Bacteria

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Introduction

- Bacteria defined as microscopic single celled organism that can penetrate into healthy tissues & start multiplying into vast numbers.
- These are unicellular, free living small microorganism which are visible under the light microscope.
- Those are belongs to kingdom prokaryotae (Monera).
- They occur in water, soil, air & all natural environments.

- The size & shape vary between the dimensions of 0.75 to 4.0 µm.
- The cocci diameter near about 1 µm & bacilli are 1 to 8 µm.
- They are found in spherical shape i.e coccoid forms or as cylindrical form i.e rod shaped forms.

Shape of Bacteria

- On basis of shape, bacteria are classified as follows...

1. Cocci
2. Bacilli
3. Vibrios
4. Spirilla
5. Spirochetes
6. Actinomycetes
7. Mycoplasams

Cocci

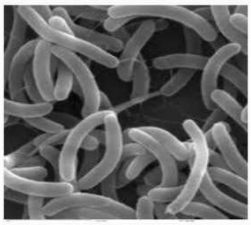
- Cocci are small, spherical or oval in shape
- In greek 'kokkos' means berry
- E.g. *Micrococcus*

Bacilli

- They are rod in shapes.
- It is derived from greek word 'Bacillum' meaning stick.
- Some of the bacilli the length of the cell may be equal to width those are called coccobacilli
- E.g. *Bracella*

Vibrios

- Vibrios are comma in shaped, curved rods
- E.g. *Vibrio comma*

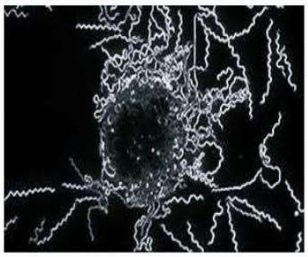


Spirilla

- Those are longer rigid rods with several curves or coils.
- Those are helical in shape & rapid bodies.
- E.g. *Spirillum ruprem.*

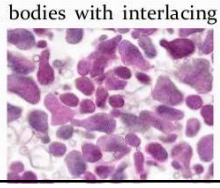
Spirochetes

- They are slender & flexuous spiral forms.



Mycoplasma

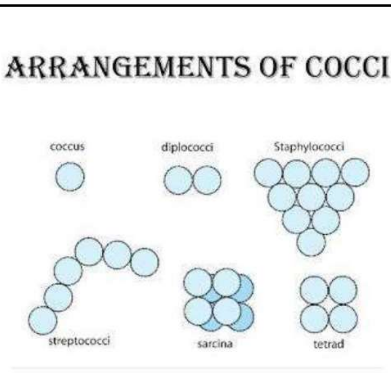
- Those are cell wall deficient bacteria
- So that, they do not have stable morphology.
- They occur as round or oval bodies with interlacing fillaments.



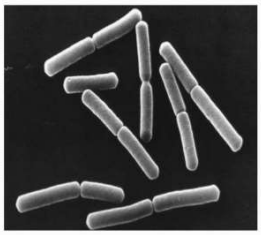
Arrangement of Bacteria

Coccoid cells to exhibit growth in aggregates. Accordingly that assembly they again exist in following five manners:

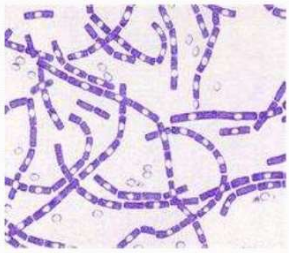
- As pairs or **diplococci.**
- As group of four systematically arranged in a cube or **sarcinae.**
- As unorganized array like a bunch of grapes or **staphylococci.**
- As chain like a string of beads or **streptococci.**
- In that cocci divided into two planes & remain in group of four that is **tetrads.**



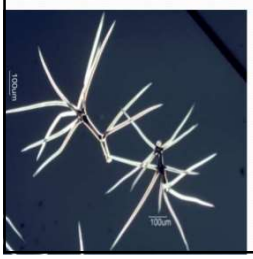
- Arrangement of groupings formed by bacilli species are limited & those split across their short axis.
- They may appear as pair those called Diplobacilli e.g. *klebisella pneumoniae*

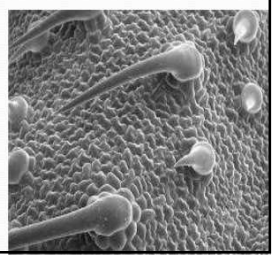


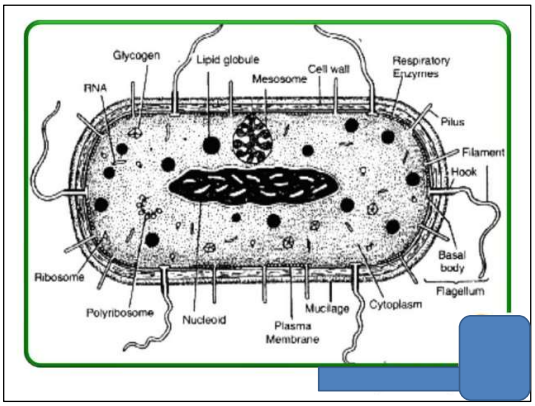
- Some bacilli species are found in chain like structure those called streptobacilli e.g *Bacillus subtilis.*



- Some bacilli species are found in chain like structure but have much large area of contact between the adjacent cells those are called trichomes e.g. *Saprospira* species







Structure of Bacterial cell

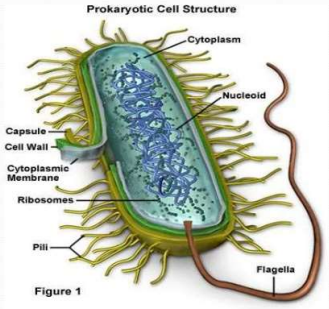


Figure 1

Flagella

- Flagella are long, slender, thin-hair like structure.
- Flagella attached with cytoplasm.
- They play important role in bacteria for motility.
- They have 0.01 to 0.02 µm in diameter.
- They have 3 to 20 µm in length.
- Flagella found in both Gram-positive & negative bacteria.
- Few coccal forms, most bacilli & almost all of the spirilla & vibrios are motile by flagella.
- They can be seen by compound microscope with special staining technique & can be seen easily under electron microscope & dark filled microscope.

Flagella seen in bacterial species in different manners..

- Monotrichous : Single polar flagella e.g. *Vibrio cholera*
- Lophotrichous : two or more flagella at only one end e.g *Pseudonomas fluorescens*
- Amphitrichous : single flagella or more flagella at both end e.g *Alcaligenes fecales*
- Peritrichous : several flagella present all over the surface e.g. *Salmonella typhi*

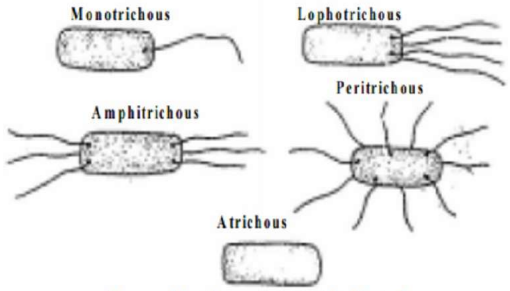


Fig : Flagellar arrangement in Bacteria

Periplasmic flagella or endoflagella or axial fibris :

- This type flagella present in some helical bacteria i.e. (spirochetes)
- That type of bacteria showing their motility only in highly viscous media.
- In that type of bacteria flagella like structure present within the cell.
- E.g. *Treponema pallidum.*

Gliding motility:

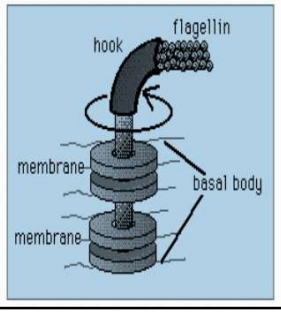
In that type of bacteria showing their motility when they are contact with solid surface. E.g. *Cytophaga species*

Parts of flagella

Three main parts present in flagella those are...

- Filament
- Hook
- Basal body

Structure of flagella



Fimbriae

- Fimbriae are similar structure like flagella but not involved in motility.
- It is shorter than flagella (3 µm).
- Fimbriae can be distributed over the entire surface of the cell.
- Fimbriae act primarily as adhesions & allow to microorganism to attach to surface.
- They responsible for haemagglutination & cell clumping in bacteria.

Pili

- Pilis are morphologically & chemically similar to fimbriae.
- But they are present in small in numbers compatibly fimbriae.
- Pilis joins to the bacterial cell for transfer of DNA (bacterial conjugation) from one cell to another cell.
- So pili also called as sex pili or fertility pili (F-pili).

Capsules & Slime layer

- Many bacteria secrets EPS (extracelluar polysaccharides) that are associated with the exterior of the bacterial cell.
- The EPS contains 2% carbohydrate & 98% water so, they produce gummy exterior to the cell.
- Morphologically two extreme forms exist...

  i. Capsules

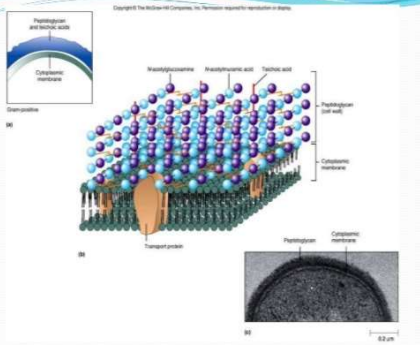
  ii. Slime
- Capsules: which forms rigid, tightly & closely associated with cell
- Slimes: which are loosely associated with cell.

Function of capsule & slime

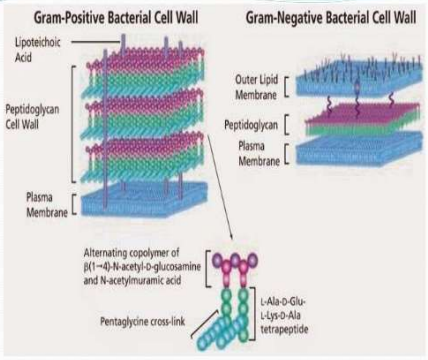
- They protect from desiccation.
- They provide a protection barrier against the penetration of biocides.
- They protect against engulfment by phagocytes & protozoa.
- They may promote the stability of bacterial suspension by preventing the cells from aggregation & settling.
- They may promote attachments of bacteria to surface.

Cell wall

- Cell wall gives definite shape to the bacteria.
- Cell wall situated between the capsule & cytoplasmic membrane.
- It is about 20- 30 nm in thickness.
- In the cell wall contains diaminopimelic acid (DAP), murmaic acid & teichoic acid.
- These substance joined together to formed a complex polymer structure known as peptidoglycan or murein or mucopeptide.



- Peptidoglycan is a large macromolecules containing glycan (polysaccharide) chains that are cross-linked by short peptide bridge.
- The glycan chain act as a backbone to peptidoglycan.
- Those short peptide bridge composed of alternating residues of N-acetyl muramic acid (NAM) & N-acetyl glucosamine (NAG).
- Each molecule of NAM attached a tetrapeptide.
- Tetrapeptide consisting of the amino acids L-alanine, D-alanine, D-glutamic acid & lycine or diaminopimelic acid (DAP).



- This glycan tetrapeptide repeat unit is cross -linked to adjacent glycan chain.
- This adjacent glycan chain occurs through a direct peptide linkage or a peptide interbridge.
- The type & number of cross linking amino acids vary from organism to organism.

Cell wall structure of Gram-positive & Gram-negative bacteria

- On the staining technique bacteria are divided into two large groups...i. Gram-positive

  ii. Gram- negative
- This staining technique are called as Gram staining technique.
- In that gram staining technique, the bacterial film treating with crystal violet & iodine solution & then washed with alcohol solution.

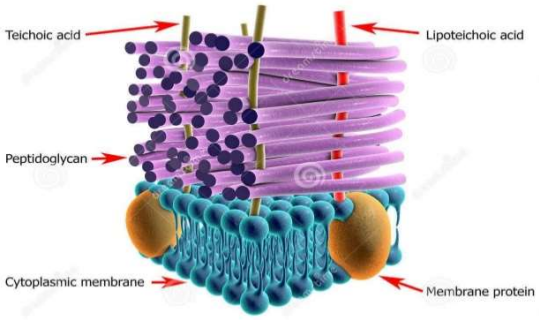
- After washing with alcohol solution the gram negative organism cells appears the colourless while, gram positive organisms are retain the dye.
- When both gram positive & negative cells are treated with different colour dye e.g carbol fuchsin (red in colour).
- That time, gram negative cells appears red & gram positive appears purple.
- On that it reflects that both have different cell wall structure.

Gram-positive cell wall structure

- Gram positive bacterial cell wall consist of a single type of molecules.
- Cell wall thick near about 20 to 80 nm.
- In that present of 60 to 80 % peptidoglycan.
- Gram positive walls frequently contains acidic polysachrides are called teichoic acids.
- Teichoic acid are either ribitol phosphate or glycerol phosphate molecules that are connected by phosphodiester bridge.

- In some gram positive bacteria glycerol-teichoic acids are bound to lipids membrane and termed as lipoteichoic acid.
- Those lipoteichoic acid create infection by killing bacteria & shows inflammation.

Cell wall structure of Gram-positive bacteria

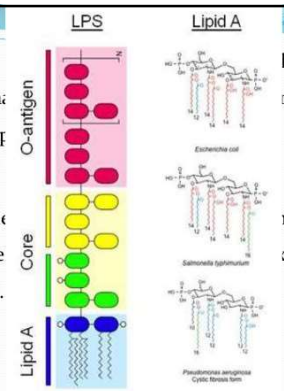


Gram-negative cell wall structure

- Gram negative cell wall are multilayered & complex type structure.
- Gram negative cell wall consist 10 to 20 % peptidoglycan.
- In that second layer found outside the peptidoglycan layer.
- This layer is asymmetrical & contains proteins, lipoproteins, phospholipids & lipopolysaccharide (LPS).

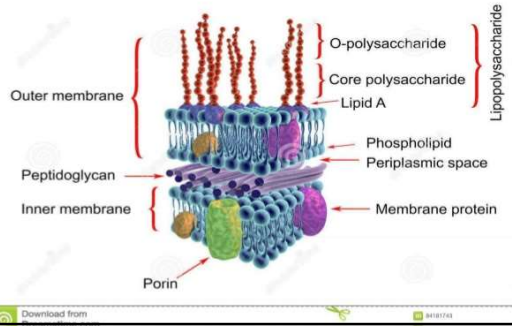
- This outer layer is attached to peptidoglycan & the other end is fixed in the outer membrane.
- In the inner leaf of the outer layer conatins phospholipids & it's outer layer composed with LPS (lipopoysaccharide), a polysaccharide-lipid molecule.
- In gram negative cell, the LPS is an important molecule because it determine the antigenicity & it is extremely toxic to animal cell.
- In the LPS molecules contains three regions
  - i. lipid A
  - ii. Core polysaccharide
  - iii. O-specific polysaccharide

- Lipid A linked to core le KDO (ketodeoxyocton re polysaccharide is the O-p
- In the O-polysaccharide is six-carbon sugars as we y sugars such as abequose.



- In the lipid A components are gives toxic & pathogenic properties to the gram-negative bacteria.
- Gram negative bacterial outer membrane is relatively permeable to small molecules but not for enzymes or large molecules.
- The region between the outer surface of the cytoplasmic membrane & the inner surface of the outer membrane is called the periplasm.

Cell wall structure of Gram-negative bacteria



Cytoplasmic Membrane

- Cytoplasmic membrane is thin near about 5 to 10 nm.
- Biochemically, the cytoplasmic membrane is fragile, phospholipid bilayer with proteins distributed randomly throughout.
- In the phospholipids bilayer most of the proteins are tenaciously held & are called integral proteins.

Functions of cytoplasmic membrane

- They including in transportation of nutrients.
- It provides mechanical strength to the bacterial cell.
- It helps in DNA replication.
- It contains the enzymes involved in the biosynthesis of membrane lipids & various macromolecules of the bacterial cell wall.

Ribosomes

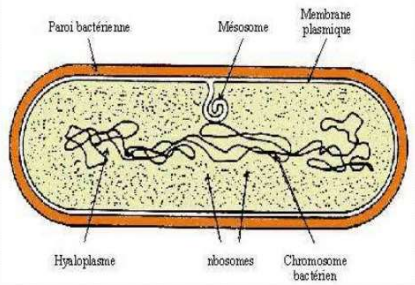
- Ribosomes are most important structure in bacterial cytoplasm.
- They involved in protein synthesis.
- Ribosomes numbers varies with the rate of protein synthesis.
- If greater the number of ribosomes then the greater the protein synthesis.
- They have 200 A° in diameter.
- They are characterised by their sedimentation properties.

Mesosomes

- In most of the bacteria, particularly in Gram-positive bacteria the growth condition depending upon the membrane appears to be infolded at more than one point.
- Such infoldings are called mesosomes.
- Mesosomes presents in two types...

In central (septal) mesosomes & peripheral (lateral) mesosomes.

Structure of mesosomes



- Central mesosomes present deep into the cytoplasm & locate near the middle of the cell.
- These are involved in the DNA segregation & in the formation of cross walls during cell division.
- The peripheral mesosomes are not present at central location & are not associated with nuclear material.
- Mesosomes are also called as **chondroids** & are visible only under electron microscope.
- Larger numbers of mesosomes have a higher respiratory activity e.g. *Azotobacter.*

Nucleus

- Nucleus appears oval or elongated bodies & generally present one per cell.
- The genome consists of a single molecule of double stranded DNA arrangement in a circle.
- It may open under certain conditions to form a long chain about 1000 µm in length.
- In bacterial nucleus does not contains nuclear membrane, nucleous & deoxyribonucleoprotein.
- The bacterial chromosome is haploid & replicated by simple fission instead of mitosis as in an eukaryotic cell.

Spores

- Many bacterial species produce spores inside the cell & outside the cell.
- Inside the spores are called endospores & outside the spores are called exospores. E.g *Bacillus anthracis, Bacillus subtilis* etc.
- Spores are extremely resistant to desiccation, staining, radiation, disinfecting chemicals & heat.
- Each bacterial spore on germination forms a single vegetative cell.
- They remain viable for long time & help bacteria to survive for long period under unfavourable condition.

- Endospores are thick-walled, highly refractile bodies that are produced one per cell.
- All the endospores contain large amount of DPA (dipicolinic acid).
- It occurs in combination with large amount of calcium, which is present in central part of the spore (core).
- That calcium & DPA complex play important role in the heat resistant of endospores.
- Endospores consists of a core or envelope or protoplast.
- In the core or protoplast consist of DNA & ribosomes, t-RNA & enzymes.
- The spore envelop consist of the inner membrane, outer membrane, cortex & spore coat.
- In some species have the outer layer called exosporium which bears ridges & fold.

Nutritional Requirements

Bacteria required the nutrition's, pH, oxygen & temperature for growth & multiplication process.

- So, for cultivation of microorganism required elements such as sodium, potassium, magnesium & iron.
- As well as in media required contains of source of carbon, nitrogen, hydrogen, oxygen & phosphorus.
- Bacteria can be classified depending upon nutritional requirements...such as carbon, energy, electron etc.

- **Source of energy**:

Energy obtained from sunlight are called **phototrophs** bacteria e.g. *Rhodospirillum rubrum.*

Energy obtained from chemical reaction those called **chemotrophs** bacteria e.g. *Escherichia coli or E-coli.*

- **Source of electrons**:

All bacteria required electrons for metabolism.

Lithotrops : In that type of bacteria species use the inorganic compounds as electron donor e.g *pseudomonas pseudoflava.*

Organotrophs : In that type of bacteria species use the organic compounds as electron donor e.g *Escherichia coli or E-coli.*

Photolithotrophs : some phototropic bacteria use inorganic compound (H_2S) as source of electron. e.g. *Chromatium okenii.*

Photoorganotrophs: some phototropic bacteria use organic compound such as fatty acids & alcohols as electron donors e.g *Rhodospirillum rubrum.*

Chemolithotrophs: some chemotrophic bacteria use inorganic compound as source of electron. e.g. *Nitrosomonas europaea.*

Chemoorganotrophs: some chemotrophic bacteria use organic compound such as sugar &amino acids as electron donors e.g *Escherichia coli or E-coli.*

- **Source of carbon:** microorganism required carbon for synthesizing cell components.

Autotrophs: some species use CO_2 as the major source of carbon these microorganisms are called autotrophs. e.g. *Chromatium okenii.*

Heterotrops: some species use organic compounds as a source of carbon such species are called heterotrophs. e.g. *Escherichia coli or E-coli.*

- **Nitrogen:**

Nitrogen is the major component of protein & nucleic acids, so that bacteria can use nitrogen from the atmosphere or from inorganic compounds such as nitrites, nitrate.

- **Sulphur:**

Sulphur is needed for synthesis of amino acids.

- **Phosphorus**:

Phosphorus usually supplied in the form of phosphate is an essential component of nucleotides, nucleic acid etc.

- **Water**:

It is the major essential nutrient as it account for about 80 to 90% of the total weight of cell.

- **Mineral salts**:

Bacteria require salts, particularly the anions such as phosphate & sulphate & the cations as sodium, potassium, magnesium, iron & calcium. These are present in the natural environment or may be added in cultural media.

Gram staining

- Gram staining technique discovered by Dr. Christian Gram in 1884.
- By that technique use for not just for determination of morphology but also use for the differentiae in between Gram-positive & Gram negative cell.
- Gram positive cell retain the violet stain.
- But gram negative cell decolourised & appears the red colour in some species e.g *E-coli, salmonella typhi, vibrio cholerae, klebsiella pneumoniae* etc.

Thank You