(4) Movement :

prokaryotes are both motile & Non motile

(A) Motile prokaryotes -

In prokaryotes two types of locomotion are present

- Gliding : Locomotion by slipping → They secrete mucilage and then glide on this mucilage. There is no particular structure like cilia, flagella for locomotion.

  eg. Myxobacteria, Cyanobacteria (BGA)

- Swimming : Flagella are present in many prokaryotes for swimming.
  eg. Eubacteria

(B) Non motile prokaryotes -
eg. Mycoplasma

Example of Prokaryotes

(1) Eubacteria (True bacteria) **(2) Actinomycetes**
(3) Blue Green Algae **(4) Archaebaceria**
(5) Rickettsia

EUBACTERIA

HISTORY

1. They were first observed in rainy water and later in teeth scum by **Leeuwenhoek** (1675) and called them "Animalcule".

   This discovery was published in his book "The Secrets of nature Discovered by Leeuwenhoek"
2. **F.H. Cohn** and Ehrenberg first of all coined the name "Bacteria".

3. **Bergey** placed bacteria in "Prosophyta group' and wrote a book "Munual of Determinative Microbiology". This book is known as "Bible of bacterial classification".

4. **Lister** developed **"culture technique".** He also developed the **"sterilization tech"** to sterlize the surgical instruments.
   He discovered the antiseptic nature of carbolic acid. Lister first of all cultured bacteria artificially.
5. **Louis Pasteur** proposed **"germ theory"** and called the bacteria "germ". He discovered the "Pasteurisation technique".
   (Pasteurisation technique - it is a process which means heating of drinks. it is carried out at 60^0C temperature and for 30 minutes duration).
6. **Robert Koch**
   - Koch first obtained pure culture of bacteria.
   - He discovered the Anthrax. T.B. and Cholera causing bacteria.
   - Koch gave some rules to prove that the bacteria are the cause of disease. These rules are known as "Koch postulates".
   - He awarded "Nobel Prize" for his work.
   - Koch postulates do not applicable on obligate parasite ***(eg. Mycobacterium leprae)***

SIZE

1. Smallest eubacteria = ***Haemophilus influenzae***
   0.2 - 0.3 × 0.5 - 2.0 micrometer
2. Longest / largest eubacteria = ***Epulopiscium fishelsoni***
   600 micrometer
3. Largest / longest Filamentous bacterium = ***Beggiatoa mirabilis***
   few mm.

SHAPE

Bacteria have variation in their shape. On the basis of their shape bacteria are of different types.

1. Coccus (Pl. Cocci → Sing. Coccus)-

- These bacteria are spherical
- These are smallest bacteria
- These are highly (Maximum) resistant.

These are following types

A. Monocossus - These spherical bacteria live alone (single sphere)
   e.g. ***Micrococcus, Dialister pneumosintes***

B. Diplococcus - These are found in pair.
   e.g. ***Diplococcus pneumniae, Neisseria***

C. Tetra occurs - These are found in group of four cocci.
   e.g. ***Micrococcus luteus***

D. Streptococcus - These are found in form of chain
   e.g. ***Streptococcus lactis***

E. Sarcinae - 8 to 64 or ore bacteria are found in cubical mass form
   e.g. ***Sarcina***

F. Staphylococcus - These bacteria are found in a irregular bunch
   e.g. ***Staphylococcus alvus***

2. Bacillus (Pl. Bacilli - Sing. Bacillus)-

- This group includes most of the bacteria.
- These are rod shaped

They are following types

A. Single Bacillus - Only one rod -like structure or bacterium.
   e.g. ***E.coli, Lactobacillus***

B. Diplobacillus - They are found in pairs
   e.g. ***Diplobacillus***

C. Streptobacillus - They are found in a chain
   e.g. ***Bacillus anthracis***
   Bacillus subtilis **-**It is surrounded by mucilagenous sheath that is known as zooglea. It is also known as hay bacteria.

D. Palisade bacillus - These roed shaped bacteria are found in form of stacks
   e.g. ***Corynebacterium diphtheriae***

3. **Spirillum (Pl. Spirilli - Sing. Spirillum)**
   - These are spiral shaped bacteria
     e.g. ***Spirillum volutans, Spirochete, Helibacter, Treponema***

4. **Comma (Vibrio)-**
   - These are comma shaped bacteria
     e.g. Vibrio cholerae, Vibrio comma

5. **Stalked bacteria -**
   - These are single called bacteria with narrow stalked
     e.g. Caulobacter
6. **Budding bacteria -**
   - They appear like a beaded cell
     e.g. Rhodomicrobium
7. **Pleomorphic bacteria -**
   - These bacteria change their shape according to the medium.
     e.g. Rhizobium

Rhizobium bacterium is found in three forms X,T and Z

MOTILITY IN BACTERIA

Bacteria are motile as well as non motile. Movement in bacteria takes place by means of flagella.

On the basis of flagella bacteria are of following types

1. **Atrichous -** When flagella are absent, it is called atrocious form
   e.g. Micrococcus, Pasteurella

2. **Monotrichous -** When only one flagellum on one end of the bacterium
   e.g. Vibrio, Thiobacillu, Pseudomonas

3. **Lophotrichous -** When a bunch of flagellum is present on one end of bacterium.
   e.g. Salmonella

4. **Amphitrichous -** When bunch of flagellum or single flagellum are present on both the ends of bacterium.
   e.g. Spirillu, Nitrosomonas

5. **Peritichous -** When flagella are found on the whole body of bacterium
   e.g. E. coli. Salmonella typhi

A flagellum of bacteria is made up of three parts.
(1) Basal body (2) Hook (3) Filament

1. **Basal body -**
   A. It is the basal part of flagellum and rod shaped in structure.
   B. It lies with in the cell wall and cell membrane
   C. This proteinaceous rod shaped structure is surrounded by two pairs of rings
      (i) Outer pair (ii) Inner pair

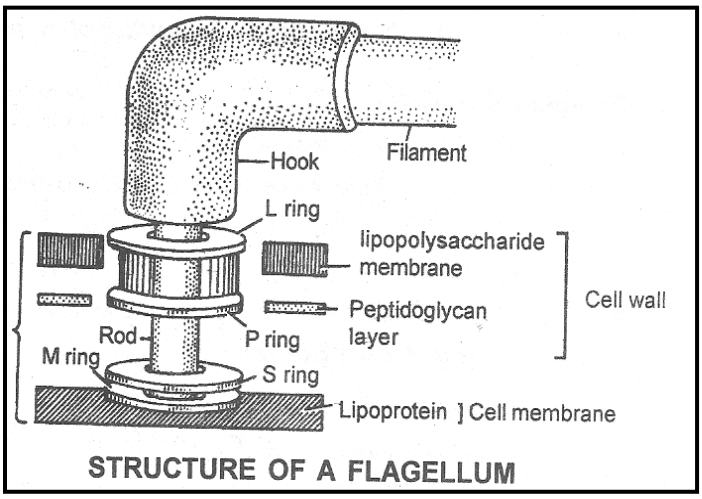
   D. Outer pair of ring lies with in the cell wall. One ring of this pair is called **L** and the another called **P.**
   E. Inner pair of ring lies with in the cell membrane. One ring of this pair is called **S** and the another is **M.**
   F. In Gram (+) bacteria only one pair of rings (inner pair) is found.

2. Hook -

A. In connects the basal body to filament
B. It is the middle part of glagellum
C. It's some part life's with in the cell wall/

3. Filament -

A. It is cylindrical hollow structure made up of protein monomers.
B. Each omonomers is made up of **flagellin** protein. Flagellin is a contractile protein like the tubulin of eucaryotes.
C. These monomers are arranged in 4 + 4 manner.
D. All monomers are joined with each other and so that in bacteria flagella in monofibrilla.



STRUCTURE OF A FLAGELLUM

Pili -

1. Bacterial cell wall is covered by numerous hair like structures called pili. Pili are smaller than the flagella. (Pl. Pili $\rightarrow$ Sing. - Pilus)
2. They are of two types (A) Longer pili, (B) Shorter pili
3. Longer pili is also known as **'F' pili** or **'sex' pili.** Longer pili occurs in only donar (F^+ or male) bacteria and help in conjugation. These are absent in recipient bacteria or female.
4. The shorter pili take part in attachment. These are also known as **'infective' pilo or fimbrae.** These are found only in pathogenic bacteria.

Structure :

1. Every pilus is cylindrical hollow structure and composed of protein monomeres.
2. Each momomere is made up of **pilin** protein. Pilin is non-contractile protein.

Note : Pili have been reported only in Gram negative E. coli bacteria.

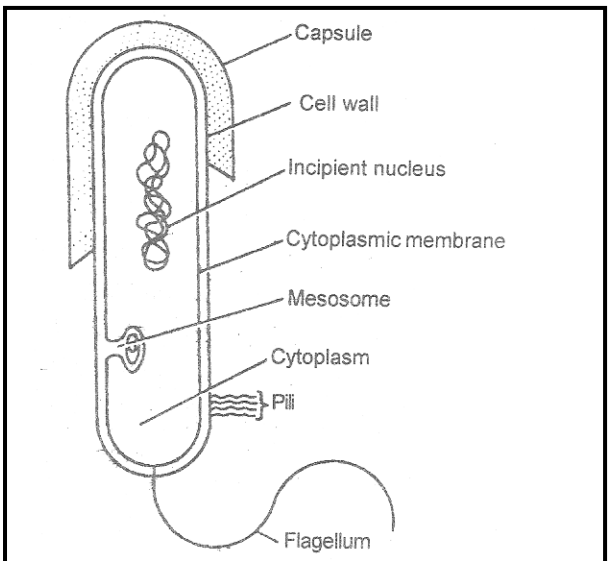
STRUCTURE OF BACTERIAL CELL

1. Capsule of Glycocolyx or Slime layer -

A. When bacteria is surrounded by capsule, it is called capsulated bacteria. Formation of capsule is done by cell membrane. Capsulated bacteria are mostly pathogenic.

B. Capsule is made up of unknown **polysaccharides** and **polypeptides.**

C. Capsule protects the bacteria from W.B.C. and also helps in colony formation.



STRUCTURE OF A BACTERIAL CELL

2. Cell Wall -

Bacterial cell wall made up of mainly **peptidoglycan** or **murein** which is type of muco-peptide.

Gram(+) and Gram (-) bacteria :

In Gram (+) bacteria cell wall is single layered and thick. It is made up of peptidoglycan. Lipids are also present but in less quantity.

While **in Gram (-)** bacteria cell wall is double layered. Inner layer is thin and composed of **peptidoglycan** while outer layer is thick and made up of lipopolysaccharide. Some quantity of lipoproteins and phospholipids are also present in outer layer. Proteins (lipoprotein) present in Gram negative bacteria are called **porins** and these proteins functions as channels for the entry and exit of hydrophilic low molecular weight substances.

Differences between Gram positive and Gram negative Bacteria

	Gram positive	Gram negative
(1)	The bacteria remain coloured purple with Gram staining even after washing with alcohol.	The bacteria do not retain the stain when washed with alcohol.
(2)	Cell wall is single layered.	Cell wall is bilayered.
(3)	Cell wall of peptidoglycal is 20-80 nm. thick	Cell waw of peptidoglycan is 8-12 nm. thick.
(4)	The wall is smooth.	Wall is wavy and comes is contact with plasmalemma only at a few loci.
(5)	Murein (Peptidoglycan) content is 70-80%.	Murein (Peptidoglycan) content is 10-20%
(6)	Basal body of the flagellum contains 2 rings (S & M)	Basal body of the flagellum has 4 rings (L, P, S & M).
(7)	Mesomes are quite prominent.	Mesosomes are less prominent.
(8)	A few pathogenic bacteria belong to Gram - positive group.	Most of the pathogenic bacteria belong to Gram - negative group.

L - form - Bacterial cell wall can be dissolved by **lyzozyme** enzyme. When bacterial cell wall is removed artificially then bacteria are surrounded by only cell membrane. These bacteria are called L - form (Lister form).

Lister form - It is first development by **Klieneberger** in lister laboratory Londo.

- **Spheroplast -** When L-form bacteria is Gram(-) it is called spheroplast.
- **Protoplast -** When L-form bacteria is Gram (+) it is called protoplast

3. Cell membrane -

Bacterial cell mem. is made up of lipoprotein (unit membrane) like the eukaryotes membrane.

4. Cytoplasm -

A. In bacterial cytoplasm membrane bound cell organelles viz. Mitochondria, Chloroplast E.R. Lysosome, Golgibody, Microbodies etc. are absent.
B. Bacterial cytoplasm show no streaming or cyclosis.

Cytoplasmic organelles -

1. **Mesosomes -**
   A. Mesosome was discovered by F. James. The cell membrane of bacteria ingeminates in cytoplasm at different places and form mesosome.
   B. These are **functionally mitochondria** like structure. Oxidative enzymes are found in mesosome. On the basis of position and function mesosomes are of two types.
   (a) **Peripheral mesosome -** They are situated near the cell mem. in pheripheral pat and their main function is cell respiration and cell wall secretion.
   (b) **Central mesosome -** They are situated depp in cytoplasm and their main function is providing help in DNA replication and cell division. These are connected with nucleid.

2. **Storage granules -**
   A. Glycogen granuels - they store carbohydrate
   B. Volutin granuels - These are also known as metachromatic granules. They are made up pf RNA. They strode RNA as a source of nitrogen and phosphorus.

3. **Photosynthetic structure -**
   Some eubacteria (purple bacteria and green bacteria) have capacity of photosynthesis.
   In photosynthetic eubacteria no special type of structure is found for photosynthesis. In bacterial cytoplasm many photosynthetic pigments are scattered. The group of pigments are called **chromatophores.**

   Pigments -
   (a) In purple bacteria (sulphur and non sulphur) - bacteriochlorophyll-a and bacteriochlorophyll-b
   (b) In green sulphur bacteria - Bacteriochlorophyll-a and chlorobiumchlorophyll or bacterioviridin

4. **Chromatin material (Nucleoid) -**
   A. Nucleus of bacterial cell is called **nucleoid** or genophore or incipient nucleus or fibrillar nucleus. Nuclear membrane and nucleolus are absent.

   B. The chromosomes are also absent in bacterial cells. Instead they contain a single chromosome. It consists of a ds circular naked DNA (without histone), and non histone proteins. Non histone proteins are polyamines. Nucleoid is connected to mesosome.

   C. Beside this DNA another small and circular DNA is also present in bacterial cell, which is called **Plasmid**. It is also known as extra chromosomal or extranuclear genetic material. (The term 'plasmid' was given by **Lederberg).**

   D. Plasmids have the ability to replicate independently.

On the basis of functions plasmids are of following types

1. **F or fertility factor** (F - plasmid) On the basis of presence or absence of 'F factor, there are two mating types of bacteria.

   (a) F^+ Cell, carrying 'F' factor act as donor and are called F^+ or male.
   (b) F^- - Cell, lacking 'F' factor act as recipient and are called F^- or female.
   When 'F' plasmid is attached with main DNA, it is designated as episome and this type of cells is known as Hfr cell. (The work episome was given by Jacob & Wollman)

2. **R or Resistance factor** (R - plasmid) - Cells, carrying this 'R' factor become resistant to certain drug.

3. **Col. or colicinogenic factor -** Cells, carrying 'col' factor secrete the colicin, which have an antibiotic effect on other microbes.