Department Of Biotechnology

Morphology of bacteria

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- SHAPE OF BACTERIA
- ARRANGEMENTS OF BACTERIAL CELLS
- STRUCTURE OF BACTERIAL CELL

INTRODUCTION

- Bacteria is unicellular, free-living, microscopic microorganisms capable of performing all the essential functions of life.
- They possess both deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA).
- Bacteria are prokaryotic microorganisms that do not contain chlorophyll.
- They occur in water, soil, air, food, and all natural environment.
- They can survive extremes of temperature, pH, oxygen, and atmospheric pressure.

SIZE OF BACTERIA

- Bacteria are very small microorganisms which are visible under the microscope.
- They are having the size range in microns.
- Bacteria are stained by staining reagents and then visualised under high power of magnification (1000X) of compound microscope.
- An electron microscope is used for clear visualization of internal structure of bacteria.

External Feature

Bacteria

Size

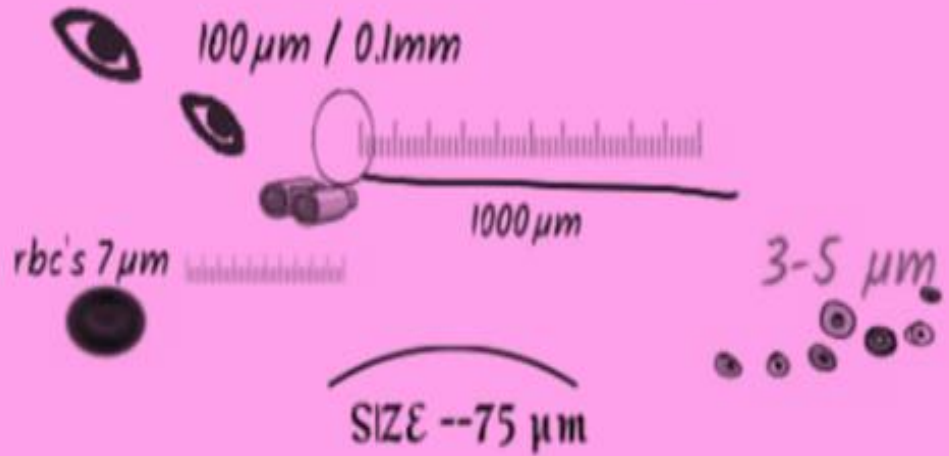
Shape

Arrangement

1cm = 10mm

1mm = 1000 µm

1 µm = 1000nm



The Size of virus is 400nm.

..... Shapes of bacteria!.....

1. Cocci 

2. Bacilli 

3. Vibrios 

4. Spirilla 

5. Spirochetes 

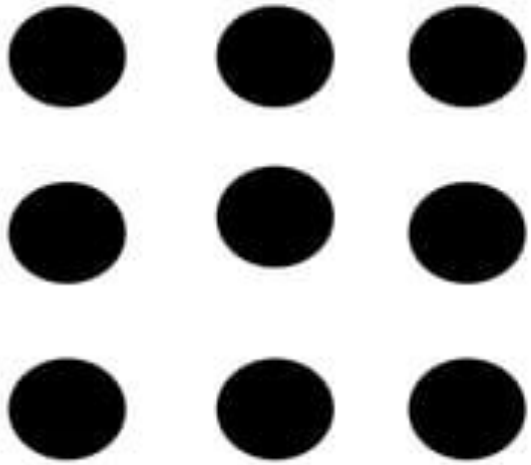
Some Uncommon shapes.

1. Mycoplasma 

2. Actinomycetes 

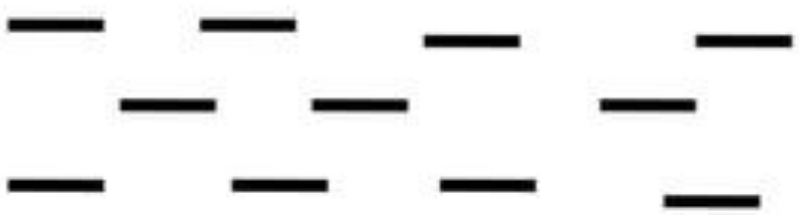
1. Cocci

- Cocci are small, spherical or oval cells. In greek 'Kokkos' means berry. Eg: micrococcus



2. Bacilli

- They are rod shaped cells. Eg: Bacillus anthracis.
- It is derived from greek word " Bacillus" meaning stick.
- In some of the bacilli the length of cell may be equal to width. Such bacillary forms are known as coccobacilli. Eg: Bracella.

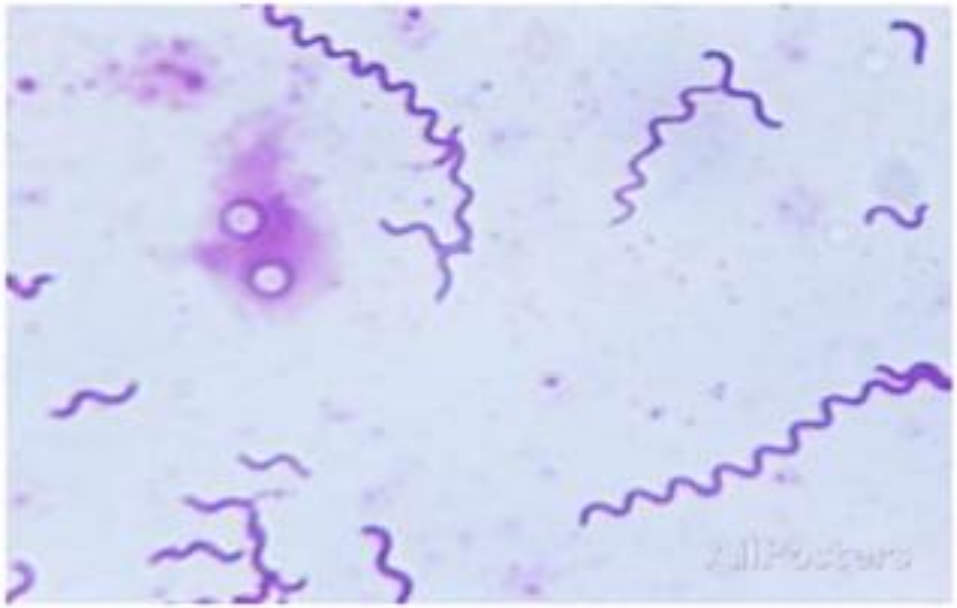


3. Vibrios

- They are comma shaped curved rods. Eg: Vibrio comma.

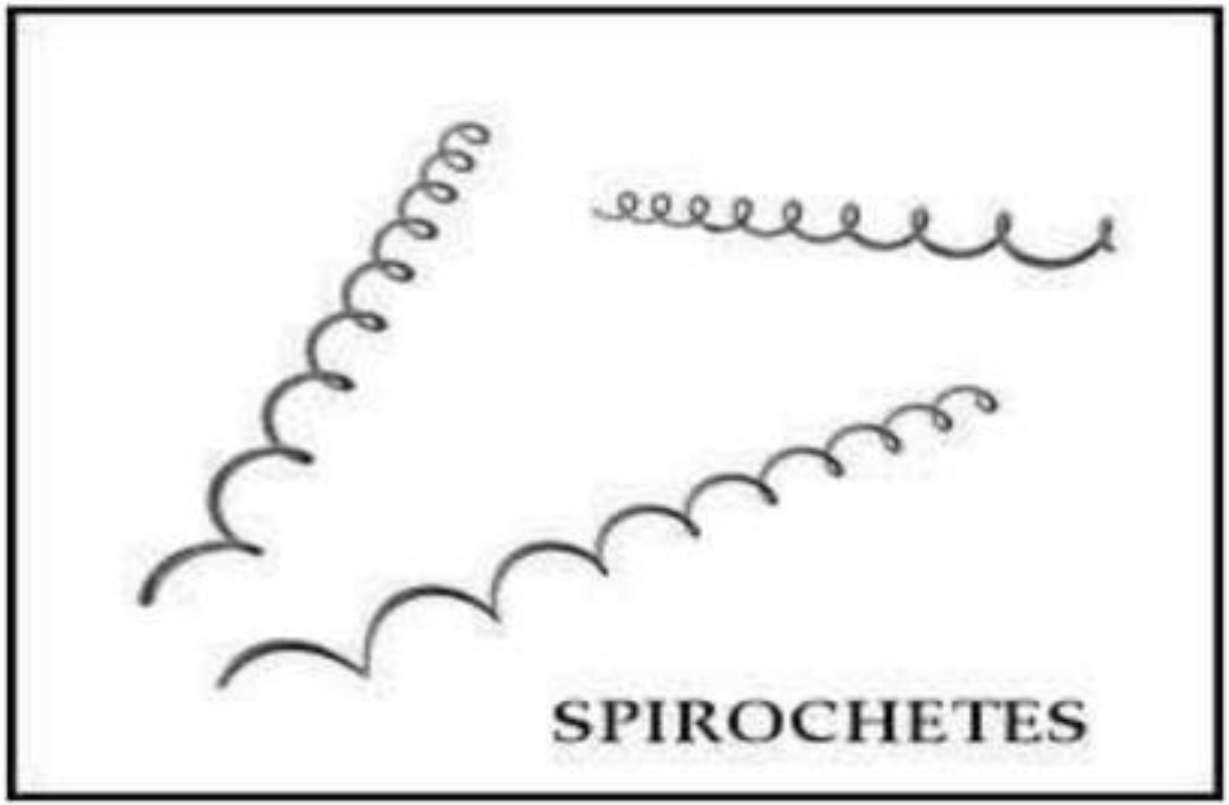
4. Spirilla

- They are longer rigid rods with several curves or coils.
- They have a helical shape and rigid body.
- Eg: Spirillum ruprem.



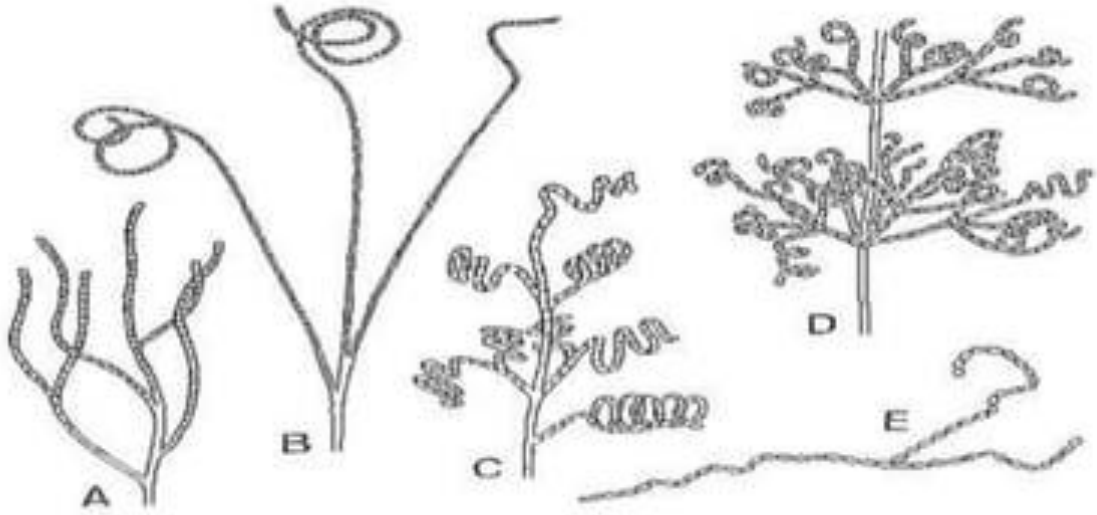
5. Spirochetes

- They are slender and flexuous spiral forms.



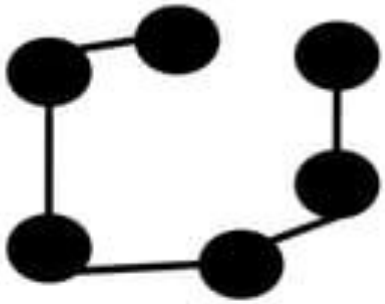
6. Actinomycetes

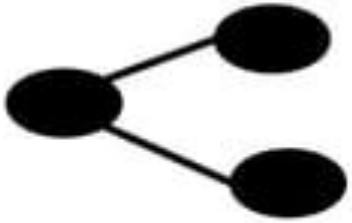
- The characteristic shape is due to the presence of rigid cell wall. Eg: Streptomyces.
- They are branching filamentous bacteria.
- Eg: Streptomyces species.



7. Mycoplasma

- They are cell wall deficient bacteria and hence do not possess stable morphology. They occur as round or oval bodies with interlacing filaments.





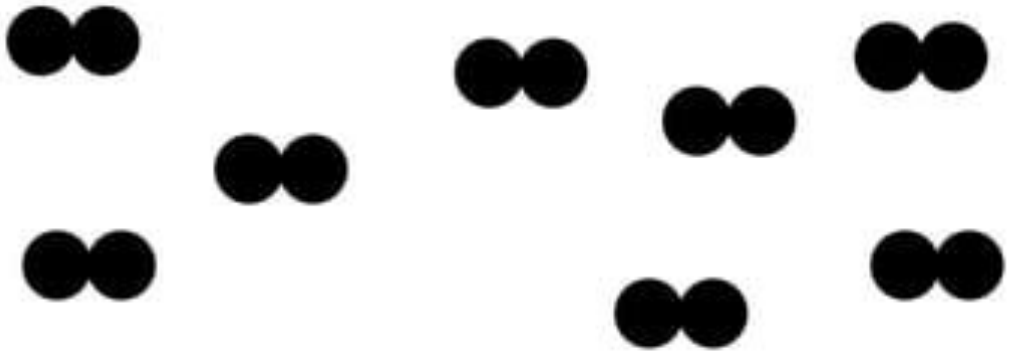
ARRANGEMENT OF BACTERIAL CELLS

Cocci appears as several characteristics arrangement or grouping.

1. Diplococci
2. Streptococci
3. Tetracocci
4. Staphylococci
5. Sarcinae

1. Diplococci

- They split in one plane and remains in pair. Eg: diplococcus pneumoniae.

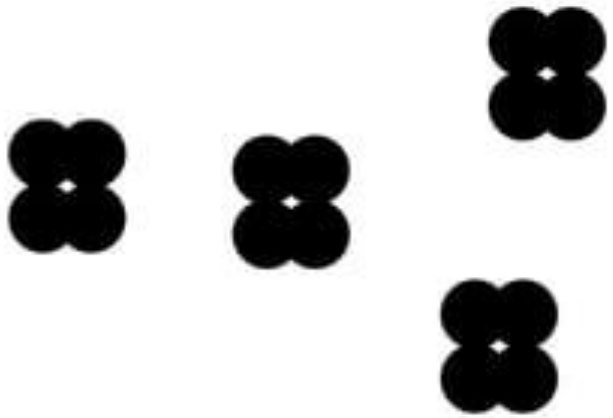


2. Streptococci

These cells divide in one planes and remain attached , to form chains. Eg: streptococcus lactis.

3. Tetracocci

- They divide in two planes and live in groups of four. Eg: Gaffyka tetragena.

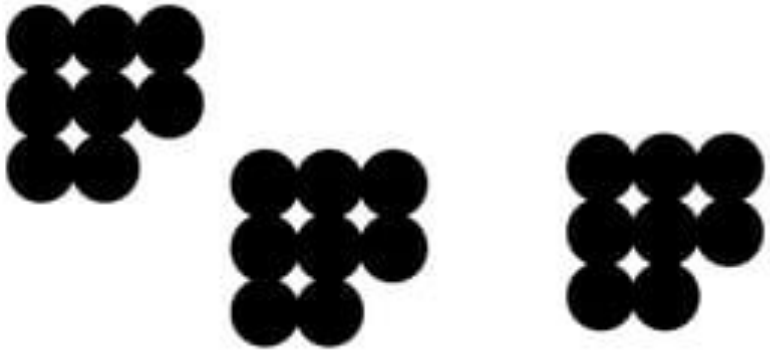


4. Staphylococci

- Cocci cells divide in three planes in an irregular pattern. These cells produce bunches of cocci as in grapes. Eg: staphylococcus aureus, staphylococcus albus.

5. Sarcinae

- Sarcinae cells divide in three planes in a regular pattern.
- These cells produces a cuboidal arrangement of group of a eight cells.
- Eg: Micrococcus tetragena.



oval or spherical

DIPLOCOCCUS PNEUMONIAE

DIPLOCOCCI

STAPHYLOCOCCUS ----GROUP

STREPTOCOCCUS---- IN CHAIN

TETRADS

MICROCOCCUS

SARCINA

SARCINA VENTRICULI

STREPTOCOCCUS

STREPTOCOCCUS SPEICES

STAPHYLOCOCCUS

STAPHYLOCOCCUS AUREUS

GREEK WORD--kokkos meaning berry

Arrangement of grouping formed by bacilli species

1. Diplobacilli
2. Streptobacilli
3. Trichomes

Diplobacilli

Trichomes

streptobacilli

Diplobacilli

Klebsiella pneumoniae

Rod shape

Streptobacillus moniliformis

Strepto-bacillus

Bacillus Anthrax

CURVED SHAPE OR COMMA SHAPED

Vibratory Motility

Vibrio Cholerae

Rigid and Short in length

contain Flagella at the end.

singular.....Spirillum
Plural.....Sprilla or spirillums

Axial filament

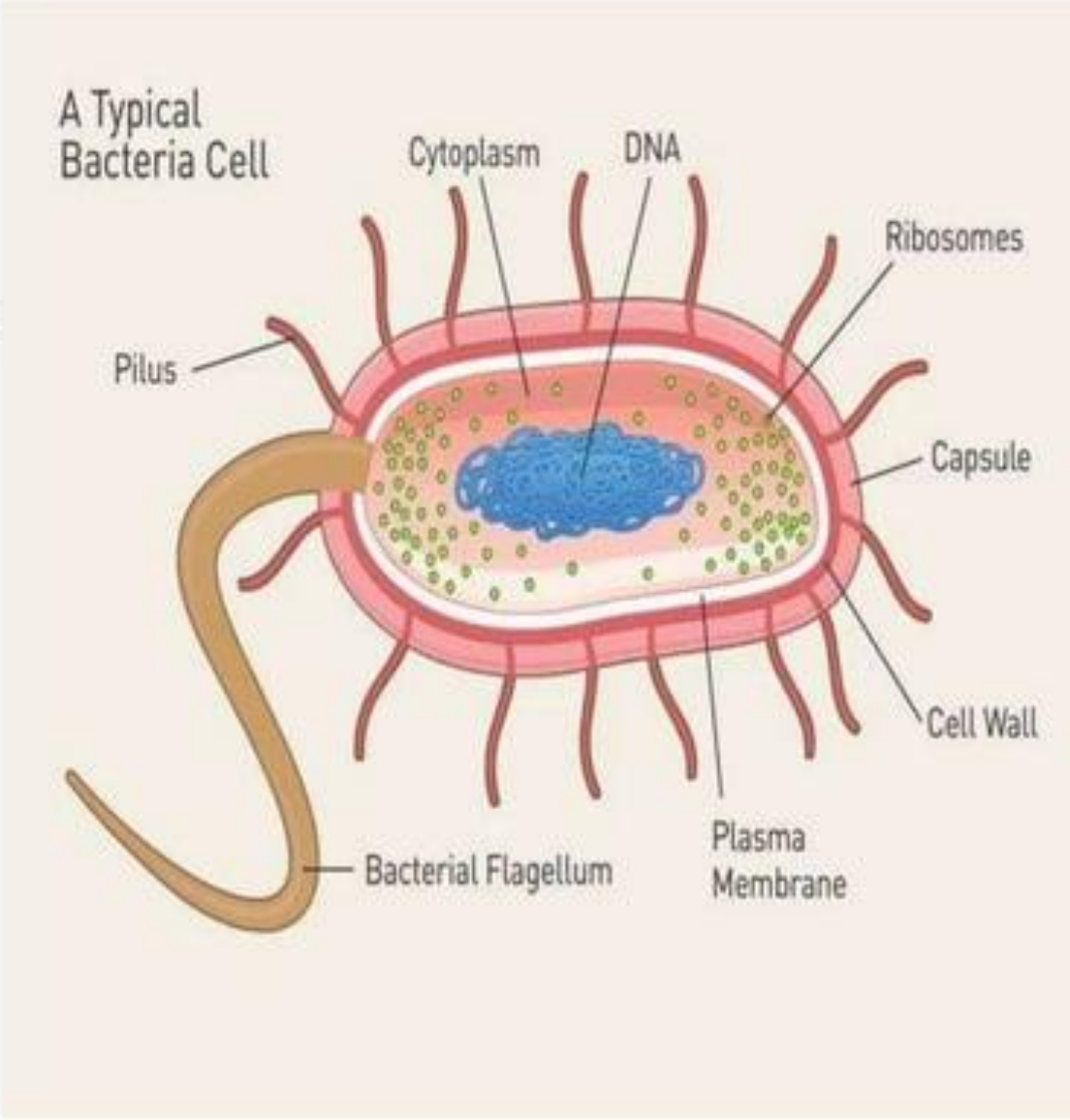
Long and flexible

corkscrew type
with internal flagella or endoflagellum

Treponema,
Borrelia, and Leptospira

Bacterial Structures

- Flagella
- Pili
- Capsule
- Plasma Membrane
- Cytoplasm
- Cell Wall
- Ribosomes
- mesosomes
- Inclusions
- Spores



Capsule

- Bacteria synthesize loose amorphous organic exopolymer which is deposited outside and tightly to cell wall called capsules.
- Capsules may be composed of complex polypeptides or polysaccharides. Water (98%) is the main component of bacterial capsule.
- Some times the capsular material is loosely associated with the bacterium, it can be easily washed away. The loose layer is called slime layer.
- Capsulated bacteria produces smooth colonies and non capsulated bacteria produces rough colonies on the surface of agar media.

Functions

1. They protect the cell from drying.
2. They protects the bacterial cell against anti-bacterial agents and phages.

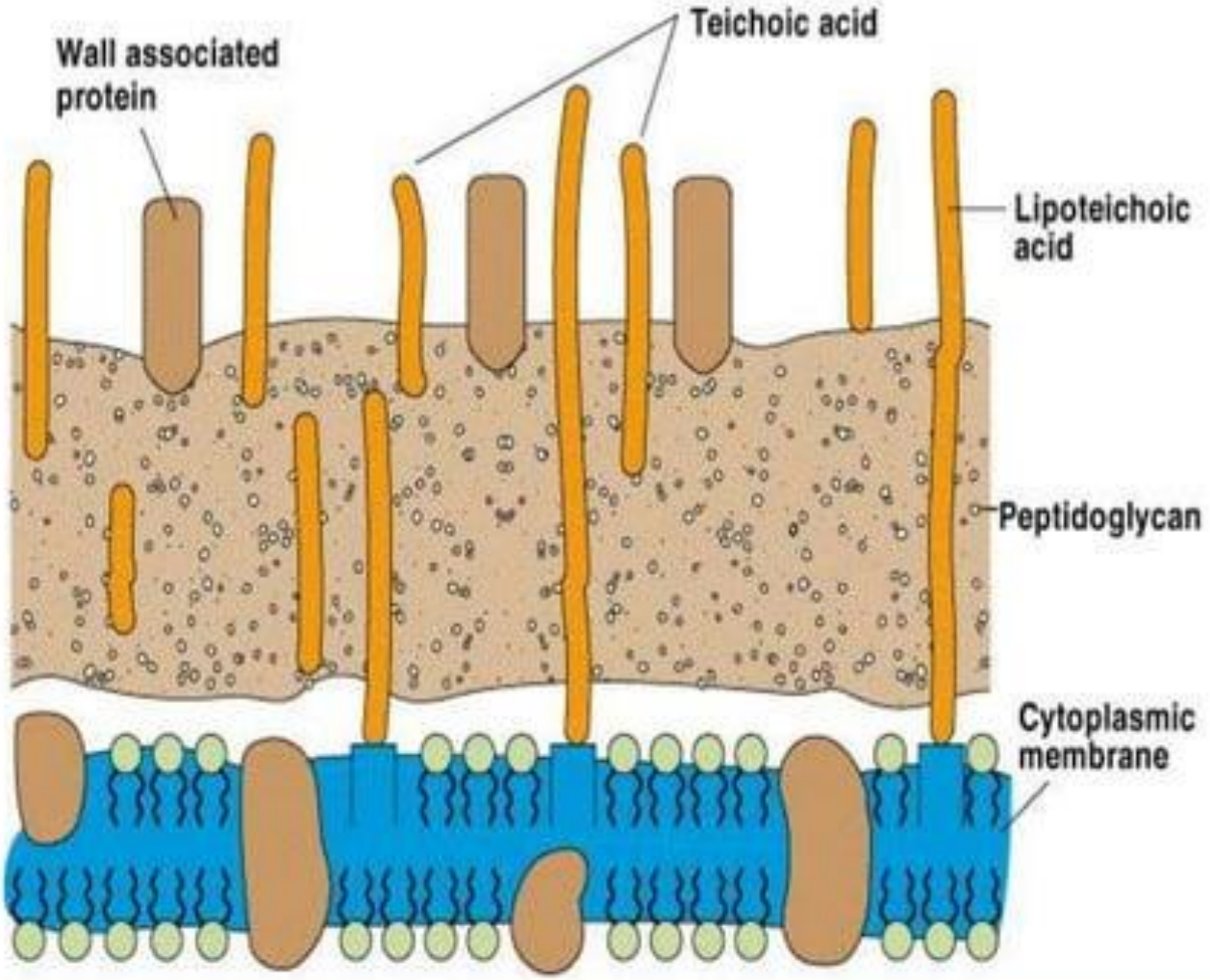
Cell wall

- Cell wall is rigid structure which gives definite shape to cell, situated between the capsule and cytoplasmic membrane.
- It is about 10 – 20 nm in thickness and constitutes 20-30 % of dry weight of cell.
- The cell wall cannot be seen by direct light microscopy and does not stain easily by different staining reagents.
- The cell wall of bacteria contains diaminopimelic acid (DAP), muramic acid and teichoic acid. These substances are joined together to give rise to a complex polymeric structure known as peptidoglycan or murein or mucopeptide.
- Peptidoglycan is the major constituent of the cell wall of gram positive bacteria (50 to 90 %) where as in gram negative bacterial cell wall its presence is only 5 -10 %.

- Composed of mucopeptide, scaffolding formed by N-acetyl glucosamine and N-acetyl muramicacid
- On the basis of staining procedure bacteria divided into two majour groups and this is due to their cell wall structure, these are

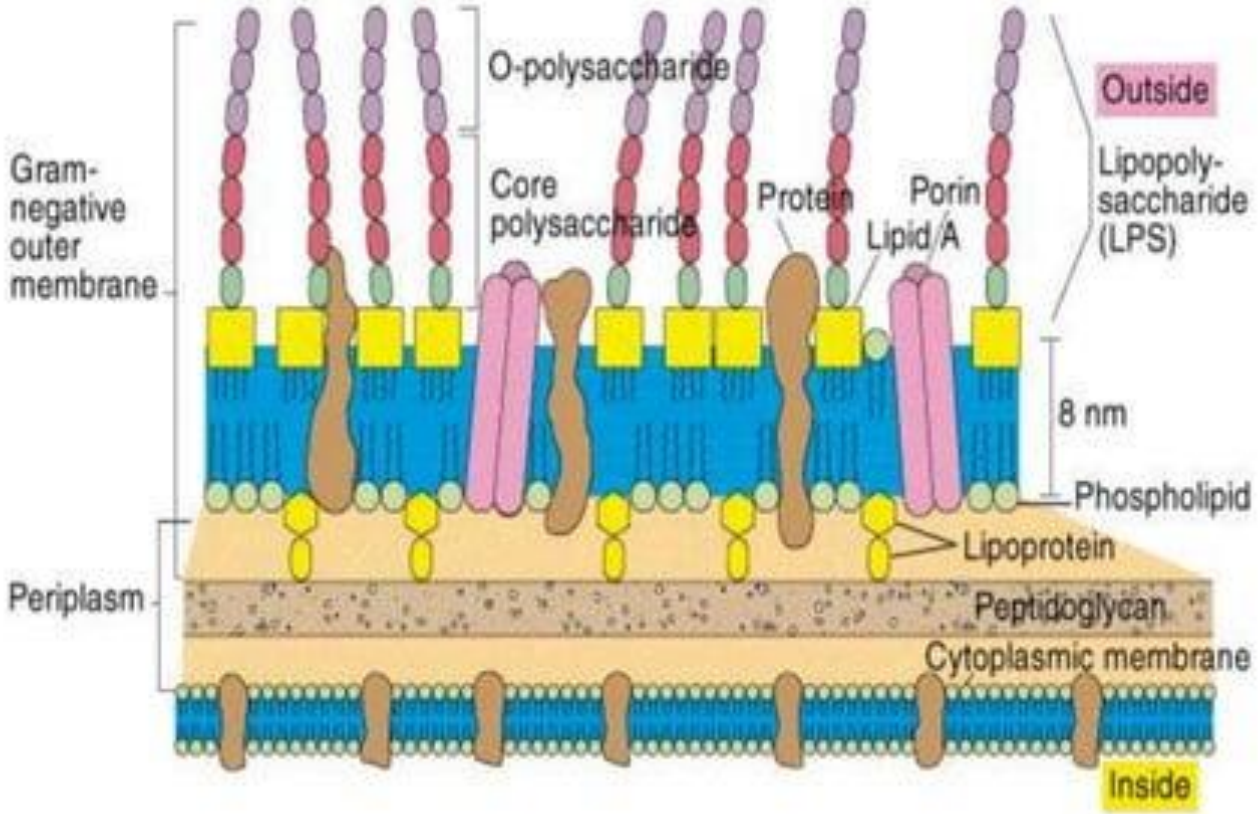
Gram Positive cell wall

- Peptidoglycan: 16-80 nm thick
- Teichoic acid : majour surface antigen, water soluble polymers, containing Ribotol or glycerol polymers
- Lipoteichoic acid


Wall associated protein
Teichoic acid
Lipoteichoic acid
Peptidoglycan
Cytoplasmic membrane

Gram Negative cell wall

- Lipoprotien layer
- Outer membrane protien (OMP)
- Lipopolysaccharides (LPS)
- Periplasmic space
- Peptidoglycan layer

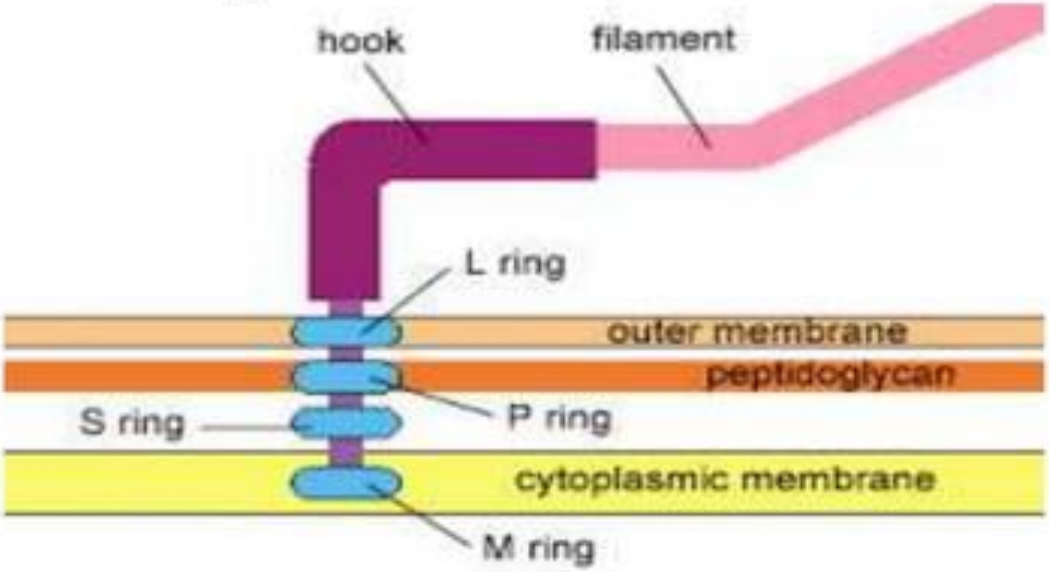

O-polysaccharide
Core polysaccharide
Protein
Porin
Lipid A
Outside
Lipopoly-saccharide (LPS)
Gram-negative outer membrane
8 nm
Phospholipid
Lipoprotein
Periplasm
Peptidoglycan
Cytoplasmic membrane
Inside

Flagella

- Flagella are long, slender, thin hair-like cytoplasmic appendages, which are responsible for the motility of bacteria.
- These are the organs of locomotion.
- They are 0.01 to 0.02 µm in diameter, 3 to 20 µm in length.
- Flagella are made up of a protein- flagellin.
- The flagellum has three basic parts ,

1. Filament
2. Hook
3. Basal body

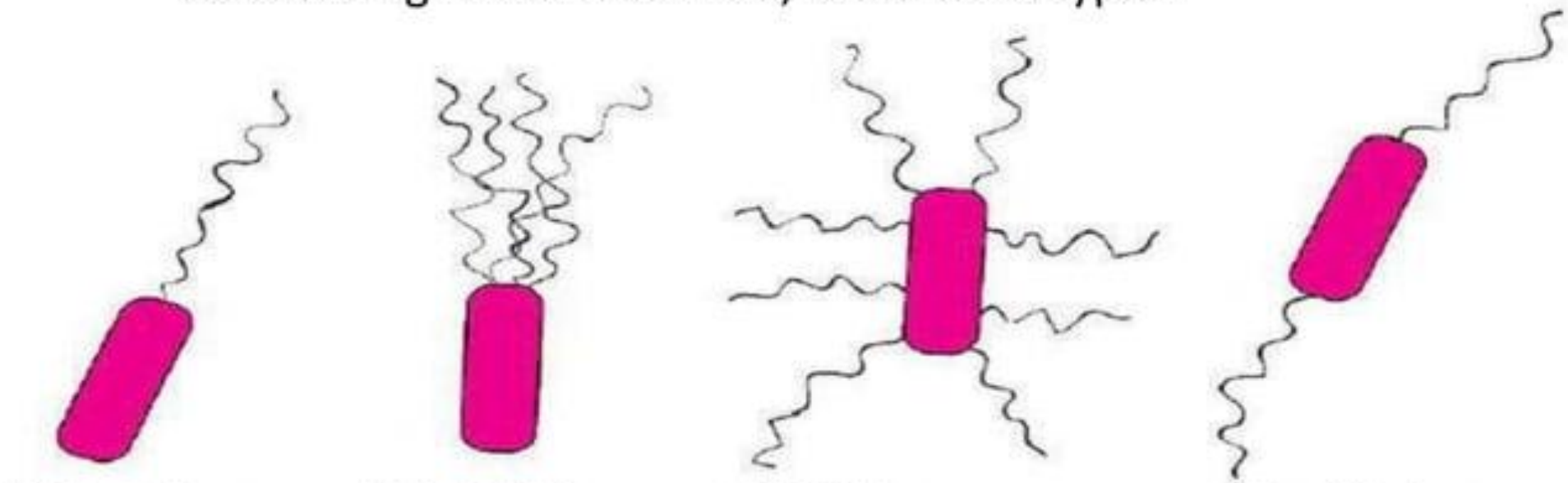
- Filament is the thin, cylindrical, long outermost region with a constant diameter.
- The filament is attached to a slightly wider hook.
- The basal body is composed of a small central rod inserted into a series of rings.



- Gram negative bacteria contain four rings as L-ring, P-ring, S-ring, M-ring whereas gram positive bacteria have only S and M rings in basal body.

Flagella may be seen on bacterial body in following manner.

1. **Monotrichous:** These bacteria have single polar flagellum. Eg: vibrio cholera
2. **Lophotrichous:** These bacteria have two or more flagella only at one end of the cell. Eg: pseudomonas fluorescence.
3. **Amphitrichous:** These bacteria have single polar flagella or tuft of flagella at both poles. Eg :Aquaspirillum serpens.
4. **Peritrichous:** Several flagella present all over the surface of bacteria. Eg: Escherichia coli, Salmonella typhi.



Flagella

Long & Thin

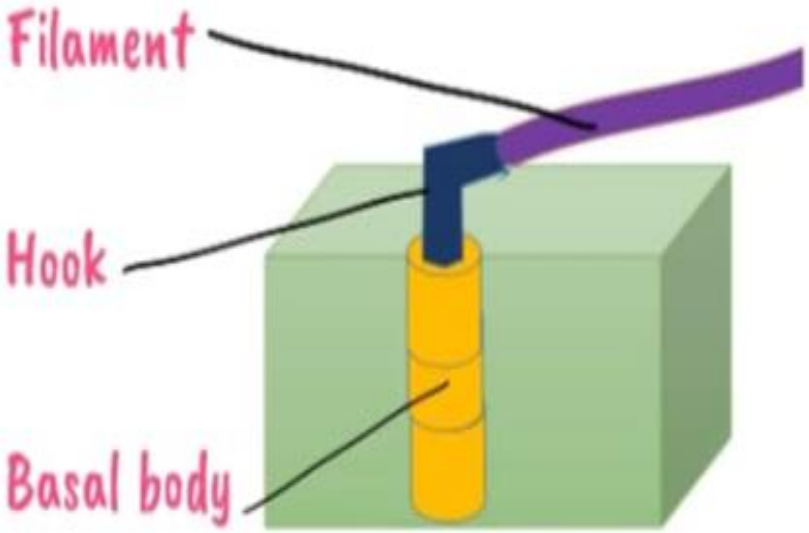
Motile Bacteria

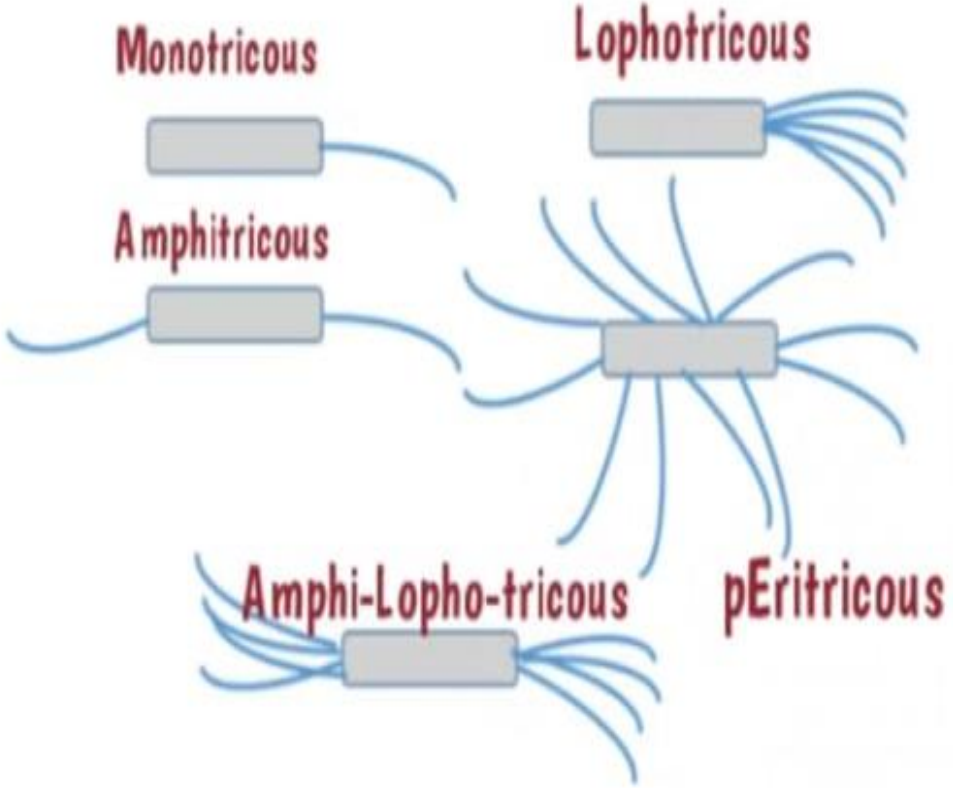
Help in moving of bacteria (Locomotion)

Composed -Flagellin Protein

Number & Arrangement

Antigenic--induce immune response





Pili or fimbriae

- Pili are hair-like microfibrils, 0.5 to 2 μm in length and 5 to 7 nm in diameter.
- They are thinner, shorter and more numerous than flagella.
- They are present only on gram negative cells.
- They are composed of protein known as pillin.
- They are unrelated to motility and are found on motile and non-motile cells.
- Fimbriae and pili, these two terms are used interchangeably but they can be distinguished.
- Fimbriae can be evenly distributed over the entire surface of the cell or they occurs at the poles of the bacterial cell. Each bacteria possess 100 to 200 fimbriae.
- Pili are usually longer than fimbriae and number only one or two per cell.

Function:

- Pili play an important role in attachment to surfaces. Hence pili is also called organ of adhesion.

Singular--Pilus

Pili

longer & thicker than fimbriae

Few in number

Pilin Protein

Transfer the genome such as plasmid from one bacteria to another== through conjugation

Electron microscope

Plasma membrane

- The cytoplasmic (plasma) membrane is a thin (5 to 10 nm).
- It separates the cell wall and cytoplasm.
- It composed of phospholipids (20 to 30 %) and proteins (60 to 70 %).
- Prokaryotic plasma membranes are less rigid than eukaryotic membrane due to lack of sterols.

Functions:

1. It acts as a semipermeable membrane controlling the inflow and outflow of metabolites to and from the protoplasm.
2. It provides the mechanical strength to the bacterial cell.
3. It helps in DNA replication.
4. It contains enzyme, permease, which plays an important role in the passage of selective nutrients through the membranes.

Contain organelles

- Chromosomal DNA
- Plasmid
- Ribosomes
- Mesosomes
- Spores
- Granules
- **********

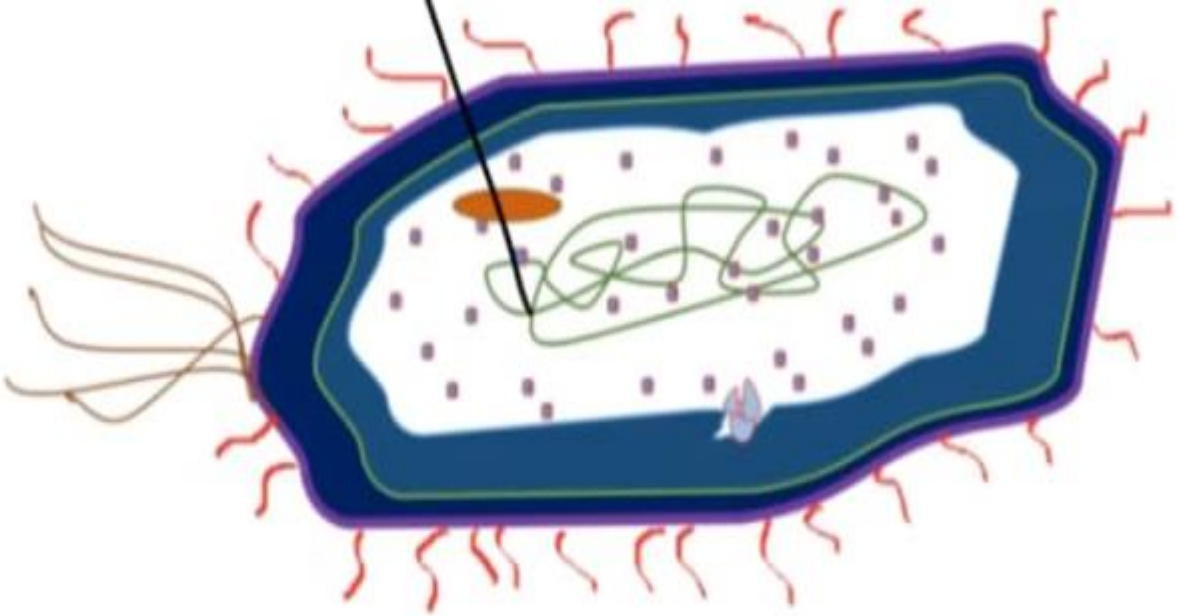
Genetic code of bacteria

double Stranded without histone

circular arrangement

Not bounded by Nuclear Membrane

Binary fission multiplication



Contain organelles

Chromosomal DNA

Plasmid

Ribosomes

Mesosomes

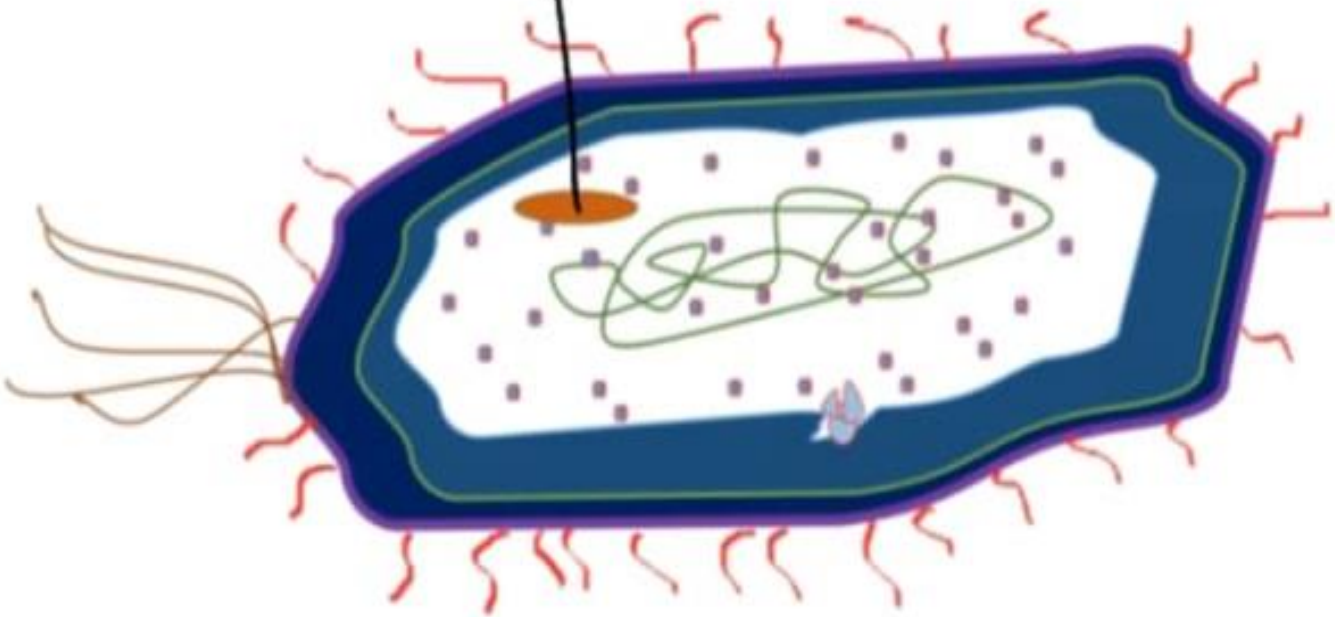
Spores

Granules

****

*Extranuclear Genetic Elements

*Transfer from one bacteria to other



Contain organelles

Chromosomal DNA

Plasmid

Ribosomes

Mesosomes

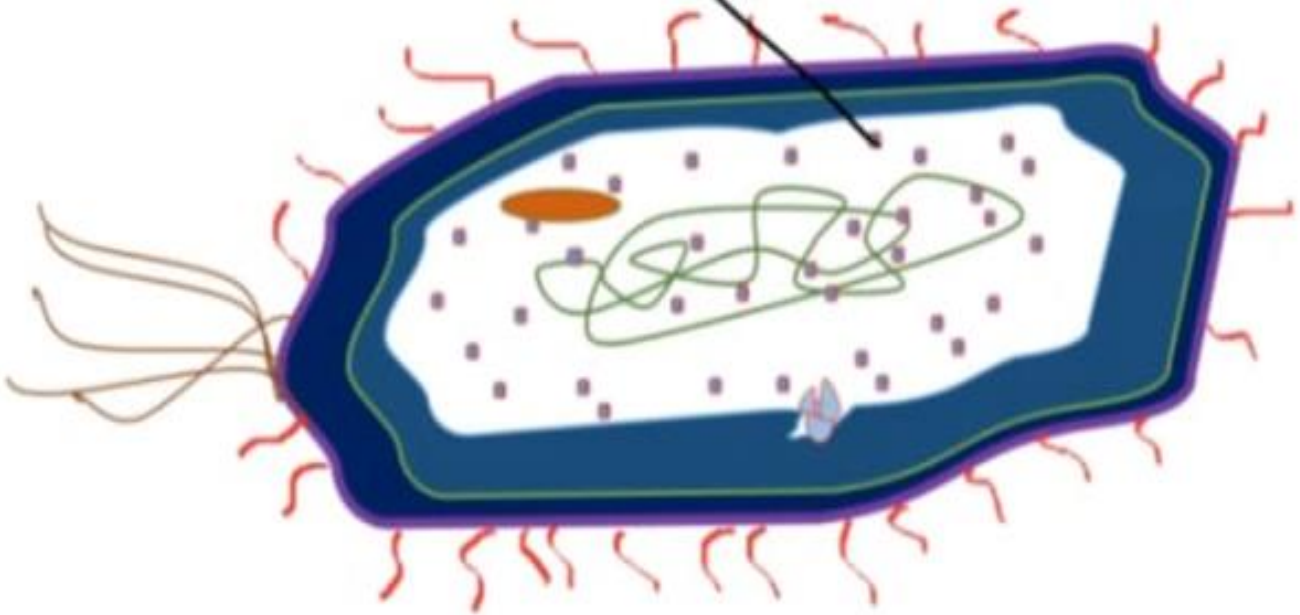
Spores

Granules

****

*center for Protein Synthesis

*Bacteria --70s (Svedberg unit)



Contain organelles

- Chromosomal DNA
- Plasmid
- Ribosomes
- Mesosomes
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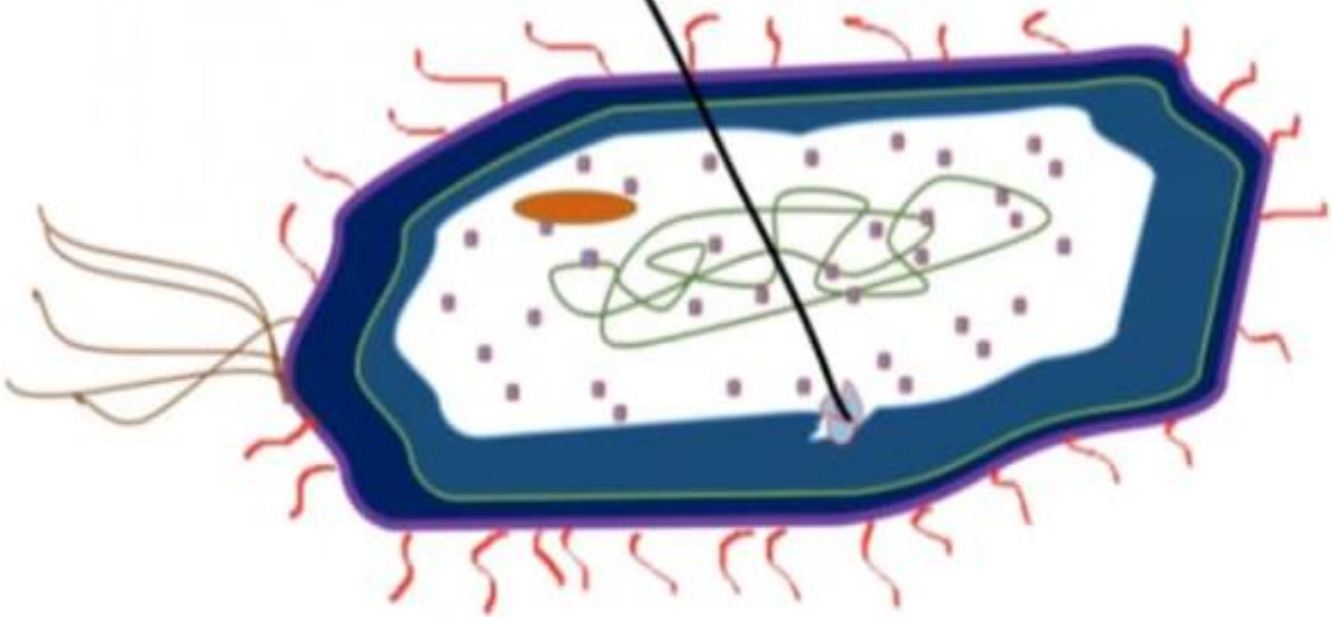
- Granules

****

*Respiratory site of enzyme

*Present near cross wall septa



Contain organelles

Chromosomal DNA

Plasmid

Ribosomes

Mesosomes

Spores

Granules

****

Stain with metachromatic stain
(Albert stain)

Poly-meta-phosphate

Corynebacterium diphtheriae

Energy Storing Granules

Babes Ernst granules

Metachromatic Granuels

Cytoplasm

- The bacterial cytoplasm is a suspension of organic, inorganic solutes in a viscous water solution.
- The cytoplasm of bacteria differs from that of higher eukaryotic microorganisms in not containing endoplasmic reticulum, Golgi apparatus, mitochondria and lysosomes.
- It contains the ribosomes, proteins and other water soluble components and reserve material.
- In most bacterial, extrachromosal DNA (plasmid DNA) is also present.

Mesosomes

- Mesosomes are respiratory sites of bacteria.
- The mesosomes are attached to the bacterial chromosomes and is involved in DNA segregation during cell division.
- They are predominant in Gram positive bacteria.

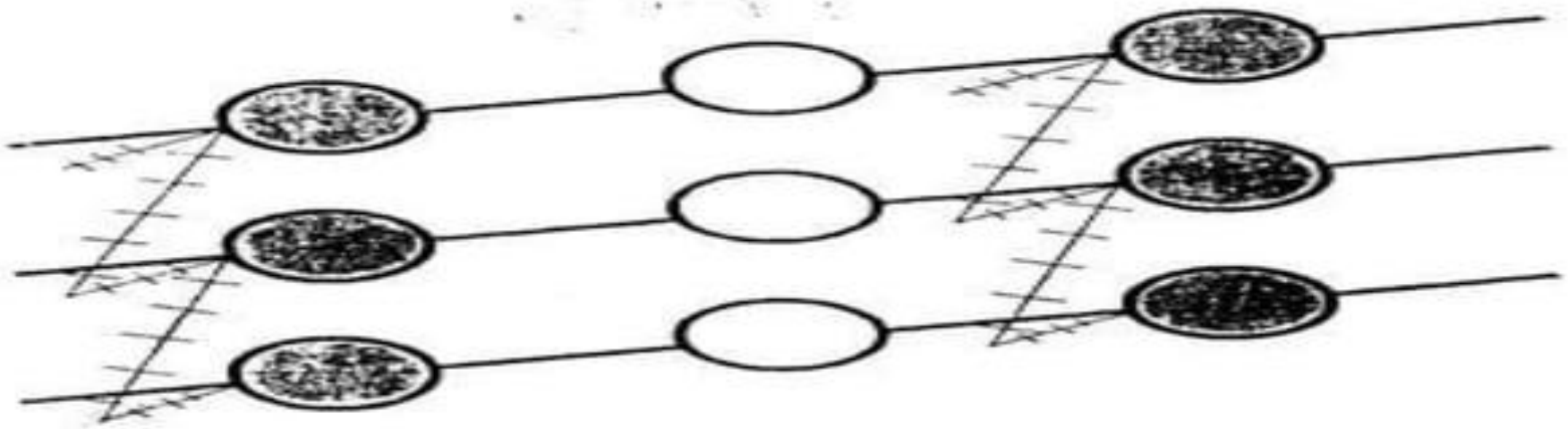
Nucleoid

- The bacterial chromosomes is not surrounded by nuclear membrane so it is called nucleoid.
- The bacterial chromosomes are made up of double strand circular DNA.

Intra Cytoplasmic inclusion

- Many species of bacteria produce cytoplasmic inclusion bodies which appears as round granules.
- They are made up of either glycogen or starch.
- They appear reddish when stained with polychrome methylene blue or toluidine blue.

Chemical structure of a bacterial cell wall



- N - Acetyl muramic acid

- N - Acetyl Glucosamine

- Peptide chain

- Penta Peptide chain

A comparison of cell walls of gram positive and gram negative bacteria

Table 4.2 : A comparison of cell walls of Gram-positive and Gram-negative bacteria

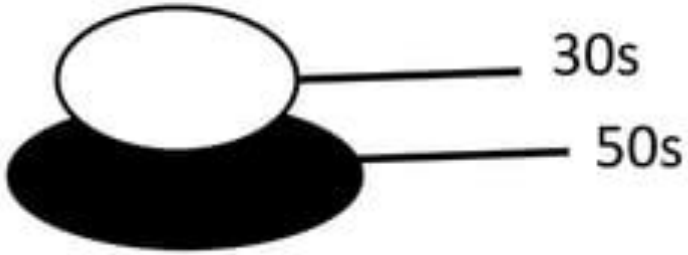
Component	Gram-positive	Gram-negative
1. Thickness	Thick (20 to 25 nm)	Thin (10 to 15 nm)
2. Peptidoglycan	More (50 – 90%)	Less (5 to 10%)
3. Teichoic acid	Present	Absent
4. Polysaccharide	Present	Absent
5. Lipids	Less or absent	More
6. Cell wall	Simple	Complex
7. Outer membrane and periplasmic space	Absent	Present
8. Effect of lysozyme	Easily destroyed	Resistant
9. Type of amino acids	Few	Several
10. Susceptibility to streptomycin and tetracycline	Slight	Marked
11. Susceptibility to penicillin and sulfonamides	Marked	Much less
12. Examples	*Bacillus anthracis* *Clostridium tetani* *Staphylococcus aureus* *Corynebacterium diphtheriae*	*Escherichia coli* *Salmonella typhi* *Vibrio cholerae* *Haemophilus influenzae*

Functions of cell wall

1. Cell wall is involved in growth and cell division of bacteria.
2. It gives shape to the cell.
3. It gives protection to internal structure and acts as supporting layer.
4. To prevent rupture of bacteria caused by osmotic pressure differences between intra cellular and extra cellular environment.
5. To provide support for flagella.
6. To regulate a certain degree of passage of molecules into and out of the cell.
7. It serve as the sites of attachment for most bacterial viruses.

Ribosomes

- Ribosomes are the center of protein synthesis.
- They are slightly smaller than eukaryotic ribosomes.
- The sedimentation constant is 70s.
- This 70s ribosomes are made up of two subunits namely a large subunits 50s and a small subunit 30s.

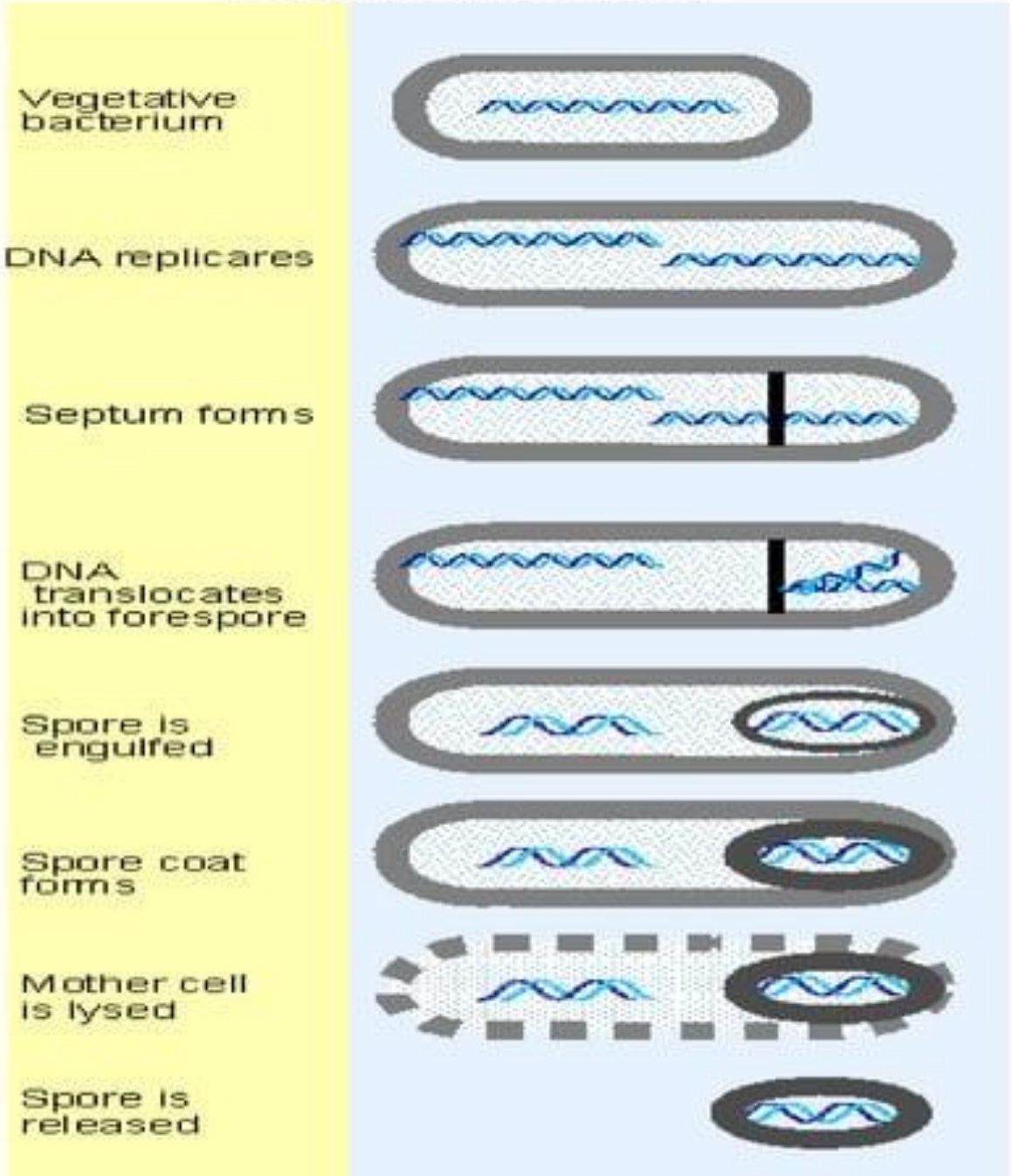


- During active protein synthesis the ribosomes are associated with mRNA and such associations are called polysomes.

Spore

- The process of endospore formation is known as sporulation and it may take 4 to 8 hours in a vegetative cell.
- Endospores are thick-walled, highly refractile bodies that are produced one per cell.
- Each bacterial spore on germination forms a single vegetative cell. Therefore, sporulation in bacteria is a method of preservation and not reproduction.
- Spores are extremely resistant to dessication, staining, disinfecting chemicals, radiation and heat.
- They remain viable for centuries and help bacteria to survive for long period under unfavorable environment. Endospore can remain dormant for thousand of years.
- Spores of all medically important bacteria are destroyed by moist heat sterilization (autoclave) at 121 °C for 20 minutes.

BACTERIAL SPORULATION



Thank You