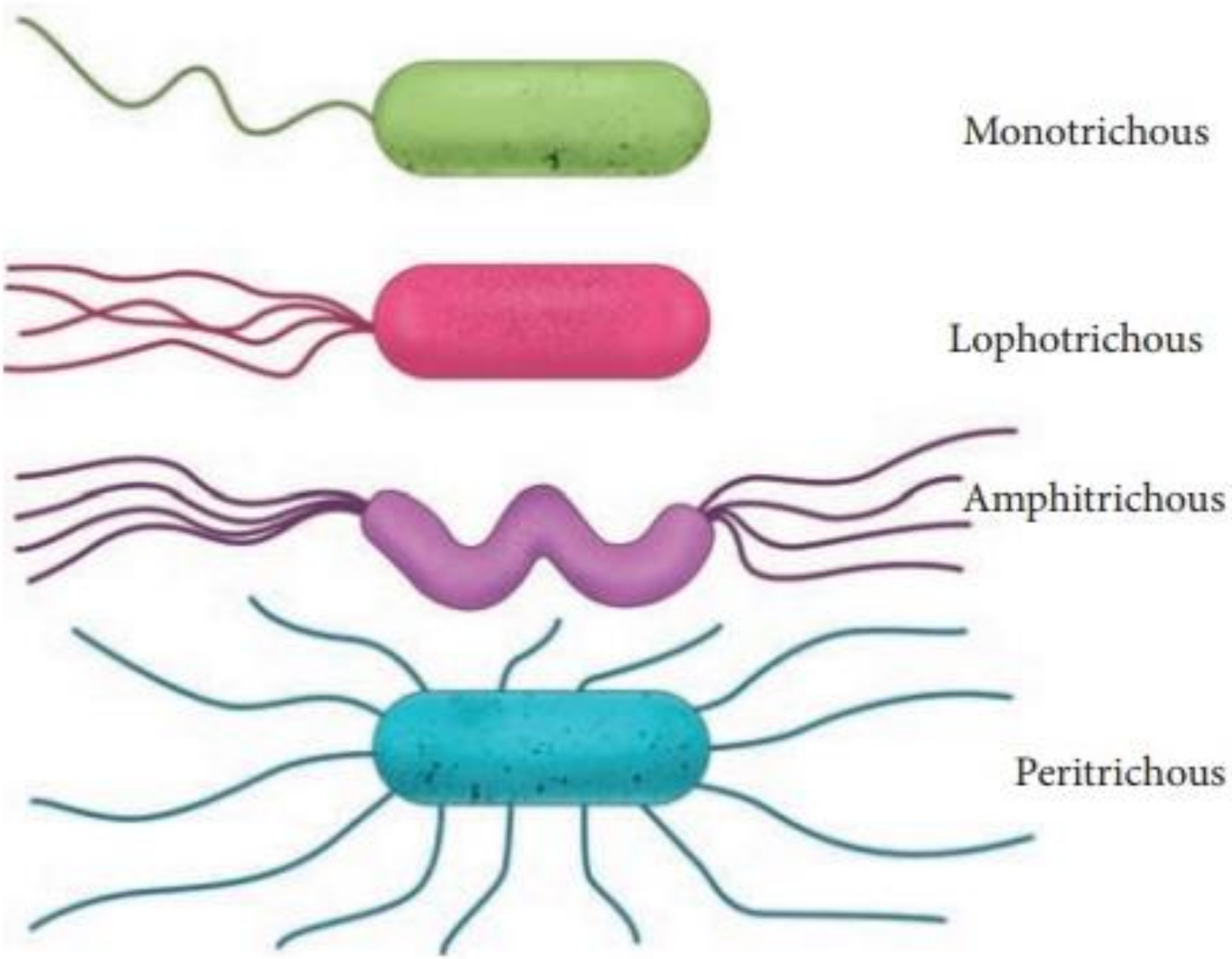
- Protection against deleterious agents (Lytic enzyme).
- Contribute to virulence of many bacteria (inhibiting phagocytosis) &it play role in adherence of bacteria to human tissues, helping to prevent the bacterial cell from being killed.
- It is used as antigen (K- antigen) in certain vaccines.
- Specific identification of MO.

B-Flagella:

An extra cellular long thin filamentous structure responsible for motility of pathogenic bacteria, can play role in production of disease because has an antigenic property. Most rod bacteria have flagella (motile), while most cocci are non motile. Bacterial cells may carry a single flagellum described **monotrichous**. If the single flagellum at one end of a rod – shaped cell it is known as a polar flagellum. if the bacterium carries a single tuft of flagella it is said to be **lophotrichous** When the tuft appears at both ends of the cell, the bacteria is **amphitrichous**. Bacteria that are covered all over body in flagella are said to be **peritrichous** as shown in the figure below.



Flagella Type



C- Pili (Fimbriae)

It is hair like filaments that extend from cell membrane. They are shorter and straighter than flagella. They are found mainly in Gram negative bacteria helps to stick to body surfaces (Fig) .

They are two types of pilli divided according to their **functions** :

-Ordinary pili which play a role in attachment of mucous membrane (specific receptor) on human cells.

-Sex pili their function was transfer DNA between conjugated bacteria

D. Storage granules

The cytoplasm contains granules which represent accumulation of food or energy reserve e.g. the **metachromatic granules**

Spores

Some bacteria can develop a highly resistant structure called endospore as a response to unfavorable growth environmental condition such as radiation , heat , and desiccation for ex., ***Clostridium , Bacillus.*** The spore is formed inside the parent vegetative cell incorporating the nuclear material ,acquiring a thick covering layer is called cortex and an outer spore coat that contains calcium and is impermeable to water as shown in figure . Spores may vary in :

-Shape : oval or round.

-Site : terminal , sub terminal or central as seen in figure below .

-Size : the same size or bulging of the vegetative cell .