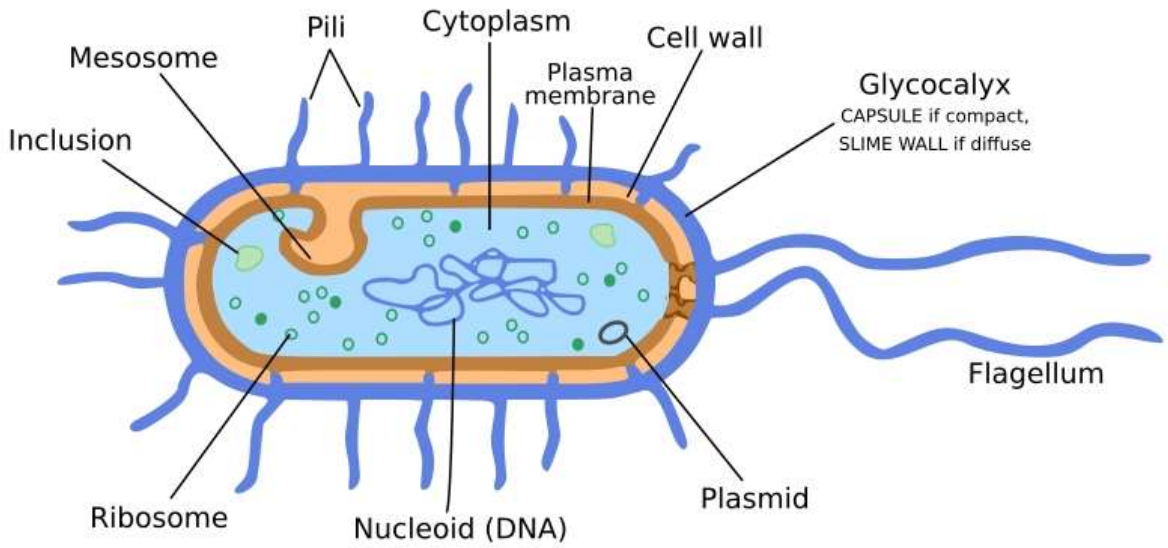
Microbiology

Structure and Morphology of Bacteria

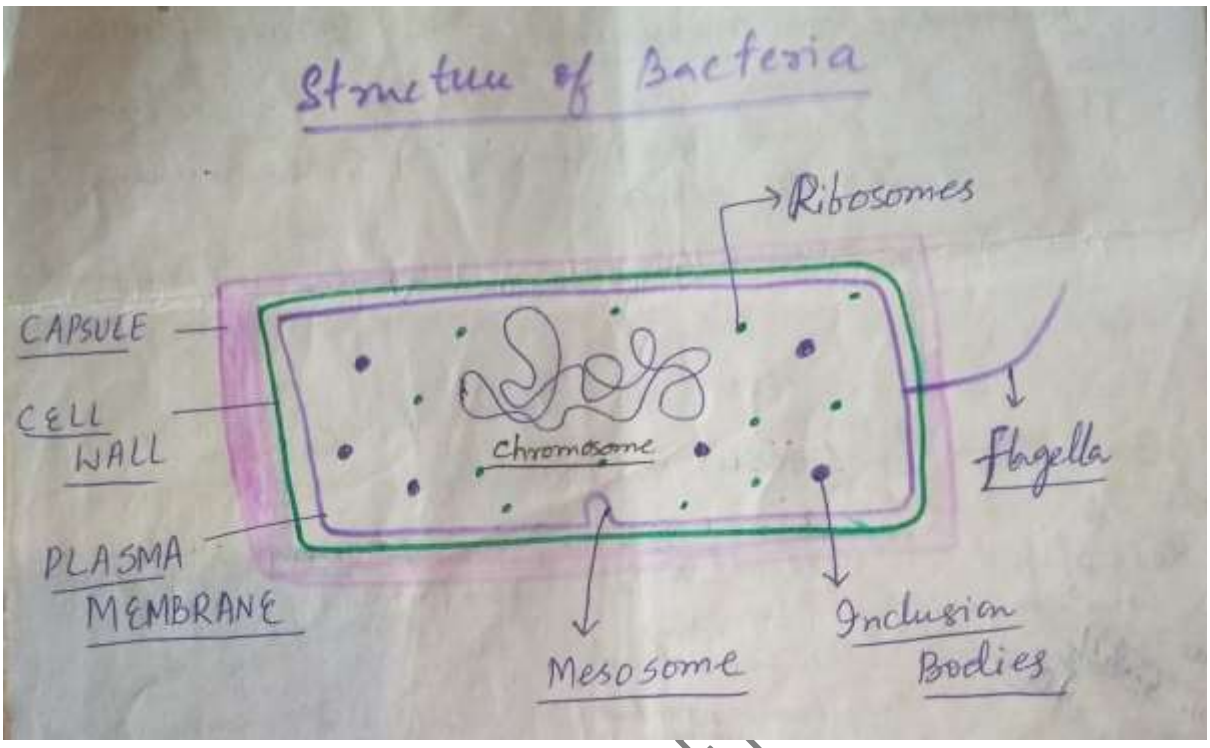
Rabia Rakhshan

STRUCTURE OF BACTERIA

Bacteria (Eubacteria) are microscopic, relatively simple, prokaryotic organisms that can be distinguished from eukaryotic organisms in their cell structure and molecular make - up. Prokaryotic cells are simpler than eukaryotic cells. Although many structures are common to both cell types, some are unique to prokaryotes. Most prokaryotes lack extensive, complex internal membrane systems.



STRUCTURE OF BACTERIAL CELL



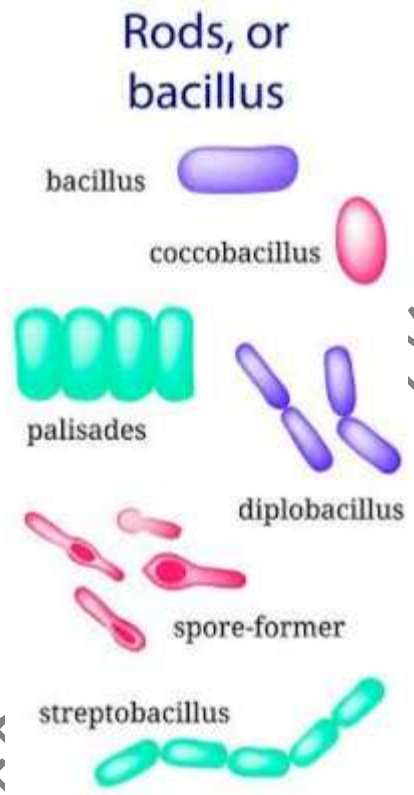
SIZE, SHAPE AND ARRANGEMENT OF BACTERIAL CELLS:

- Bacteria range in size from 0.2 to 2 micrometers in diameter and 0.5 to 5 micrometers in lenght.
- The smallest known bacteria are members of the Genus ***MYCOPLASMA*** (0.3 micrometers in dia.)
- Some bacteria are visible to unaided eye .e.g ; ***Thiomargarita namibiensis*** and **Epulopiscium fishelsoni.**
- Most bacteria are small in size because of which they have large surface area to volume.
- Cell shape is generally characteristic of a given bacterial species.

❖ Four basic shapes of bacteria are:

1. BACILLUS (RODS):

These type of bacteria are rod shaped. Mostly they appear as single rods . They are also present in pairs (diplobacillus) or in chain like patterns (streptobacillus).

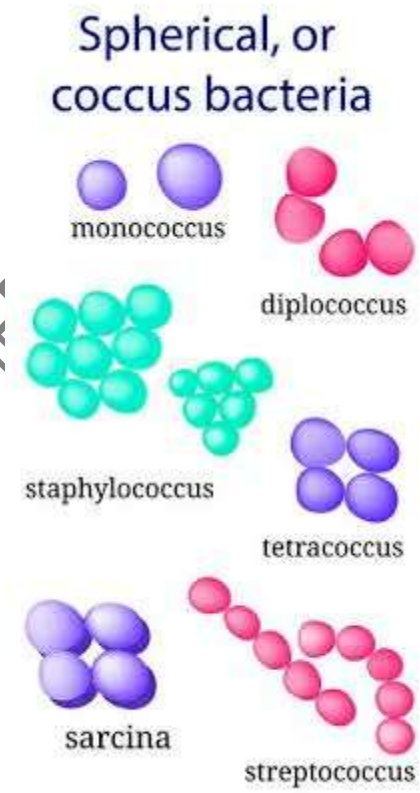


2. COCCUS:

These bacteria are spherical (ovoid) in shape.When cocci divide they remain attached to one another.

They occur in following forms:

- ***DIPLOCOCCI*** (that remains in pairs)
- ***STREPTOCOCCI*** (that remain in chain like patterns)
- ***TETRADS*** (that remain in groups of 4, forming squares)
- ***SARCINAE*** (that remain in groups of 8, forming cube like pattern)
- ***STAPHYLOCOCCI*** (that form grape like structure)

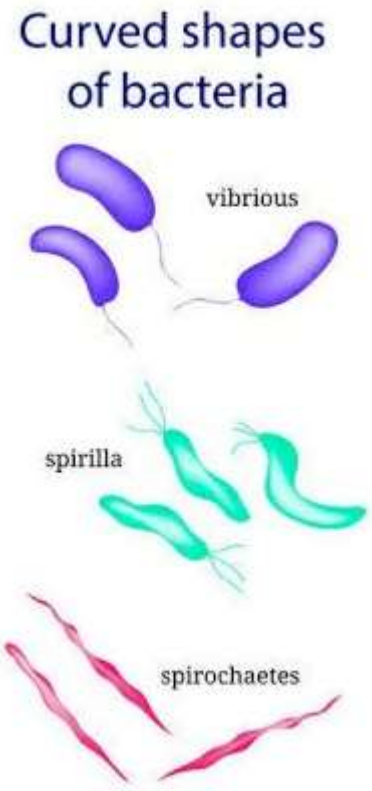


3. VIBRIO:

These are comma shaped bacteria. They look like curved rods.

4. SPIRILLA:

These bacteria are spiral or helical shape , having rigid bodies. Another group of Spirilla have helical shape but flexible bodies known as spirochetes.



POLYMORPHIC BACTERIA

Some bacteria which have many shapes and lack characteristic shape are known as polymorphic bacteria eg ***Corynebacterium.***

MORPHOLOGY OF BACTERIA

CELL WALL:

Bacterial cells almost always are bounded by chemically complex a cell wall. The cell protects bacteria against osmotic lysis. The cell wall is chemically composed of ***Peptidoglycans*** (also termed as ***Murein***) which are unique to bacterial cells.

In Gram positive bacteria***, peptidoglycans*** consists of single 20 to 80 nm thick layer outside plasma membrane. Many Gram +ve bacteria have an acidic substance known as ***Teichoic Acids*** in their cell wall.

In contrast ; in Gram negative bacteria , cell wall consists of 2 to 7 nm thick ***peptidoglycan*** layer covered by 7 to 8 nm thick ***outer layer (LPS Layer).***

Among bacteria certain types of bacteria have no cell wall. Examples are bacteria of Genus Mycoplasma , L - form bacteria and cell wall deficient bacteria.

PLASMA MEMBRANE:

The bacterial membrane is a unit membrane , composed primarily of proteins and phospholipids. The structural and chemical features are similar to eukaryotic cells ; while as sterols are absent in bacterial plasma membrane except ***Mycoplasma***. Molecules similar to sterols known as ***Hopanoids*** are present in membranes of bacteria .

The main function of plasma membrane is transport and energy transduction.

An invagination in plasma membrane in the shape of vesicles, tubules or lamella known as ***Mesosomes*** is present in both Gram +ve and Gram -ve bacteria that may be involved in :

- Chromosomal replication
- Cross wall formation in dividing bacteria

OUTER MEMBRANE (LPS LAYER):

In addition to peptidoglycan cell wall, Gram -ve bacteria contains an additional membran, The Outer Membrane. It contains lipopolysaccharides, lipoproteins, proteins and phospholipids. The lipids and polysaccharides are linked to form lipopolysaccharides, therefore it is often known as LPS Layer. The most abundant protein in LPS Layer is ***BRAUN'S PROTEIN.***

GLYCOCALYX :

Glycocalyx is thick, high molecular weight secreatory substance and is present in many bacteria external to the cell wall. It is viscous, gelatinous polymer.It is composed of *polysaccharide, polypeptide* or both.

The glycocalyx can be thick or thin, rigid or flexible, depending on their chemical nature. The terms capsule and slime layer are frequently used to describe glycocalyx.

CAPSULE:

The rigid layers of glycocalyx are organised in tight matrix known as capsule. Most capsules consists of polysaccharides. However the capsules of some bacilli (*Bacillus anthracis*) consists of polypeptides mainly **Poly-D-Glutamic acid**.

SLIME LAYER:

If the layers of glycocalyx are more easily deformed and loosely attached to cell wall, it is known as slime layer.

CYTOPLASM:

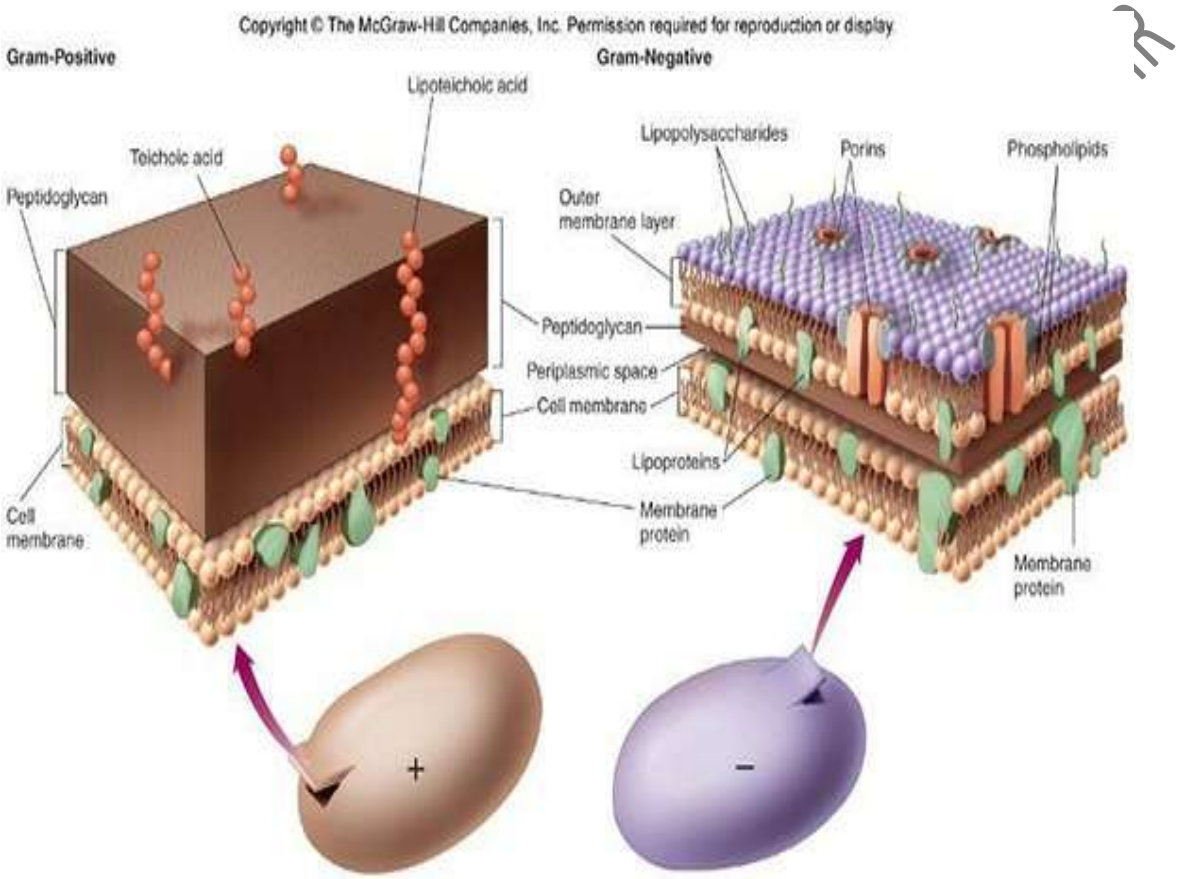
It is a substance of cell inside plasma membrane. Cytoplasm is about 80% water and contains primarily proteins, lipids, carbohydrates, inorganic ions and mainly low molecular weight compounds.

It lacks a unit membrane bound organelles. The major structures present in cytoplasm are ***ribosomes (70 S***) and reserve deposits known as ***Inclusion bodies***. Examples of inclusion bodies present in bacterial cytoplasm are:

- Glycogen
- Cyanophycin granules
- Carboxysomes
- Polyphosphate granules (volutin granules) and others.

GAS VESICLE:

It is hollow, spindle shaped structure made of proteins. It is impermiable to liquid (H_2O) but highly permiable to gases. It provides buyoncy to planktonic cells by decreasing cell density.



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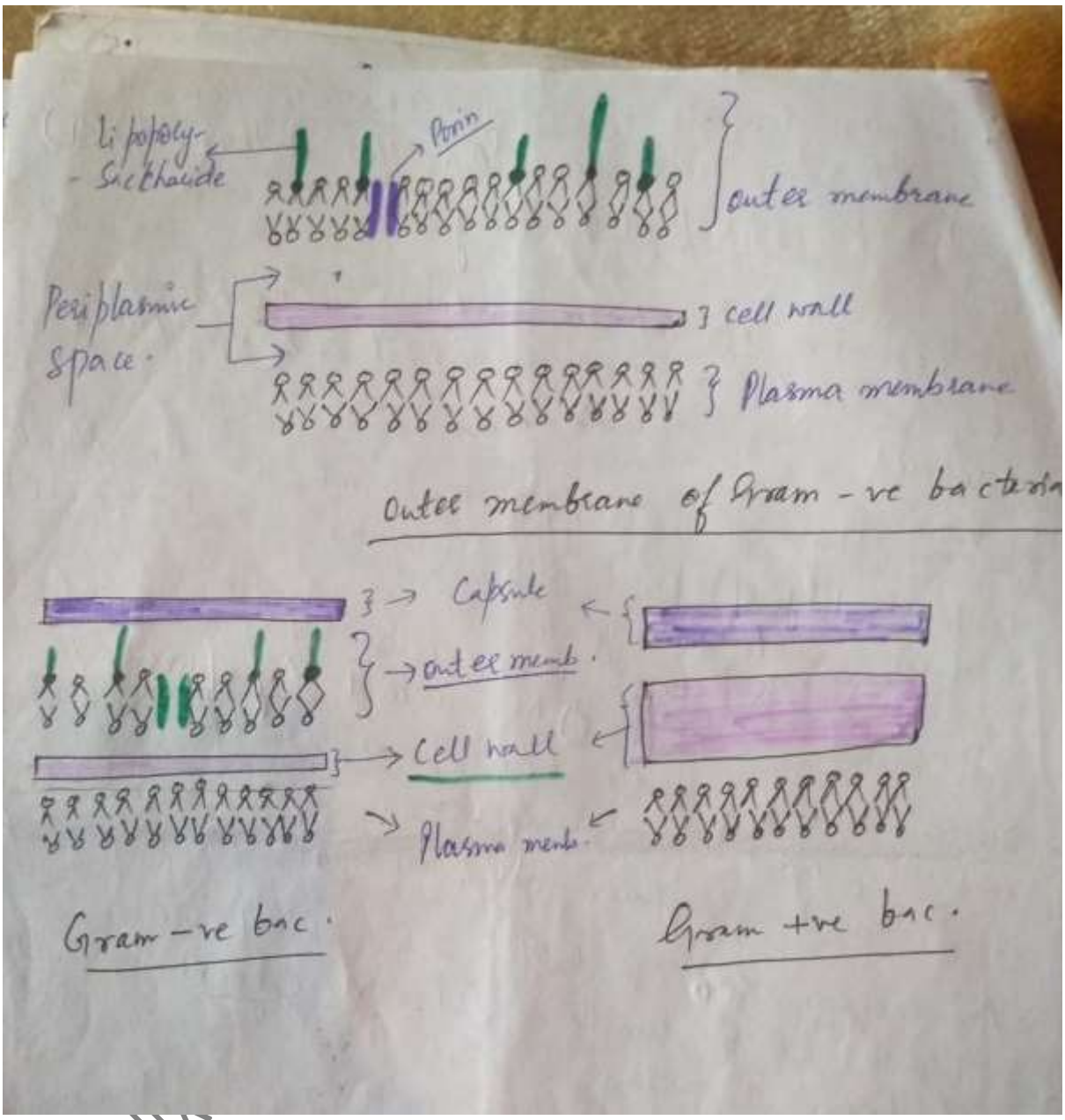


FLAGELLA

Flagella occur in both Gram +ve and Gram -ve bacteria. Structurally flagella are long, filamentous surface appendages. Flagella are organs of locomotion.

A Flagellum of Gram -ve bacteria such as e.coli, consists of 3 parts:

1. The long Filament, which lies external to cell surface (rigid)

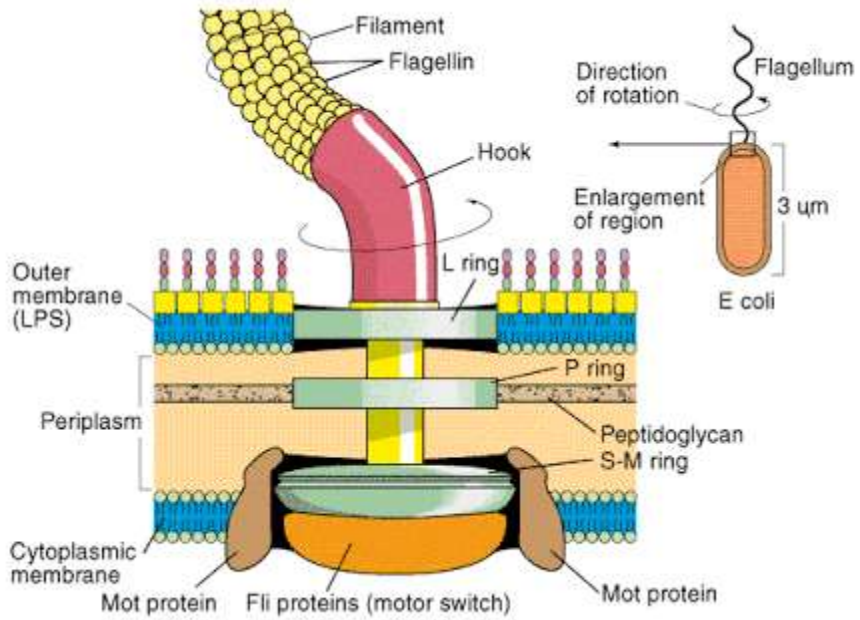
2. The Hook, structure at the end of filament (flexible)

3. The Basal Body, to which Hook is anchored and which imparts motion to flagellum.

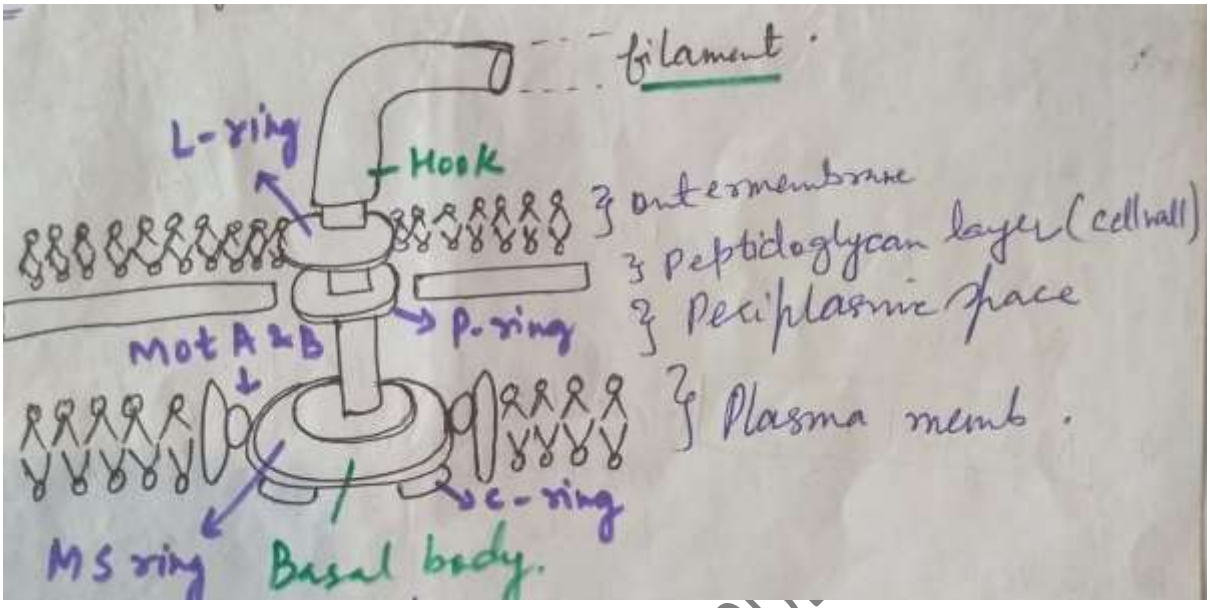
- The flagellar Filament is made up of **Flagellin Protein**.
- The Basal Body traverses the outer membrane and membrane structures. It consists of 4 Rings:

✓ L Ring (L for lipopolysaccharide)
✓ P Ring (P for peptidoglycan)
✓ MS Ring (M for membrane and S for supramembranous)
✓ C Ring (C for cytoplasmic). It is also known as Switch Complex. c Ring consists of 3 proteins which are Fli G, Fli M and Fli N.

Both MS - and C - Rings acts as Rotor while as Mot A and Mot B act as Stator and torque generating unit.



STRUCTURE OF FLAGELLUM



STRUCTURE OF FLAGELLUM

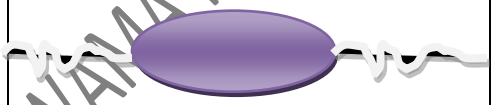
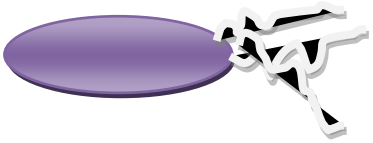
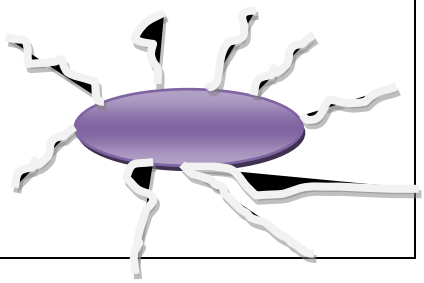
FLAGELLAR MOTION:

Bacterial Flagellar motion is Rotatory in nature. Necessary energy is derived from Proton gradient across the plasma membrane. ATP is not directly required for flagellar motion.

The rotation of Flagella can be Clockwise or anticlockwise.

When the flagella rotate clockwise, forward motion ceases and cell tumbles; Whereas, counter clockwise rotations of flagella impart forward motion (run).

NUMBER AND DISTRIBUTION OF FLAGELLA:

FLAGELLA TYPE	NO./DISTRIBUTION	STRUCTURE
Monotrichous (trichous : hair)	Have 1 flagellum Eg; Vibrio cholerae	
Amphitrichous (amphi : both)	Have 1 flagellum at each side eg; A.serpens	
Lophotrichous (lopho : tuft)	Cluster of flagella at 1 end or both Eg; Pseudomonas	
Peritrichous (peri : around)	Flagella spread fairly/evenly over the whole area Eg; E.coli	

ENDOSPORES

Bacteria in genera Bacillus and Clostridium form an exceptionally heat resistant and dehydrated structure capable of surviving for long periods in an unfavourable conditions (environment). This dormant structure is known as Endospore, since it develops within cell. These structures are resistant to environmental stress such as heat, UV

radiations, Gamma radiations, chemical disinfectants and desiccation.

ENDOSPORE STRUCTURE:

- The endospore structure is very complex and has many layers that are absent from vegetative cell.
  - ***EXOSPORIUM:*** It is a thin delicate protein covering.
  - ***SPORE COAT:*** It lies beneath exosporium and is composed of several protein layers.
  - ***CORTEX:*** It is present beneath the spore coat and is made of peptidoglycan.
  - ***SPORE CELL WALL OR CORE WALL:*** It is present beneath the cortex and surrounds the protoplast or spore core. the spore core has normal cell structures such as Ribosomes and a nucleoid, but is metabolically inactive.
- The endospore contains large amount of ***Dipicolinic Acid***, complexed with ***calcium ions.*** It is thought to contribute to endospore's heat resistance.
- The endospore morphology and location vary with species. The most commonly used endospore stain is the ***Schaeffer - Fulton Endospore Stain.***