MEDICAL MICROBIOLOGY

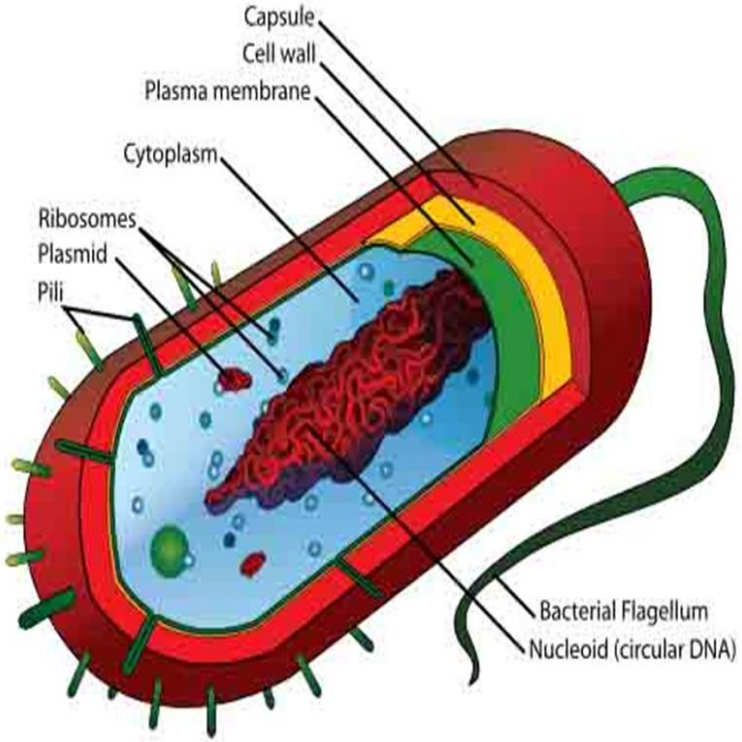
LEC. 2
STRUCTURE OF BACTERIAL CELL

By:
Lecturer Shaima'a Al-Salihy

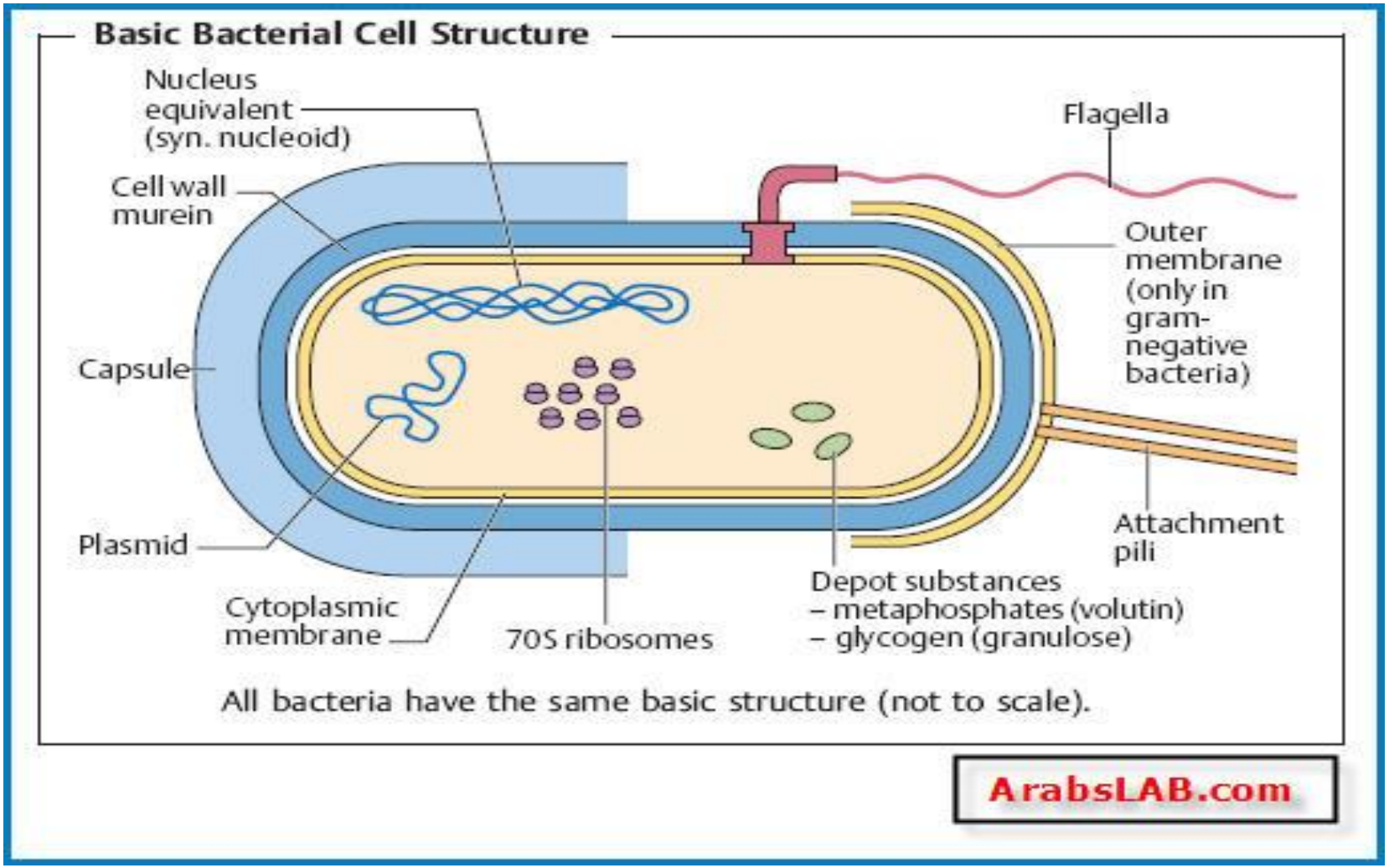
Structure of Bacterial Cell

The principal structure of a typical bacterial cell can be divided into three main groups:

- **Cell envelope:** consist of:
- Cell wall
- Cytoplasmic membrane
- **Protoplasm:**
- Cytoplasm
- nucleoid
- Ribosomes
- Mesosomes
- Inclusion granules
- Vacuoles
- **Additional components** outside the cell wall (capsule, glycocalyx, pili, flagella) or inside the bacterial cell (plasmid and endospore)



Basic Bacterial structure



❑ The cell envelope

The layers surround the bacterial cell are referred collectively as cell envelope. The structure & composition of cell envelope is differing between G positive & G negative bacteria.

❖ G positive cell envelope:

It composed of, the cytoplasmic membrane and a thick peptidoglycan layer (15-80 nm in diameter); some bacteria have an outer layer either capsule or S-layer.

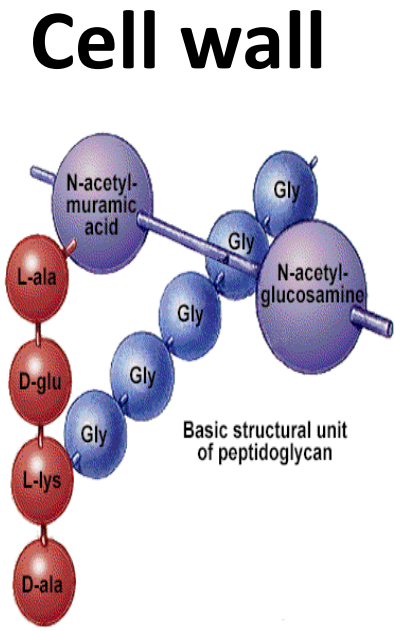
❖ G negative cell envelope:

This is a highly complex, multilayer structure. The cytoplasmic membrane is called the **inner membrane** surrounded by single sheet of **peptidoglycan** (2 nm in diameter) to which is anchored a complex layer called **outer membrane**. The outermost capsule or S-layer may also be present. The space between the inner & outer membrane is called **periplasmic space**.

❖ Cell wall:

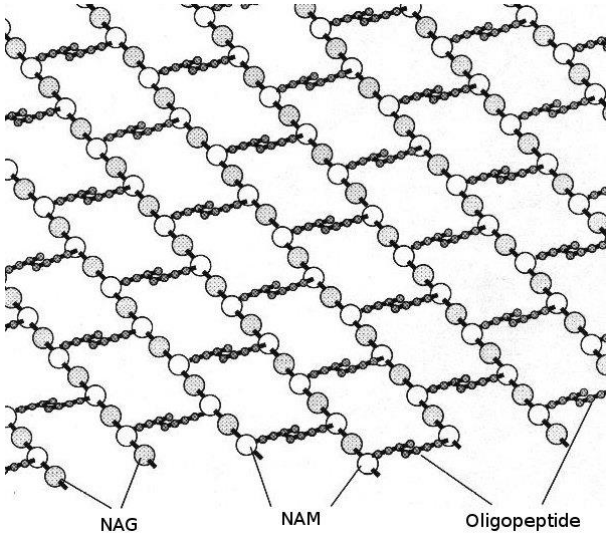
The rigid outer covering of the bacterial cell.

It composed of huge mucopeptide polymer formed by N-acetyl glucoseamine and N-acetyl muramic acid linked alternatively by peptide in a chain. Called **PEPTIDOGLYCAN**.



Function of the cell wall:

1. Give shape and rigidity of the cell and supports the weak cytoplasmic membrane.
2. Osmotic protection
3. It plays an important role in cell division.
4. It is the site of major antigenic determinants of the cell surface.
5. It is a good target for antibiotic treatment.
6. In G negative, it is responsible for the non-specific endotoxin.



Special components of G +ve cell wall:

1. teichoic & teichuronic acids:

These are water-soluble polymers found within the cell wall of Gram-positive bacteria. Functions of teichoic acids are:

1- Provide rigidity to the cell-wall by attracting cations such as magnesium and sodium.

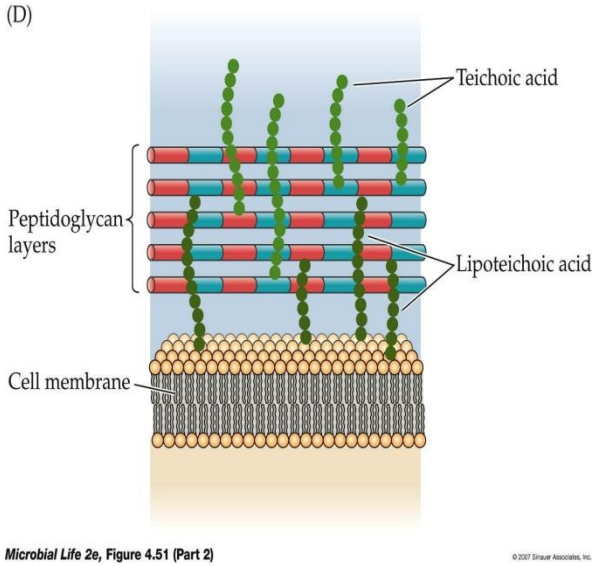
2- Assist in regulation of cell growth by limiting the ability of autolysin to break the bond between the *N*-acetyl glucosamine and the *N*-acetylmuramic acid.

- Lipoteichoic acids also act as receptor molecules for some Gram-positive bacteriophage.

2. polysaccharides:

These include certain neutral sugars e.g. mannose, arabinose & galactose which exists as subunits of polysaccharide in the cell wall**.**

Special components of G + & G - cell wall



Special components of G -ve cell wall:

1. Outer membrane: it is bilayered structure; its inner leaflet resemble cell membrane and the outer leaflet composed of a lipopolysaccharide (LPS).

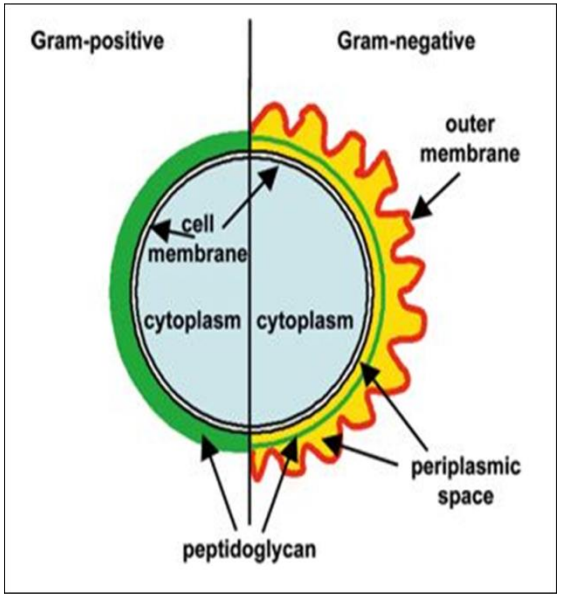
2. Lipopolysacharride: it is extremely toxic to animals called the **endotoxin**. It composed of three distinct units:

a- A phospholipid called lipid A: responsible for the toxic effect.

b- A core polysacharride of five sugars linked to lipid A,

c- An outer polysaccharide repeating units represent the major surface antigen called **O antigen**.

Special components of G + & G - cell wall



Special components of G -ve cell wall:

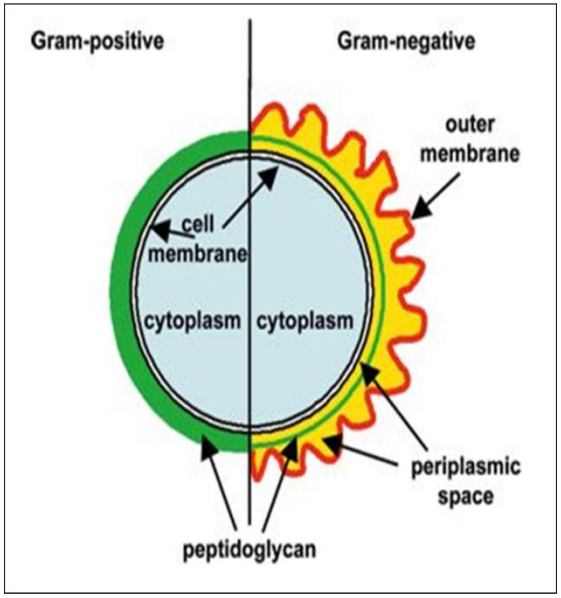
3. lipoprotein:

Molecules of lipoprotein, its function is to stabilize the outer membrane & anchor it to the peptidoglycan layer.

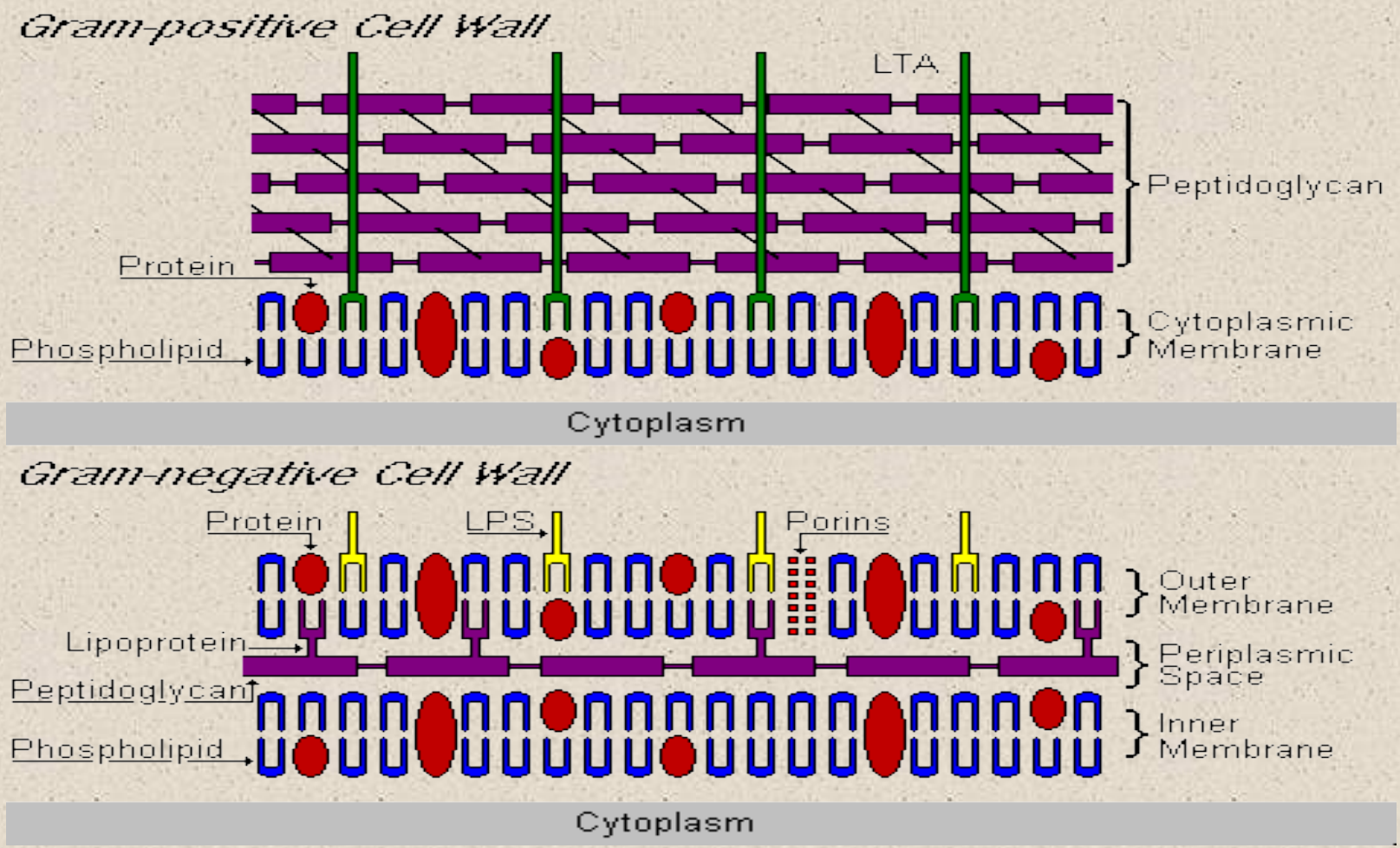
4. The perplasmic place:

The space between the inner and outer membranes, contains peptidoglycan layers and gel like solution of proteins. It constitute approximately 10-20% of the cell volume.

Special components of G + & G - cell wall



Comparison between G+ & G- cell wall



❖ The cytoplasmic membrane:

It composed of phospholipid bilayer similar to that in eukaryotic cells, lies just inside the peptidoglycan layer of the cell wall. The membranes of prokaryotes are distinguished from those of eukaryote cells by the absence of sterols(except Mycoplasma).

Functions of cytoplasmic membrane:

1. **Permeability and active transport of molecules into the cells.**
2. **Energy generation by phosphorylation.**
3. **Synthesis of precursors of the cell wall.**
4. **Secretion of enzymes and toxins.**

❖ Mesosomes:

-They are invaginations of the plasma membrane into the cytoplasm forming twisted multilayered vesicular structures.

- They are important during cell division when it functions as the origin of transverse septum that divides the cell in half.

❖ Cytoplasm and cytoplasmic structure:

It is a viscous watery solution which has many organic and inorganic solutes. It contains certain structures such as ribosomes, mesosomes, inclusion granules and vacuoles.

It has two distinct areas when seen in electron microscope:

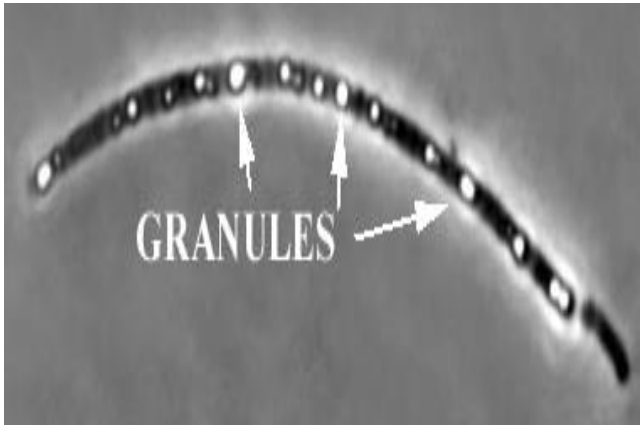
1- an amorphous matrix: contains ribosomes, nutrient granules, metabolites, and plasmids.

2- an inner area: nucleoid region composed of DNA.

A- Granules: storage areas for nutrients, and stain characteristically with certain dyes and aids in identification.

B- Ribosomes: the site of protein synthesis, and the differ from eukaryotic ribosomes in size and chemical composition.

Cytoplasmic structures



C- Nucleoid:

- Is the area of cytoplasm in which DNA is located. It is equivalent to eukaryotic nucleus.
- The nuclear membrane & mitotic apparatus are absent.
- Bacterial DNA consist of a single continuous circular molecule (single haploid chromosome).
- The DNA is associated at one end with mesosome. This attachment thought to play a role in the separation of the two sister chromosomes following chromosomal replication.

D- Plasmids:

- They are extrachromosomal, double stranded, circular DNA molecules that are capable of replicating independently of the bacterial chromosome.
- They can be transferred from one bacterium to another through conjugation.
- They are responsible for properties like toxigenicity and drug resistance.

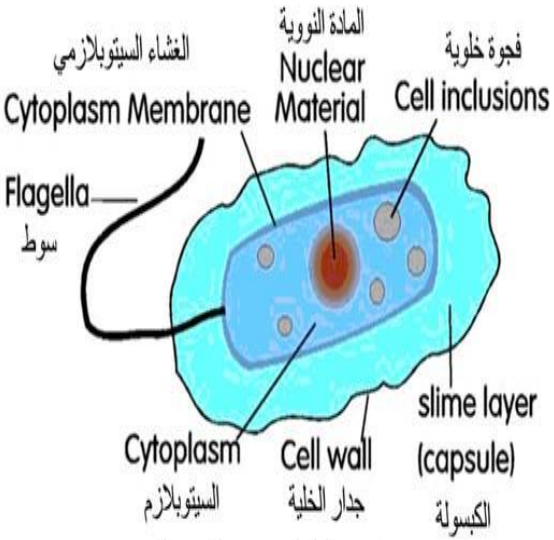
❖ Additional components outside the cell wall:

1- Capsule is a gelatinous layer surrounding the bacterial cell. This layer usually composed of polysaccharide with one exception, the capsule of *B. anthracis* is poly D-glutamic acid.

The importance of capsule:

- Virulence factor since it resist phagocytosis.
- Specific identification of microorganism made by using antiserum against the capsular polysaccharide (quellung reaction).
- Capsular polysaccharides are used as antigens in certain vaccines.
- May play an important role of adherence of bacteria to host tisues.

2- Glycocalyx is a loss meshwork of polysaccharide layer covering the cell. It play a role in the adherence of bacteria to surfaces in the environment.

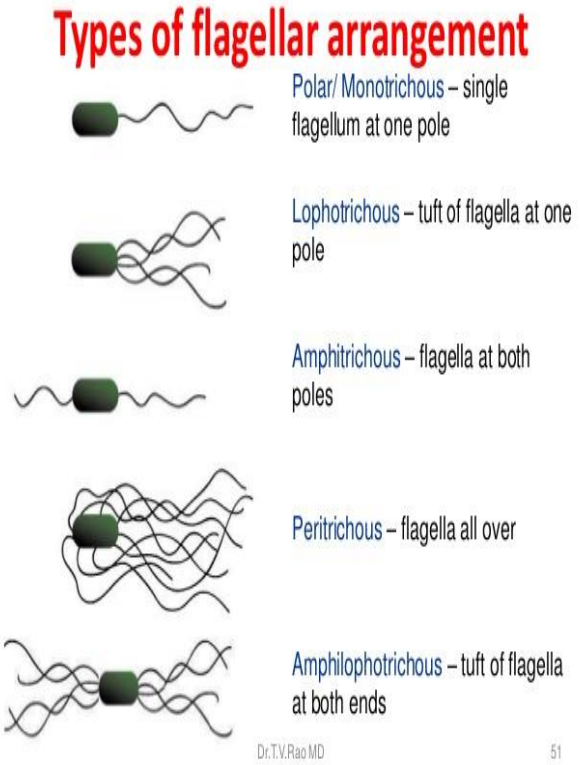


تركيب الخلية توضح الكبسولة

❖ Additional components outside the cell wall:

3- Flagella (flagellum):

Bacterial flagella are long, thread-like extensions composed entirely of protein, that moves the bacteria toward nutrients and other attractants in a process called **chemotaxis**. Three types of arrangement are recognized:



Medical Importance of flagella:

- May play an important role in UTI causing bacteria by propelling the bacteria up the urethra into the bladder

- Specific identification by using specific antibody against flagellar protein.

4- Pilli (fimbria):

Many G negative bacteria possess rigid surface appendages called **pilli** (hair) or **fimbriae** (fingers). They are shorter & finer than flagella, & composed of structural protein subunits called **pillin**. It is responsible for the attachment of bacteria. Two types of pilli are exist:

- **Ordinary pilli**: which play a role in the adherence of symbiotic or pathogenic bacteria to host cell, & considered as a virulence factor.
- **Sex pilli**: which responsible for the attachment of donor & recipient cells in bacterial conjugation.

➢ Endospore:

The spore is a resting cell that is highly resistant to desiccation, heat & chemical agents that is formed under unsuitable environmental conditions by a process called **sporulation**.

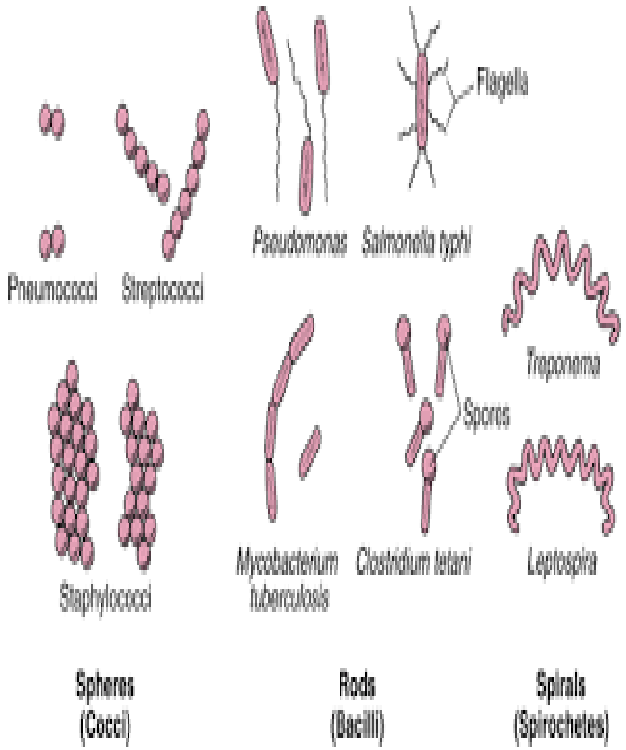
*** Germination:**

The return of the spore to its vegetative bacteria called germination. It occurs in three stages; activation, initiation & outgrowth.

Classification of bacteria may depend on **structural, physiologic, biochemical or genetic criteria**, of these are:

1. **Shape and arrangement**
2. **Spore formation:** spores are specialized cell structure that may allow survival of bacteria in unsuitable environments.
3. **Fermentation of carbohydrate.**
4. **Gram staining:** is an effective criterion that divide bacteria into gram positive and gram negative bacteria.
5. **Genetic criteria**

Bacteria



Appearance of bacteria

1. Size:

Bacteria of medical importance generally measure 0.2- 1.5 μ in diameter and 3-5 μ in length.

2. Shape:

The shape of cell is determined by its rigid cell wall and can be divided to:

- Cocci: spherical or oval cell
- Bacilli: rod shaped cell
- Spirochetes: spiral-shaped
- Pleomorphic: many-shaped.

Appearance of bacteria

3. arrangement:

It is determined by the orientation and the degree of attachment of bacteria at the time of cell division.

- Pair (diplococci)
- Chain (streptococci)
- Cluster (staphylococci)