LEC. : 3 Structure of Bacteria Dr. Selda S. Yaseen

Bacteria are Prokaryotes , lacking well defined nuclei and membrane bound organelles, and with **chromosomes composed of a single closed DNA circle** . They come in many shapes and sizes, from minute spheres , cylinders and spiral threads, to flagellated rods, and filamentous chains.

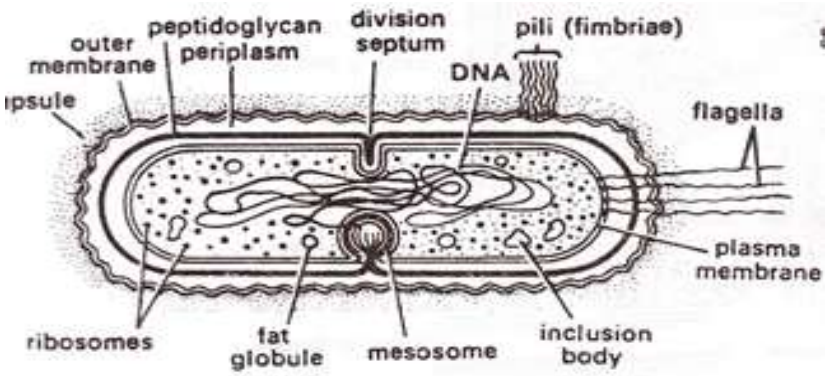


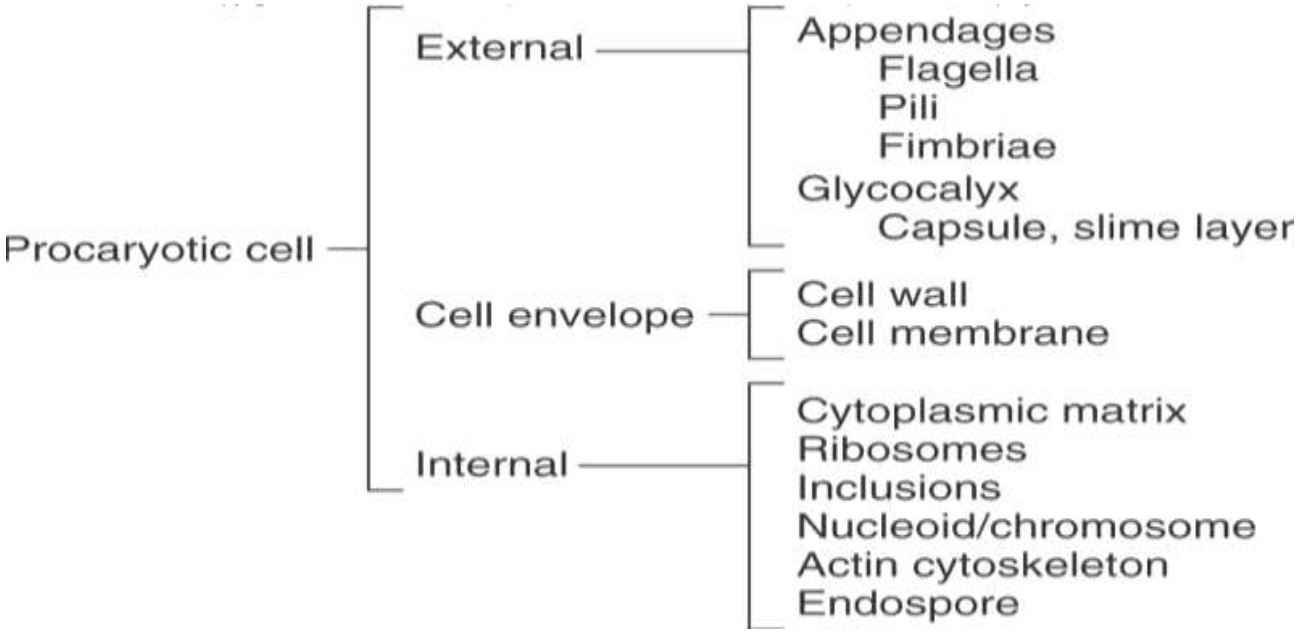
Fig. 302. Structure of a typical bacterial cell.

Essential Structures

- Cell wall
- cell membrane
- Cytoplasm
- Nuclear material .

Particular Structures

- Capsule
- Flagella
- Pili
- Spore



Cell Envelop (External)

—The cell envelope is all the layers from the cell membrane outward, including the cell wall , the periplasmic space, the outer membrane, and the capsule .

—- All free-living bacteria have a cell wall

—- Periplasmic space and outer membrane are found in Gram-negatives bacteria .

—- The capsule is only found in some strains .

Cell wall .

Situation : outmost portion . (15-30) nm in thickness, 10%-25% of dry weight.

Cell wall : The main component of the bacterial cell wall is Peptidoglycan layer a hydrated, semi-rigid polymer of two sugar derivatives : N-acetyl glucosamine acid and N- acetyl Muramic acid , Both discovered in Gram positive and Gram negative bacteria .

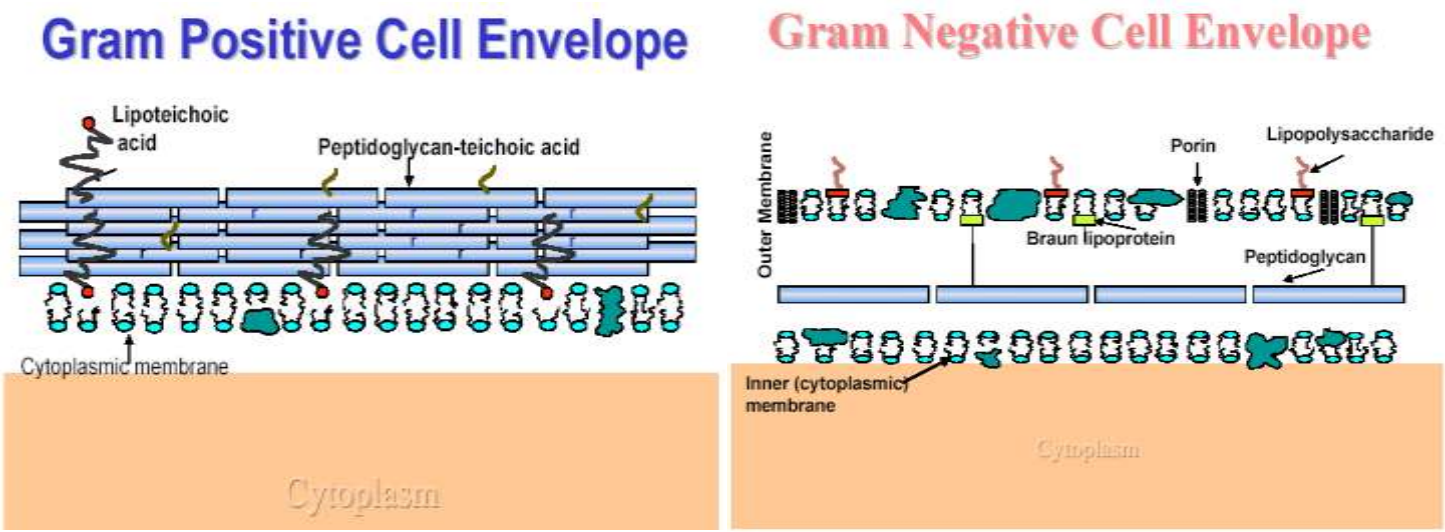
Special component of Gram positive cell wall is :- Teichoic acid .

Special components of Gram negative cell wall :- Lipopolysaccharide .

An endotoxin that may become toxic when released during infections .

Functions of Cell Wall .

- Maintaining the cell's characteristic shape- the rigid wall compensates for the flexibility of the Phospholipids membrane and keeps the cell from assuming a spherical shape .
- Countering the effects of osmotic pressure .
- Providing attachment sites for bacteriophages .
- Providing a rigid platform for surface appendages- flagella, Fimbriae, and pili all emanate from the wall and extend beyond it .
- Play an essential role in cell division .
- Resistance of Antibiotics .



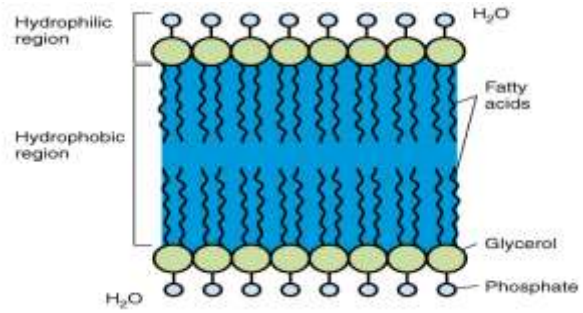
The main differences between Gram + & Gram bacteria .

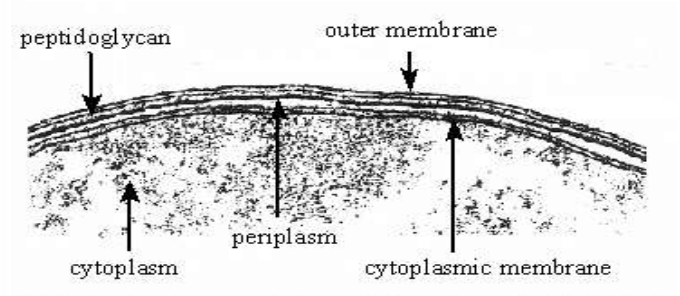
Bacterial component	Gram +	Gram -
Outer membrane	–	+
Cell wall	Thicker	Thinner
LPS	–	+
Endotoxin	–	+
Teichoic acid	Often present	-
Sporulation	+	–
Lysozyme	Sensitive	Resistant
Penicillin	Sensitive	Resistant
Capsule	Sometimes	Sometimes
Exotoxin	Some	Some

Cell Membrane .

Cytoplasmic membrane is a thin (5-10 nm) layer lining the inner surface of the cell wall. It separates the cell wall from the cytoplasm. Chemically, the Cytoplasmic (plasma) membrane consists of lipoprotein with small amounts of carbohydrates. The lipid may reach up to 30% and protein up to 75%. Some vesicular, pocket-like structures are formed as invaginations of the Cytoplasmic membrane into the cytoplasm. These are called mesosomes. They are supposed to be the principal sites of respiratory enzymes , **General characteristic** are :-

- Bilayer Phospholipid
- Site of biosynthesis of DNA, cell wall polymers and membrane lipids. Selective permeability and transport of solutes into cells
- Electron transport and oxidative phosphorylation
- Water can penetrate





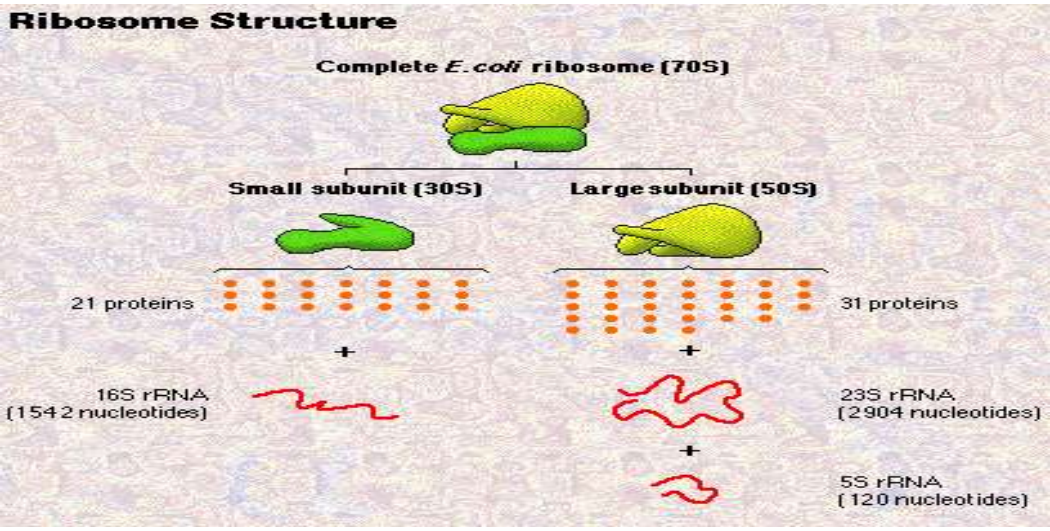
INTERNAL STRUCTURE

1- Cytoplasm

- Composed largely of water, together with proteins, nucleic acid, lipids and small amount of sugars and salts .
- 70-80% water .
- Serves as solvent for materials used in all cell functions .

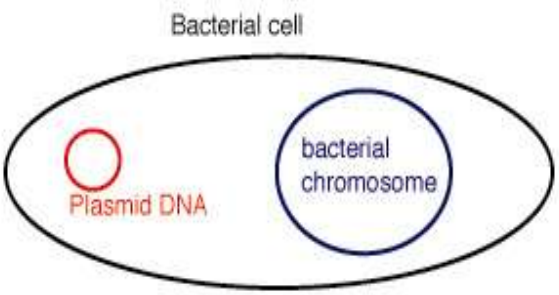
2- Ribosome

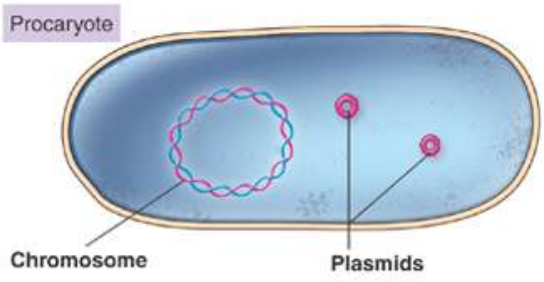
- made of 60% ribosomal RNA and 40% protein .
- consist of two subunits : large (50S) and small (30S) .
- prokaryotic differ from eukaryotic ribosomes in size and number of proteins .
- Site of protein synthesis .
- present in all cells .
- sensitive to streptomycin and erythromycin site of protein synthesis .



3- Plasmid .

Plasmids are small , circular/ line , extra chromosomal , double-stranded DNA molecules。 They are capable of self-replication and contain genes that confer some properties , such as antibiotic resistance , virulence factors。 Plasmids are not essential for cellular survival .





Inclusions of Bacteria

Inclusions are aggregates of various compounds that are normally involved in storing energy reserves or building blocks for the cell. Inclusions accumulate when a cell is grown in the presence of excess nutrients and they are often observed under laboratory conditions .

Nucleus .

Nuclear material is present in each bacterial cell, but there is no nuclear membrane or nucleolus. Bacteria are, therefore, prokaryotic. The low electron density regions in the cell are actually the densely packaged DNA regions, called 'nuclear bodies' or 'nucleoids'. Nucleoid is, therefore, made up of DNA. The so called bacterial 'chromosome' is equivalent to its DNA, the genetic material of the cell. Lacking nuclear membrane, absence of nucleoli, hence known as nucleic material or nucleoid, one to several per bacterium.

Endospores (spores) .

1.Dormant cell, Some gram-positive bacteria such as Bacillus & Clostridium , but never gram-negative bacteria .

2.Produced when starved .Under harsh environmental conditions, such as the loss of a nutritional requirement, these bacteria can convert from a vegetative state to a dormant state, or spore.

3. The location of the spore within a cell is a characteristic of the bacteria and can assist in identification of the bacterium.

4. It contains (a) a complete copy of the chromosome .

5. The structure of the spore protects the genomic DNA from desiccation, intense heat, radiation, and attack by most enzymes and chemical agents .

6. pressurized steam at 120^{o}C for 20-30 minutes will destroy .

Endospores have a 2-phase life cycle **:-**

- vegetative cell
- endospore

sporulation is formation of endospores .

Germination is return to vegetative growth .

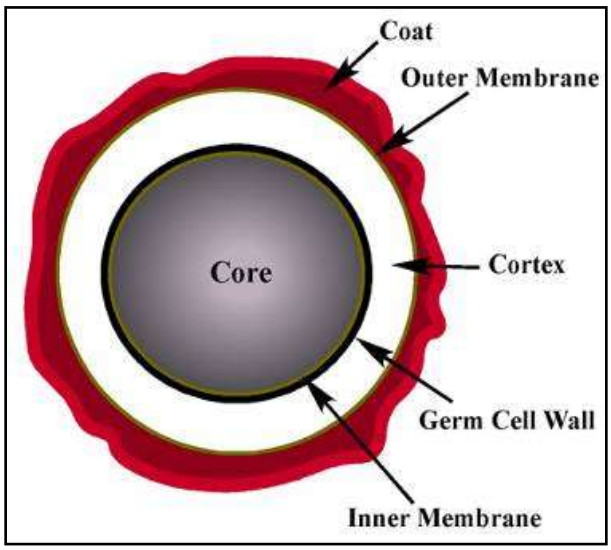
Spore structure .

1- Core : one copy of DNA and cytoplasmic contents Inner membrane and Spore wall .

2- Cortex : peptidoglycan layer .

3- Coat : Keratine - like protein which protect the spore.

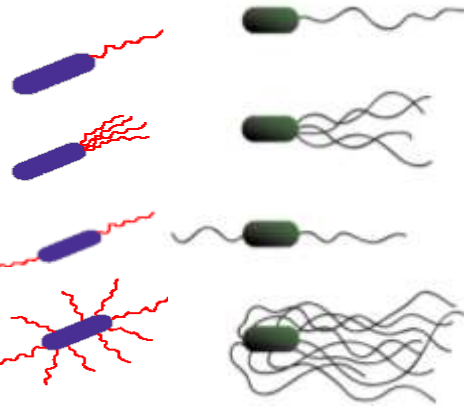
4- Exosporium .



EXTERNAL STRUCTURE .

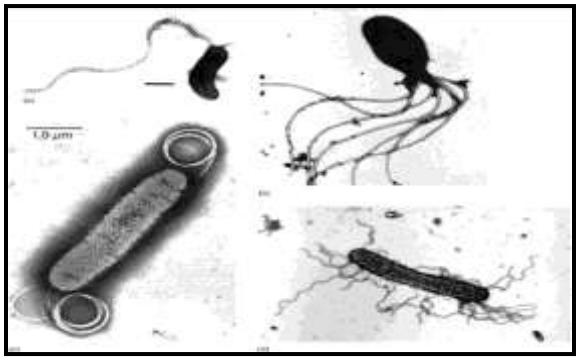
Flagella

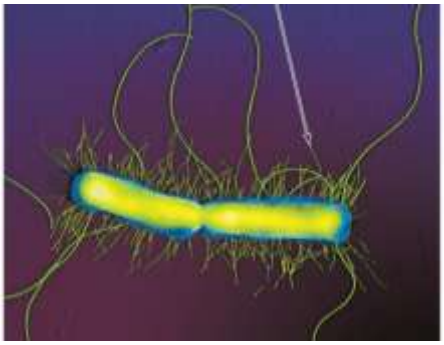
- Some bacterial species are mobile and possess locomotory organelles - flagella. Flagella consist of a number of proteins including flagellin .
- The diameter of a flagellum is thin, 20 nm, and long with some having a length 10 times the diameter of cell. Due to their small diameter, flagella cannot be seen in the light microscope unless a special stain is applied. Bacteria can have one or more flagella arranged in clumps or spread all over the cell.
- Identification of Bacteria .
- Pathogenesis .
- Motility of bacteria .

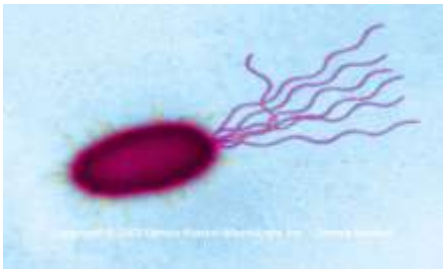


Flagellar Arrangements .

1- Monotrichous – single flagellum at one end
2- Lophotrichous – small bunches arising from one end of cell
3- Amphitrichous – flagella at both ends of cell .
4- Peritrichous – flagella dispersed over surface of cell ; slowest

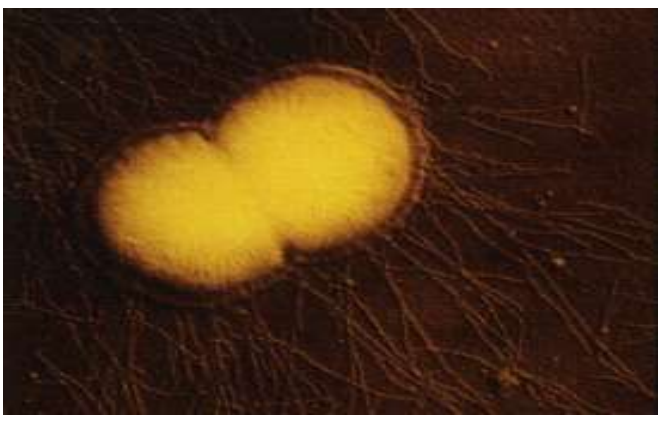


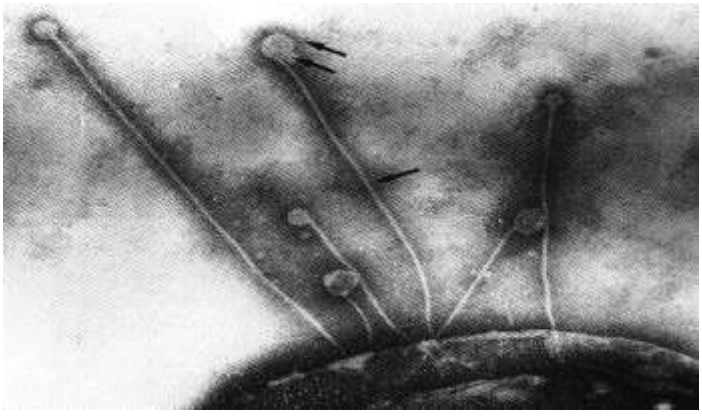




Pili .

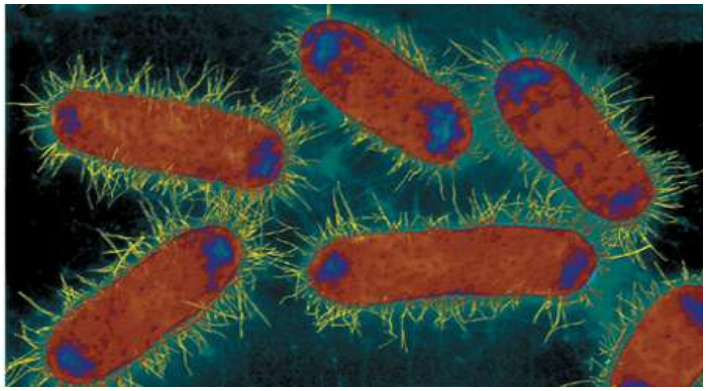
Pili are hair-like projections of the cell , They are known to be receptors for certain bacterial viruses. Rigid tubular structure made of pilin protein. Found only in Gram negative cells . Common pili or fimbriae rigid numerous, related to bacterial adhesion. Sex pili is longer and coarser, only 1-4, related to bacterial conjugation .

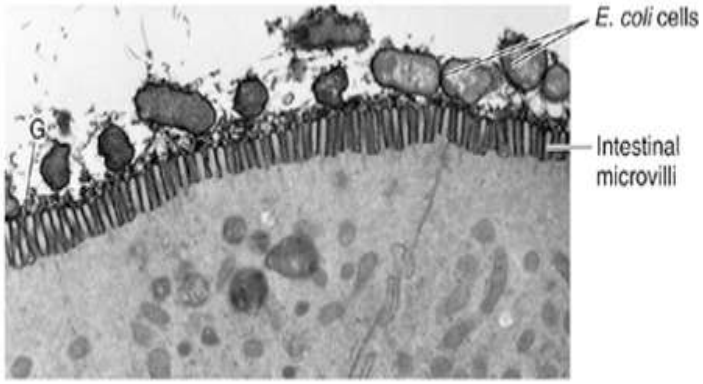


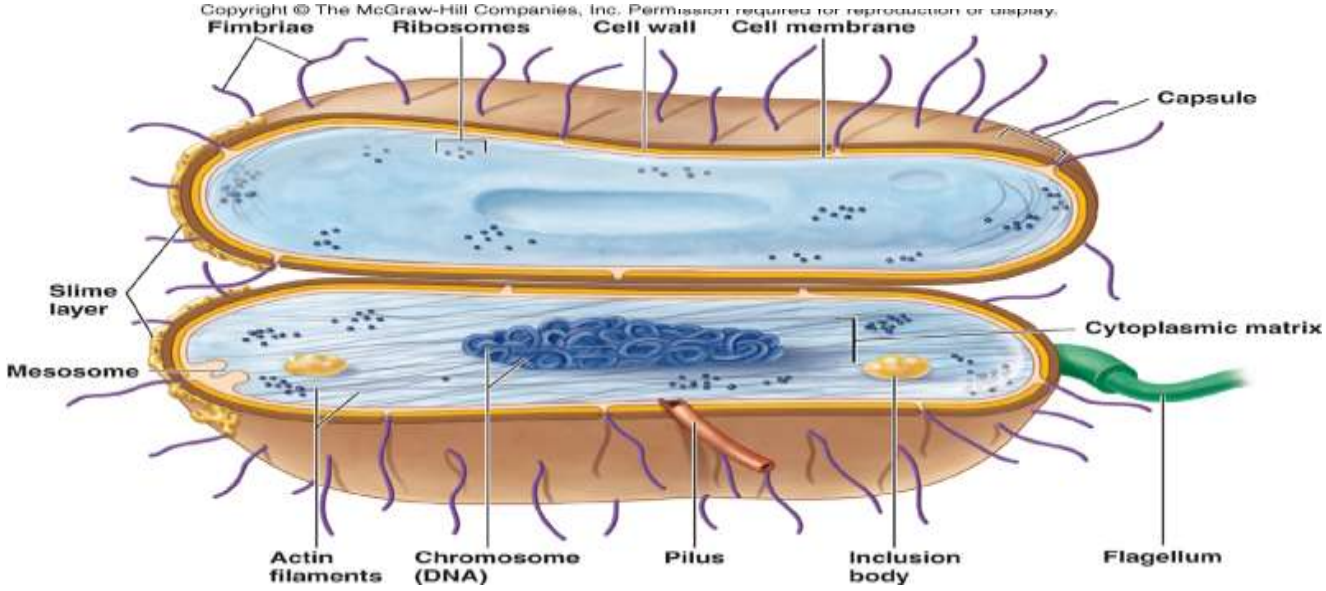


Fimbriae

- Fine, proteinaceous , hair like bristles from the cell surface
- Function in adhesion to other cells and surfaces .







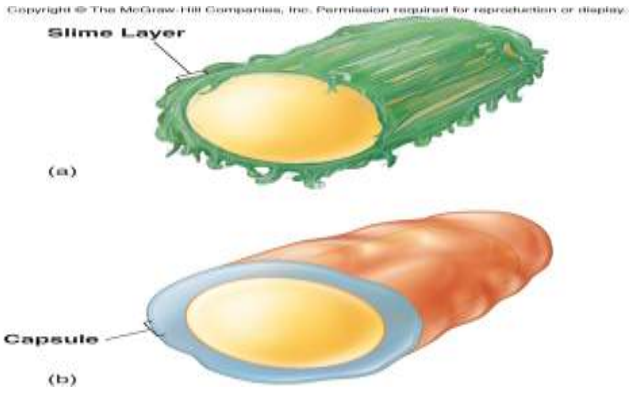
Glycocalyx

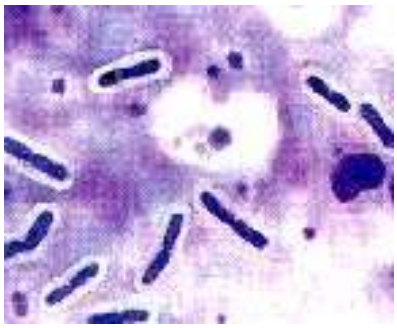
Coating of molecules external to the cell wall, made of sugars and/or proteins
Two types :-

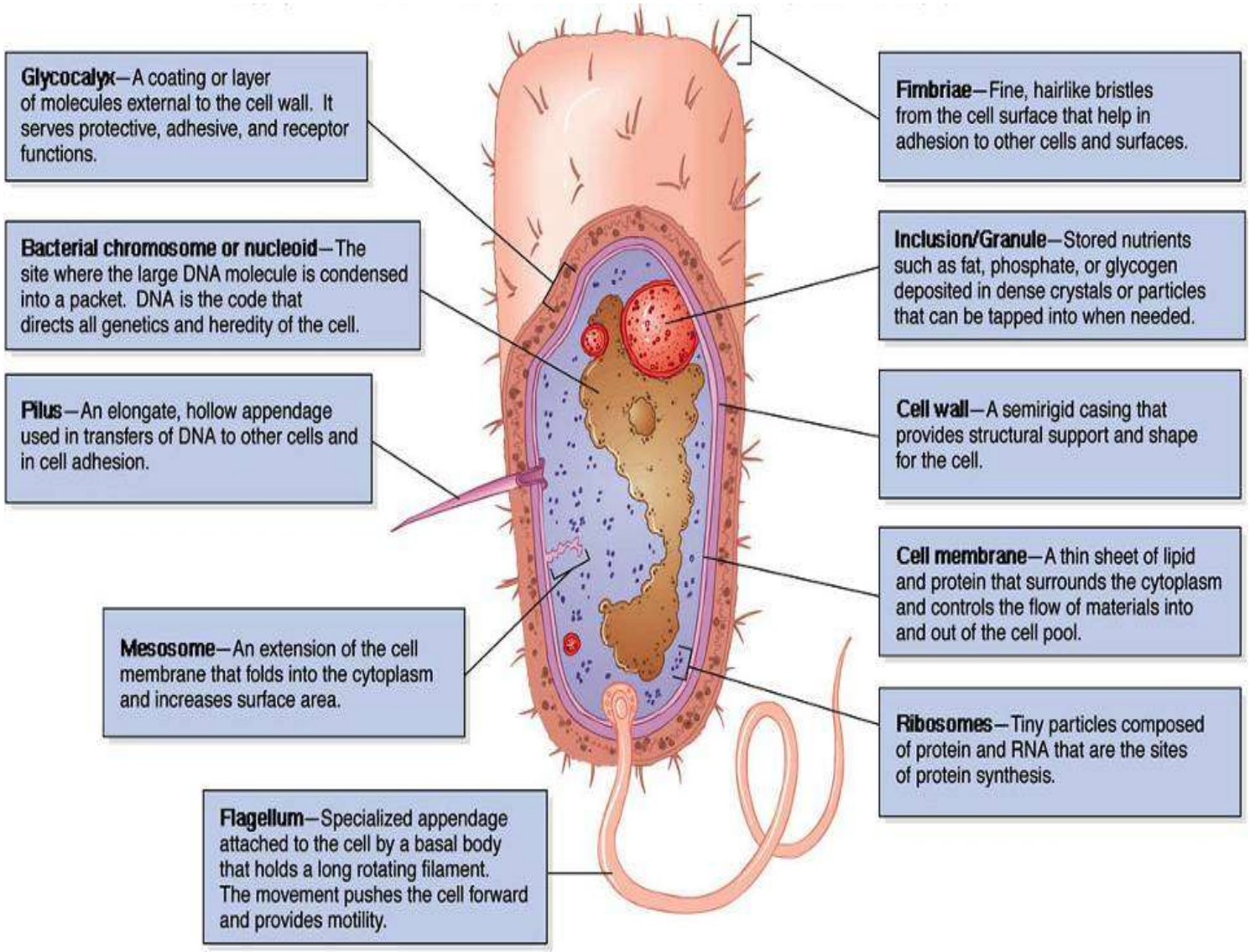
- slime layer - loosely organized and attached
- capsule - highly organized, tightly attached

Functions .

protect cells from dehydration and nutrient loss
inhibit killing by white blood cells by phagocytosis contributing to pathogenicity
attachment - formation of biofilms .






Glycocalyx—A coating or layer of molecules external to the cell wall. It serves protective, adhesive, and receptor functions.
Bacterial chromosome or nucleoid—The site where the large DNA molecule is condensed into a packet. DNA is the code that directs all genetics and heredity of the cell.
Pilus—An elongate, hollow appendage used in transfers of DNA to other cells and in cell adhesion.
Mesosome—An extension of the cell membrane that folds into the cytoplasm and increases surface area.
Flagellum—Specialized appendage attached to the cell by a basal body that holds a long rotating filament. The movement pushes the cell forward and provides motility.
Fimbriae—Fine, hairlike bristles from the cell surface that help in adhesion to other cells and surfaces.
Inclusion/Granule—Stored nutrients such as fat, phosphate, or glycogen deposited in dense crystals or particles that can be tapped into when needed.
Cell wall—A semirigid casing that provides structural support and shape for the cell.
Cell membrane—A thin sheet of lipid and protein that surrounds the cytoplasm and controls the flow of materials into and out of the cell pool.
Ribosomes—Tiny particles composed of protein and RNA that are the sites of protein synthesis.