Introduction to General Bacteriology I

Kusum Shrestha
Assistant Professor
School of Health and Allied Sciences
Pokhara University

Introduction

- Bacteria are unicellular organisms belonging to the prokaryotic group where the organisms lack a few organelles and a true nucleus
- The study of bacteria is called bacteriology
- Considered as one of the oldest forms of life on earth
- The most recent taxonomic classification of bacteria is based on Cavalier and Smith's six kingdom classification
- It is a molecular classification which divides all living structures of the earth into six kingdoms-Bacteria,Protozoa, Chromista, Plantae, Fungi and Animalia.

contd

- Most of the bacteria of medical importance generally measure 0.2-1.5 µm in diameter and about 3-5 µm in length,
- Bacteria follow an asexual **mode of reproduction,** called binary fission in which a single bacterium divides into two daughter cells.
- They can be either useful of harmful to us
- Bacteria can be divided into several types based on several characteristics such as shape, cell wall composition, mode of respiration, mode of nutrition etc

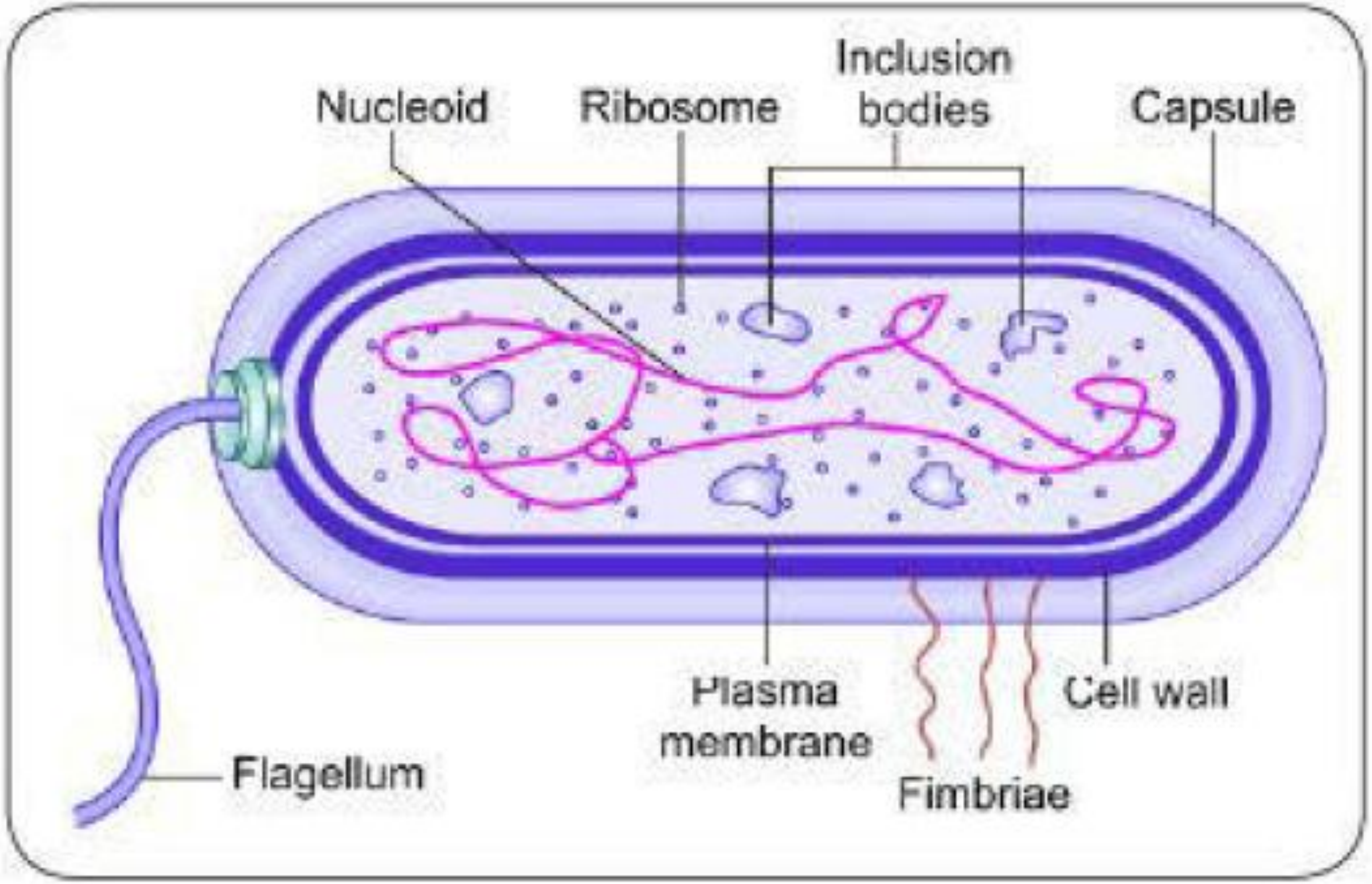


Fig. 2.10: Structure of bacterial cell

Classification of bacteria

Approaches of classification

- Numerical/Phenetic approach:

➢ depends upon phenotypes or physical appearances of organisms

➢ Classifies organisms based on giving equal weight to every character of the organism

- Phylogenic/Phylogenetic approach:

➢ This system is called phylogenetic because it depends upon evolutionary relationships of organisms.

➢ hierarchical classification representing a branching tree-like arrangement; one characteristic is being employed for division *at* each node of the *tree*

contd

- Genotypic approach: depends upon comparison of genes or genomes between organisms.
- Polyphasic Approach: combines all the aspects

Classification of bacteria based on:

- Gram stain
- Morphology
- Mode of nutrition
- Temperature requirement
- Oxygen requirement
- Salt requirement
- Flagella/Motility
- Spore formation
- Cultural Characteristics

On the basis of shape

1)Cocci: are oval or spherical cells

2)Bacilli or rods: rod shaped

- ❖Cocci are arranged in groups (clusters), pair or chains
- ❖Similarly, bacilli can be arranged in chain, pair, and some bacilli are curved, comma shaped, or cuneiform shaped
- ❖Both cocci and bacilli are further classified based on Gram staining property into : Gram-positive cocci, Gram-negative cocci, Gram-positive bacilli, Gram- negative bacilli

contd

❖On the basis of arrangement, cocci are classified as:

- **Monococcus:** Cocci in singles. E.g. *Micrococcus flavus*
- **Diplococci:** Cocci in pairs. E.g. *Streptococcus pneumoniae*
- **Streptococci:** Cocci in chain. E.g. *Streptococcus pyogenes*
- **Staphylococci:** Cocci in cluster. E.g. *Staphylococcus aureus*
- **Tetrad:** Cocci in group of four. E.g. *Micrococcus spp.*
- **Sarcina:** Cocci in group of eight. E.g. *Sarcina lutea*

contd

❖On the basis of arrangement, bacilli are further classified as:

- Diplobacilli: *Diplobacilli*
- Streptobacilli: *Streptobacillus moliniformis*
- Palisades

3) **Vibrio:** Comma shaped bacteria. Eg. *Vibrio cholera*

4) **Spirilla:** Spiral or spring shaped bacteria. E.g. *Spirillum volutans*

5. Others:

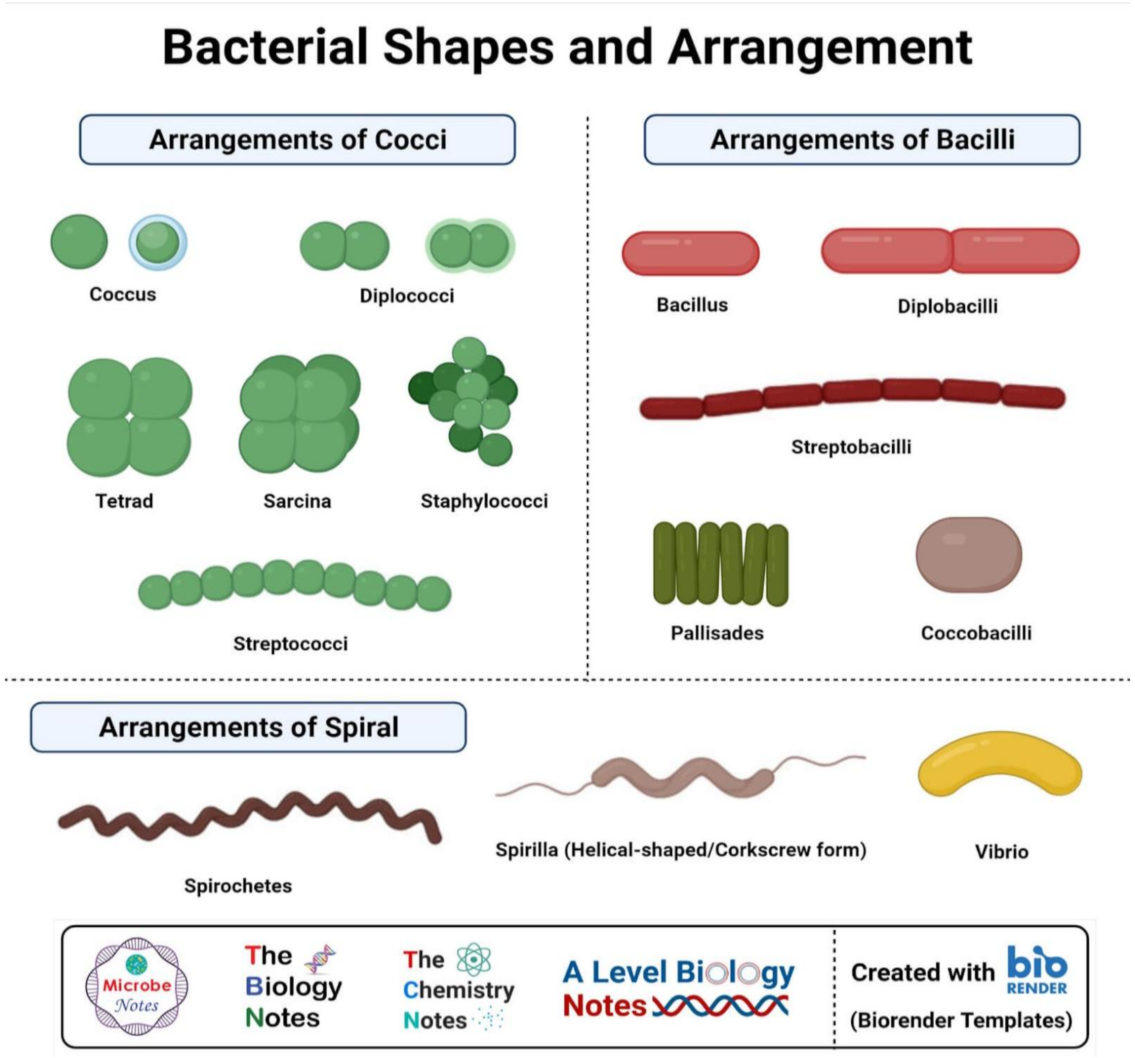
- Mycoplasma: Pleomorphic, no definite shape
- Actinomycetes: branching filamentous bacteria

On the basis of Gram staining

Gram negative bacteria	Gram positive bacteria
Salmonella typhi	*Staphylococcus aureus*
Salmonella typhimurum	*Staphylococcus epidermidis*
Pseudomonas aeroginosa	*Staphylococcus saprophyticus*
Proteus merabilis	*Steptococcus pyogenes*
Proteus vuligaris	*Streptococcus pneumoniae*
Klebsiella pneumoniae	*Streptococcus mutanus*
Acinetobacter	*Streptococcus fecalis*
Escherichia coli	*Streptococcus agalagtia*
Escherichia coli	
Serratia spp.	

TABLE 2.4: Classification of bacteria depending on their morphology and Gram staining property

Bacteria	Example
Gram-positive cocci arranged in	
Cluster	*Staphylococcus*
Chain	*Streptococcus*
Pairs, lanceolate shaped	Pneumococcus
Pair or in short chain, spectacle eyed shape	*Enterococcus*
Tetrads	*Micrococcus*
Octate	*Sarcina*
Gram-negative cocci arranged in	
Pairs, lens shaped	Meningococcus
Pairs, kidney shaped	Gonococcus
Gram-positive bacilli arranged in	
Chain (bamboo stick appearance)	*Bacillus anthracis*
Chain	*Streptobacillus*
Chinese letter or cuneiform pattern	*Corynebacterium diphtheriae*
Palisade pattern	Diphtheroids
Branched and filamentous form	*Actinomyces* and *Nocardia*
Gram-negative bacilli arranged in	
Pleomorphic (various shapes)	*Haemophilus, Proteus*
Thumb print appearance	*Bordetella pertussis*
Comma shaped (fish in stream appearance)	*Vibrio cholerae*
Curved	*Campylobacter* (Gull-wing shaped) and *Helicobacter*
Spirally coiled, flexible	Spirochetes
Rigid spiral forms	*Spirillum*
Bacteria that lack cell wall	*Mycoplasma*


Bacterial Shapes and Arrangement
Arrangements of Cocci
Coccus
Diplococci
Tetrad
Sarcina
Staphylococci
Streptococci
Arrangements of Bacilli
Bacillus
Diplobacilli
Streptobacilli
Pallisades
Coccobacilli
Arrangements of Spiral
Spirochetes
Spirilla (Helical-shaped/Corkscrew form)
Vibrio
Microbe Notes
The Biology Notes
The Chemistry Notes
A Level Biology Notes
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Nutritional type of microorganisms

1)On the basis of carbon source

- Autotrophs: can synthesize all of their organic compounds by using atmospheric CO2, as their sole source of carbon
- Heterotrophs: use reduced, preformed organic molecules as carbon sources

2) On the basis of energy source

a) Chemotrophs:

➢ obtain energy from oxidation of external chemical compounds.

➢ The compound may be organic or inorganic.

contd

b) Phototrophs: They obtain energy from light

3) On the basis of electron donor

a) Lithotrophs: These bacteria obtain reducing equivalents (electron) from inorganic compounds.

b) Organotrophs: They obtain reducing equivalents from organic compounds.

- Bacteria usually possess combination of these properties.
- Most of the pathogenic bacteria fall into chemoorganoheterotrophs group. These bacteria obtain energy, carbon, and reducing equivalents for biosynthetic reactions from organic compounds, e.g. Escherichia coli.

Table 5.2 Major Nutritional Types of Microorganisms

Nutritional Type	Carbon Source	Energy Source	Electron Source	Representative Microorganisms
Photolithoautotrophy (photolithotrophic autotrophy)	CO_2	Light	Inorganic e^- donor	Purple and green sulfur bacteria, cyanobacteria
Photoorganoheterotrophy (photoorganotrophic heterotrophy)	Organic carbon, but CO_2 may also be used	Light	Organic e^- donor	Purple nonsulfur bacteria, green nonsulfur bacteria
Chemolithoautotrophy (chemolithotrophic autotrophy)	CO_2	Inorganic chemicals	Inorganic e^- donor	Sulfur-oxidizing bacteria, hydrogen-oxidizing bacteria, methanogens, nitrifying bacteria, iron-oxidizing bacteria
Chemolithoheterotrophy or mixotrophy (chemolithotrophic heterotrophy)	Organic carbon, but CO_2 may also be used	Inorganic chemicals	Inorganic e^- donor	Some sulfur-oxidizing bacteria (e.g., *Beggiatoa*)
Chemoorganoheterotrophy (chemoorganotrophic heterotrophy)	Organic carbon	Organic chemicals often same as C source	Organic e^- donor, often same as C source	Most nonphotosynthetic microbes, including most pathogens, fungi, many protists, and many archaea

Oxygen requirement

- Obligate aerobe
- Obligate anaerobe
- Facultative anaerobe
- Aerotolerant anaerobe
- Miceroaerophile

Classification of Bacteria by Response to Oxygen

Type of Bacteria	Growth Response: Aerobic	Growth Response: Anaerobic	Possession of Catalase and Superoxide Dismutase	Comment	Example
Aerobe (strict aerobe)	+	–	+	Requires O_2; cannot ferment	*Mycobacterium tuberculosis* *Pseudomonas aeruginosa* *Bacillus subtilis*
Anaerobe (strict anaerobe)	–	+	–	Killed by O_2; ferments in absence of O_2	*Clostridium botulinum* *Bacteroides melaninogenicus*
Facultative	+	+	+	Respires with O_2; ferments in absence of O_2	*Escherichia coli* *Shigella dysenteriae* *Staphylococcus aureus*
Indifferent (aerotolerant anaerobe)	+	+	+	Ferments in presence or absence of O_2	*Streptococcus pneumoniae* *Streptococcus pyogenes*
Microaerophilic	(+)[a]	+	(+)[a]	Grows best at low O_2 concentration; can grow without O_2	*Campylobacter jejuni*

[a](+) indicates small amounts of growth or catalase and superoxide dismutase.

TEMPERATURE REQUIREMENT

Classification of Bacteria-Basis on Temperature

Prepared by Thepharmapedia.com

Psychrophiles	Mesophiles	Thermophiles	Hyperthermophiles
• Cold loving • Optimum temp- 10-20 °C (<20 °C)	• Moderate temp. Loving • Optimum temp- 25-40 °C	• Heat loving • 50 -80 °C	• Extreme Heat loving • -80 or more °C
Examples: Vibrio marinus Polaromonas vaculata Psychroflexus.	**Examples:** E. Coli Salmonella Klebsiella Staphylococci	**Examples:** Bacillus stearothermophilus Thermus aquaticus.	**Examples:** Thermodesulfobacterium Pyrolobus fumar Thermotoga.

pH REQUIREMENT

Bacteria

Acidophiles

- Grow best in acidic pH.
- Cytoplasm is acidic in nature.
- Eg: *Thiobacillus*

Alkaliphiles

- Grow best in alkaline pH.
- *Eg. Vibrio cholerae* optimum ph of growth is 8.2

Neutrophiles

- Grow best at neutral pH (6.5-7.5)
- Most of the bacteria grow at neutral pH
- Example: *E. coli*

SALT REQUIREMENT

Bacteria

Mild Halophiles

- Require moderate to large salt conc.
- Ocean water contains 3.5% salt. Most such bacteria are present in the oceans.
- Eg: *Archeobacteria*, *Halobacterium*,

Extreme Halophiles

- Require a very high salt concentrations (20 to 30%).
- Bacteria in Dead Sea, brine vats.

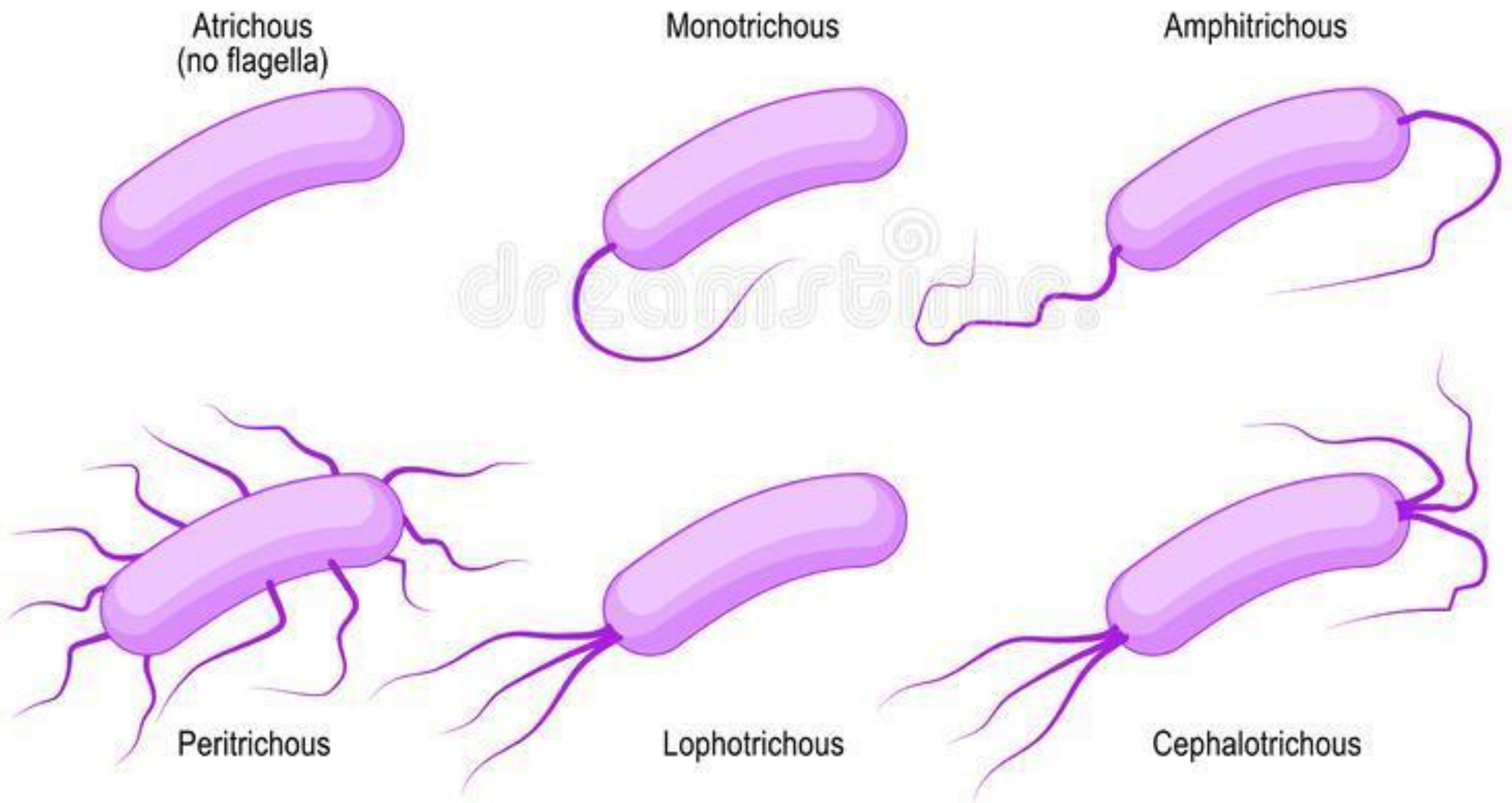
Halotolerant

- Do not require high salt concentrations for growth, but tolerate upto 2% salt or more.
- Example: *E. coli*

FLAGELLA/MOTILITY

- Atrichos: No flagella. Example: *Corynebacterium diptherae*.
- Monotrichous: One flagellum is attached to one end of the bacteria cell. Example: *Vibro cholerae*.
- Lophotrichous: Bunch of flagella is attached to one end of the bacteria cell. Example: *Pseudomonas*.
- Amphitrichous: Bunch of flagella arising from both end of the bacteria cell. Example: *Rhodospirillum rubrum*.
- Peritrichous: The flagella are evenly distributed surrounding the entire bacterial cell. Example: *Salmonella*

Types of flagellar arrangement



SPORE FORMATION

Bacteria

Spore forming Bacteria

produce spore during unfavorable condition

Non-spore forming Bacteria

Do not produce spores

Endospore forming Bacteria

Spore is produced within the bacterial cell

Example: *Bacillus, Clostridium, Sporosarcina etc*

Exospore forming Bacteria

Spore is produced outside the cell.

Example: *Methylosinus*

CULTURAL CHARACTERISTICS

- Extra growth factors requirements
  - **Fastidious** – *Hemophilus influenzae*
  - **Non-fastidious** – *Escherichia coli*

- Hemolysis on Sheep Blood Agar
  - **Alpha-hemolysis** – *Streptococcus pneumoniae*
  - **Beta-hemolysis** – *Streptococcus pyogenes*
- Utilization of carbohydrates
  - **Oxidative** - *Micrococcus*
  - **Fermentative** – *Escherichia coli*

- Growth rate
  - **Rapid growers**– *Vibrio cholerae*
  - **Slow growers** – *Mycobacterium tuberculosis*
- Pigment production
  - **Pigment producer** – *Staphylococcus aureus*
  - **Pigment non-producer** – *Escherichia coli*

On the basis of

Capsule:

❖Capsulated(presence of capsule)

❖Non-capsulated(absence of capsule)

Acid fastness:

❖Acid fast: Mycobacterium spp, Nocardia

❖Non acid fast: Escherichia coli, Salmonella spp

OTHER METHODS OF CLASSIFICATION

- Pathogenic/Non-pathogenic
- Various biochemical properties
- Sensitive/Resistance to particular antibiotics (or chemicals)
- Relationship with their host

Etc…

Table 2.1 Distinguishing features of prokaryotes and eukaryotes

Characteristic	Eukaryotes	Prokaryotes
Size	Normally > 10 µm	Typically 1–5 µm
Location of chromosomes	Within a true nucleus separated from the cytoplasm by a nuclear membrane	In the cytoplasm, usually attached to the cell membrane
Nuclear division	Exhibit mitosis and meiosis	Mitosis and meiosis are absent
Nucleolus	Present	Absent
Reproduction	Asexual or sexual reproduction	Normally asexual reproduction
Chromosome number	>1	1
Mitochondria and chloroplasts	May be present	Absent
Cell membrane composition	Sterols present	Sterols absent
Cell wall composition	Cell walls (when present) usually contain cellulose or chitin but not peptidoglycan	Walls usually contain peptidoglycan
Ribosomes	Cytoplasmic ribosomes are 80S	Ribosomes are smaller, usually 70S
Flagella	Structurally complex	Structurally simple
Pili	Absent	Present
Fimbriae	Cilia	Present
Storage compounds	Poly-β-hydroxybutyrate absent	Poly-β-hydroxybutyrate often present

MORPHOLOGY

The Structure of a Generalized Bacterial Cell

- Bacterial cell
  - External
    - Flagella
    - Pilli
    - Fimbriae
    - Glycocalyx
    - Capsule, slime layer
  - Cell envelope
    - Cell wall
    - Cell membrane
  - Internal
    - Cytoplasmic matrix
    - Ribosomes
    - Inclusions
    - Nucleoid/chromosome
    - Actin cytoskeleton
    - Endospore

Components of bacterial cell

1)Cell wall

- Tough and rigid structure, surrounding the bacterium
- 10-25 nm in thickness and weighs about 20-25% of the dry weight of the cell
- Made up of peptidoglycan in Gram positive and comprises additional LPS layer in Gram negative bacteria
- Peptidoglycan is composed of alternating units of N-acetyl muramic acid(NAM) and N-acetyl glucoasmaine (NAG)

contd

- The Gram-negative cell wall is much more complex than the Gram-positive cell wall
- The Gram-negative cell wall outside the peptidoglycan layer contains three main components

(a) lipoprotein layer

(b) outer membrane

(c) lipopolysaccharides

contd

- Acid fast organism:
  - Have a gram-positive cell wall structure but also contain a waxy layer of glycolipids and fatty acids (mycolic acid) bound to the exterior of the cell wall
  - More than 60% of the cell wall is lipid, and the major lipid component is mycolic acid

contd

Functions of cell wall:

- Protection against osmotic lysis
- Confers rigidity and shape
- Adhesion with bacteria and with mammalian cells
- Takes part in cell division
- Virulence factor
- Protect a cell from *toxic* substances

TABLE 2.5: Differences between gram-positive and gram-negative cell wall

Characters	Gram-positive cell wall	Gram-negative cell wall
Peptidoglycan layer	Thicker (15–80 nm)	Thinner (2 nm)
At third position of tetrapeptide side chain	L-Lysine present	Mesodiaminopimelic acid present
Pentaglycine bridge	Present	Absent
Lipid content	Nil or scanty (2–5%)	Present (15–20%)
Lipopolysaccharide	Absent	Present **(endotoxin)**
Teichoic acid	Present	Absent
Variety of amino acids	Few	Several
Aromatic amino acids	Absent	Present

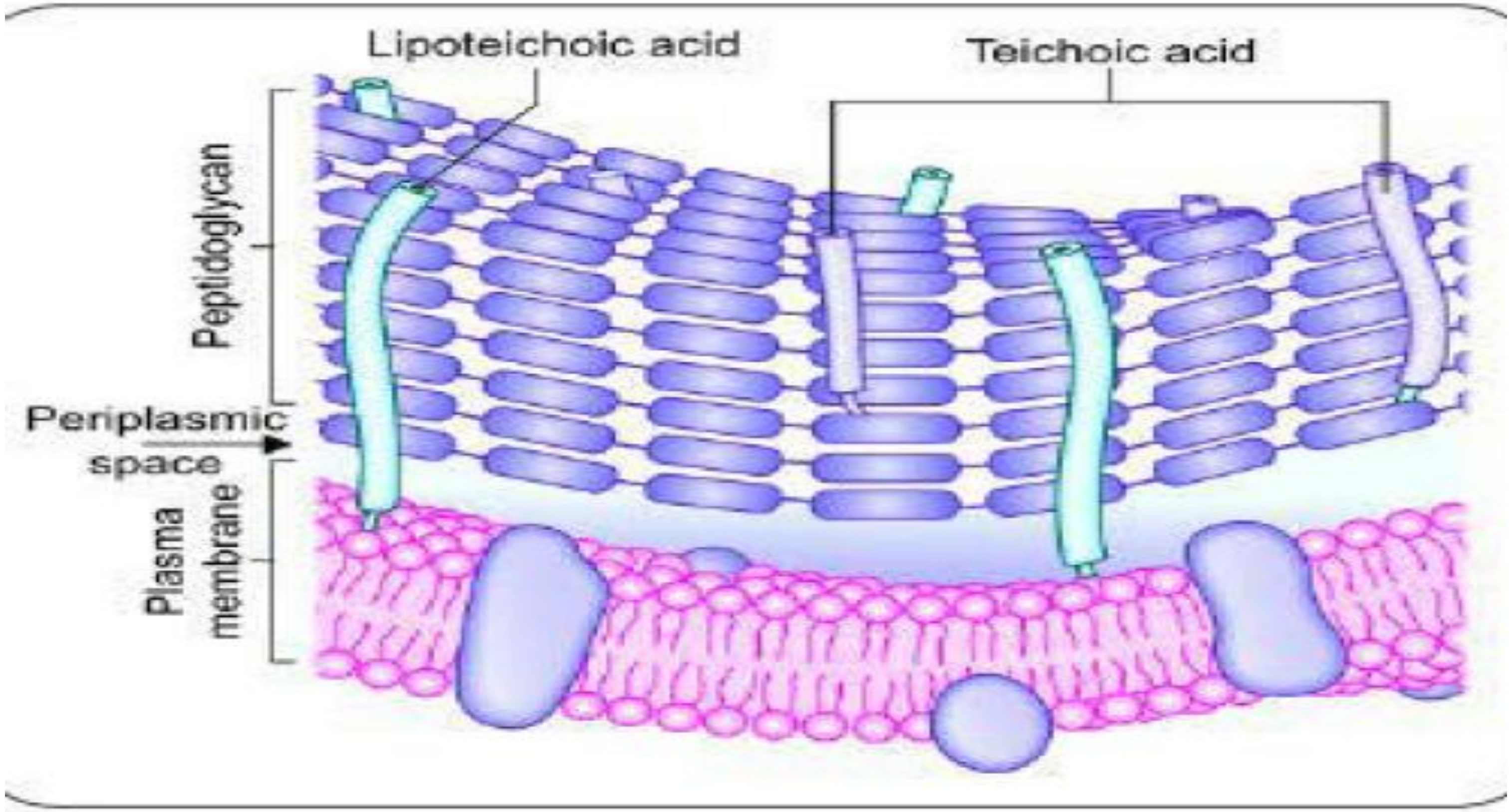


Fig. 2.11: Structure of gram-positive cell wall

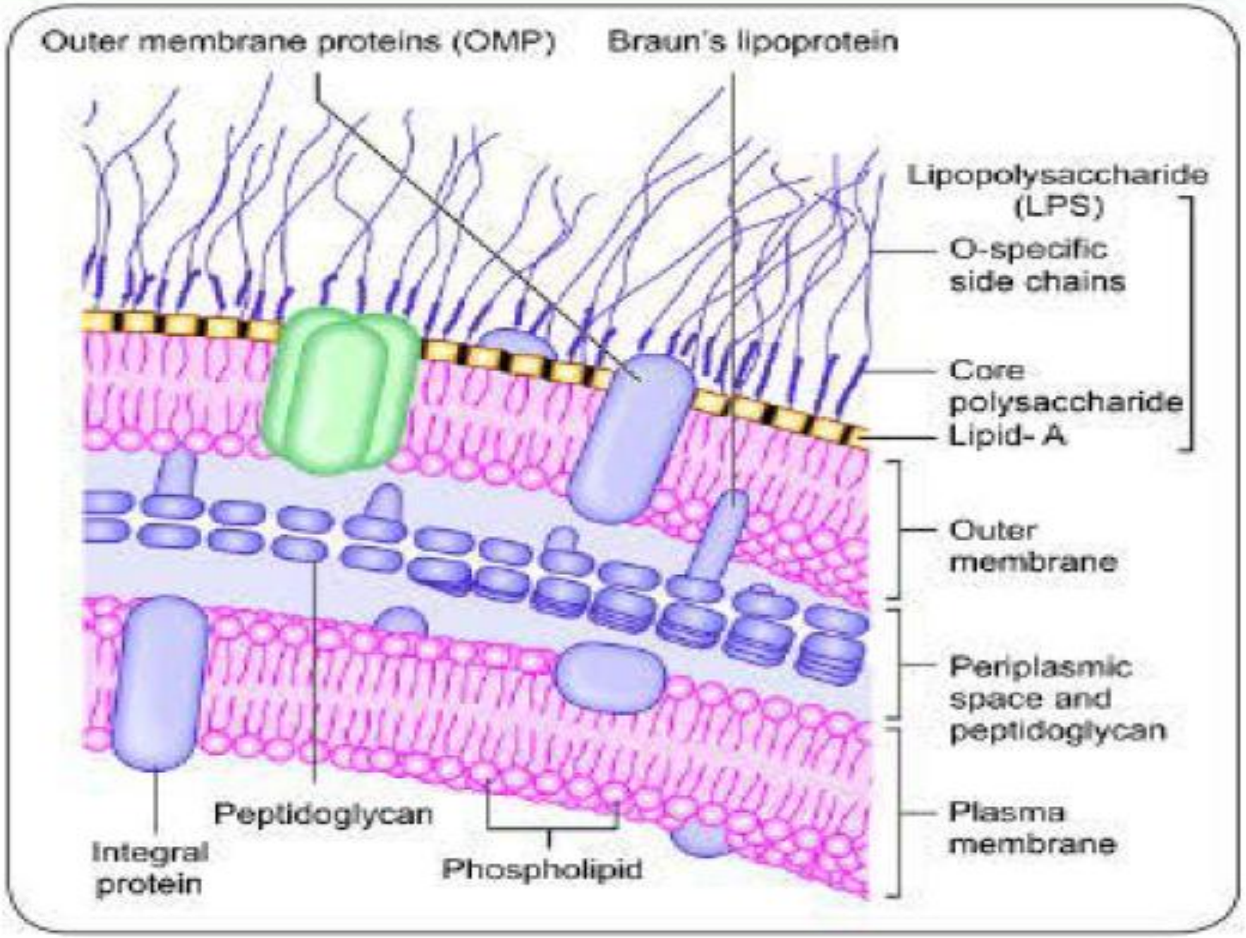


Fig. 2.13: Gram-negative cell wall

contd

2)Cell membrane

- 5-10 nm thick
- 10% of the dry weight of a cell.
- Composed of bilayered phospholipid in which several proteins are embedded, such as integral proteins and peripheral proteins
- Differs from eukaryotic membranes in lacking sterols such as cholesterol (except in *Mycoplasma)*
- Some carbohydrates are often attached to the outer surface of plasma membrane proteins

Fluid mosaic model of cell membrane

- ❖Fluid mosaic model was proposed by Jonathan Singer and Garth Nicolson in 1972.
- ❖Describes the dynamic and fluid nature of biological membranes.
- ❖Membranes are mainly made up of lipids, proteins, and small amounts of carbohydrates.

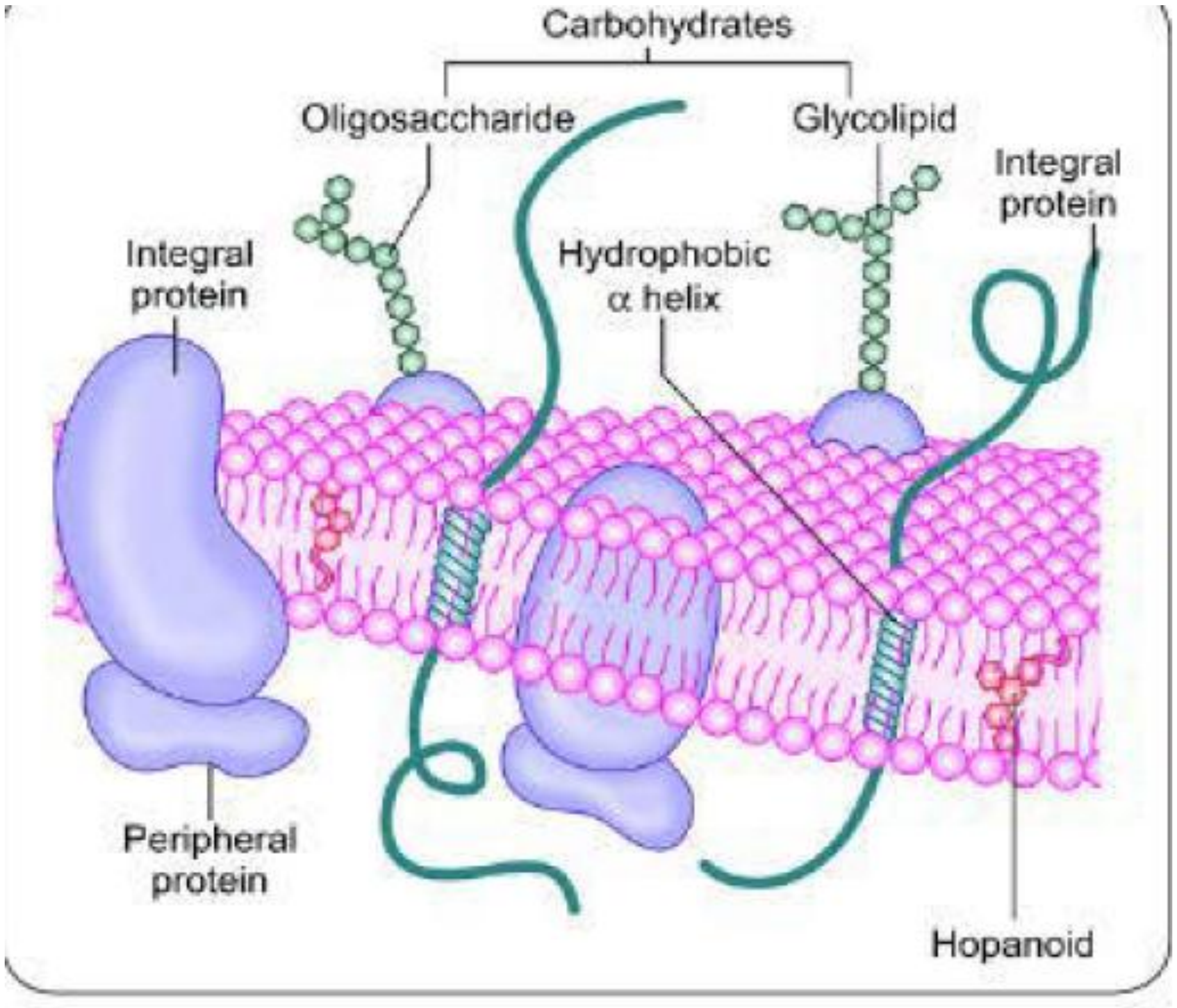


Fig. 2.15: Structure of bacterial cell membrane

contd

Functions of cell membrane:

- Semi permeable membrane acting as an osmotic barrier
- Transport system
- Site for metabolic processes
- Special receptor molecules located in membrane help bacteria to detect and respond to chemicals in their surroundings
- Synthesis of precursors of the cell wall
- Secretion of enzymes and toxins.

contd

3)Periplasmic Space:

- Distinct space between cell membrane and outer membrane (innermost layer of Gram-negative cell wall) in Gram-negative bacteria
- This space is filled with a loose layer of peptidoglycan matrix
- The periplasmic space of Gram negative bacteria contains many proteins that participate in nutrient acquisition, and many hydrolytic enzymes betalactamases binding proteins, and enzymes that participate in the peptidoglycan synthesis

contd

- Polymers of D-glucose, called membrane-derived oligosaccharides, appear to play a role in osmoregulation.
- The periplasmic space is less distinct in Grampositive cell walls.

contd

4)Cytoplasm:

- Extra nuclear cell content that possess both organelles and other material constitutes cytoplasm
- Cytoplasmic matrix mainly composed of water (about 70% of bacterial mass is water)
- Ribosomes , storage granules called inclusions and cell membrane invaginations called mesosomes
- Lack true cytoskeleton, but do have a cytoskeleton-like system of proteins

contd

5)Ribosomes

- 10- 20 nm size and 70 S
- Composed of rRNA and ribosomal proteins
- Sites for protein synthesis

6)Nucleoid

- Bacteria do not have true nucleus, but genetic material is located in an irregularly shaped region called the nucleoid
- Bacteria possess a single haploid chromosome
- Bacterial DNA lacks basic proteins

contd

7)Intracytoplasmic Inclusions

- Storage sites of nutrients/energy present in some bacteria
- Formed under nutritional deficiency conditions and disappear when deficient nutrients are supplied
- Organic inclusion bodies: Glycogen granules and polyhydroxyl butyrate granules
- Inorganic inclusion bodies: Polymetaphosphate or metachromatic granules, sulfur granules

contd

Starch/Glycogen granules - blue-greens and enteric bacteria
Poly-ß-hydroxybutyrate granules - Azotobacter and Rhizobium
Nitrogen-reserve granules - blue-greens
Sulphur inclusions – Thiotrix

Metachromatic granules: Corynebacterium diptheriae
Sulfur granules- Actinomycetes

contd

8)Mesosomes

- Invaginations of plasma membrane
- Site of bacterial respiration
- Involved in cell wall formation during division
- Probably play role in chromosome replication and distribution of daughter cells

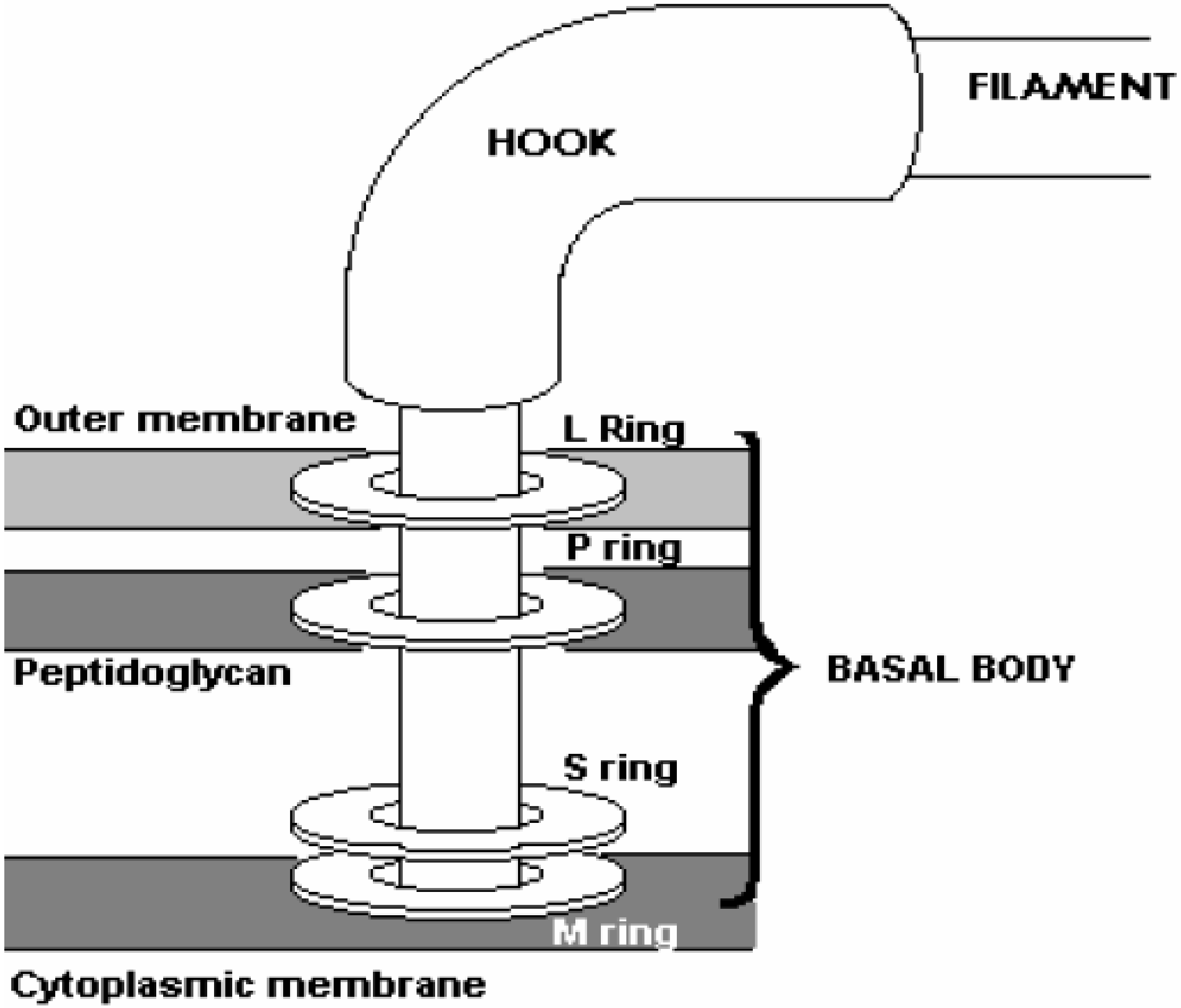
contd

9)Cell wall appendages:

a)Flagella:

- Thread -like appendages, protruding from the cell wall which confer motility to bacteria (organ of locomotion)
- Measures 5-20 µm in length and 0.01-0. 02 µm in thickness
- It consists of filament, basal body and hook
- Filament is composed of single protein called flagellin

Structure of flagellum of Gram negative bacilli



contd

- Arrangement of flagella:
  - Monotrichous: One flagellum is attached to one end of the bacteria cell. Example: *Vibro cholerae*.
  - Lophotrichous: Bunch of flagella is attached to one end of the bacteria cell. Example: *Pseudomonas*.
  - Amphitrichous: Bunch of flagella arising from both end of the bacteria cell. Example: *Rhodospirillum rubrum*.
  - Peritrichous: The flagella are evenly distributed surrounding the entire bacterial cell. Example: *Salmonella*

TABLE 2.7: Types of motility shown by different bacteria

Types of motility	Bacteria
Tumbling motility	*Listeria*
Gliding motility	*Mycoplasma*
Stately motility	*Clostridium*
Darting motility	*Vibrio cholerae, Campylobacter*
Swarming motility	*Proteus, Clostridium tetani*
Corkscrew, lashing, flexion extension motility	Spirochete

contd

b)Fimbriae or pili:

- Short, fine, hair-like appendages that are thinner than flagella and not involved in motility
- Measures 0.5µm long and 10 nm in thickness
- A bacterium can have as many as 1,000 fimbriae
- made up of protein called pilin

contd

Types

Different types of fimbriae are as follows (Fig. 2.19A)—

- **Common pili:** There are six types of common pili depending on their morphology, number per cell, adhesive properties and antigenic nature.
- **Sex or F (fertility) pili:** Sex pili are special type of large fimbriae present 1-10 per cell (e.g. as found in gonococcus). Sex pili help in bacterial conjugation. They are present in male bacterium; form the conjugation tube in male bacterium and thereby help in transfer of genetic material from male bacteria to the female bacteria via the conjugation tube.
- Col I (colicin) pili.

contd

Functions

- Fimbriae are called the organ of adhesion. This property enhances the virulence of bacteria.
- Certain fimbriae called sex pili also help in bacterial gene transfer.
- Fimbriae are not related to motility and can be found both in motile as well as in nonmotile organisms.

contd

c) Capsule:

Some bacteria possess a layer of amorphous viscid material lying outside the cell wall called **glycocalyx**.

- When the glycocalyx layer is well organized and not easily washed off, it is called **capsule** (Fig. 2.16).
- When the glycocalyx layer is in the form of diffuse, unorganized loose material that can be removed easily, it is called **slime layer** (Fig. 2.16).

  (Some bacteria may possess both capsule and slime layer, as in *Streptococcus salivarius*)

contd

TABLE 2.6: Capsulated bacteria

Capsulated bacteria	Composition
Pneumococcus	Polysaccharide
Meningococcus	Polysaccharide
Haemophilus influenzae	Polysaccharide
Klebsiella pneumoniae	Polysaccharide
Pseudomonas aeruginosa	Polysaccharide
Bacteriodes fragilis	Polysaccharide
Bacillus anthracis	Polypeptide (glutamate)
Streptococcus pyogenes (some stains)	Hyaluronic acid

contd

Functions of capsules;

- Capsules are anti-phagocytic.
- Prevent complement mediated bacterial lysis
- Protects from dessication
- Protects from action of lysozyme and bacteriophages
- Biofilm formation and adhesion

Biofilm Formation

A biofilm is a living ecosystem made of millions of adherent bacterial cells embedded within a self-produced matrix of extracellular polymeric substance (i.e. the polysaccharide slime layer).

- Persistent biofilms containing pathogenic bacteria are capable of adherence to damaged tissues and plastic surfaces (e.g. medical devices, such as catheters and pacemakers).
- This is the first step in bacterial colonization and sometimes it leads to disease, e.g. prosthetic valve endocarditis and catheter related urinary tract infection (Fig. 2.16).

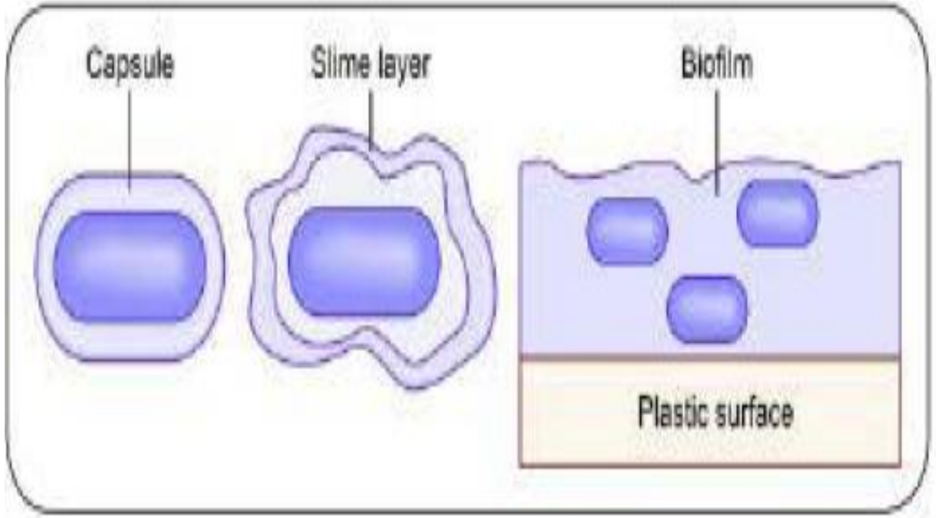
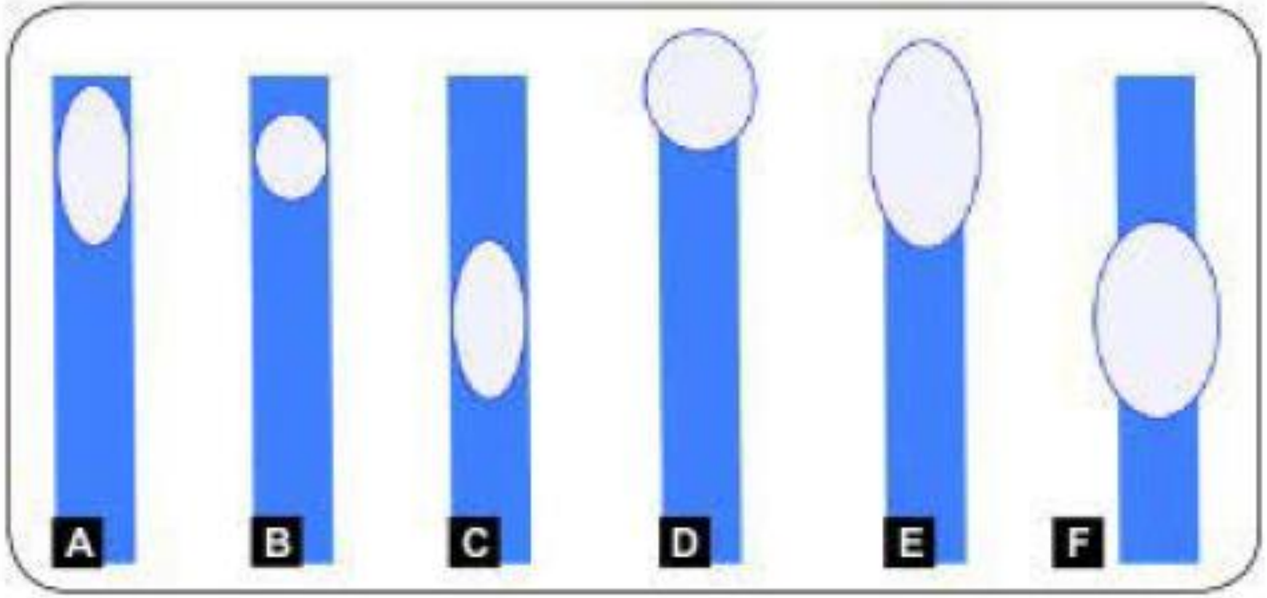


Fig. 2.16: Capsule, slime layer and biofilm

contd

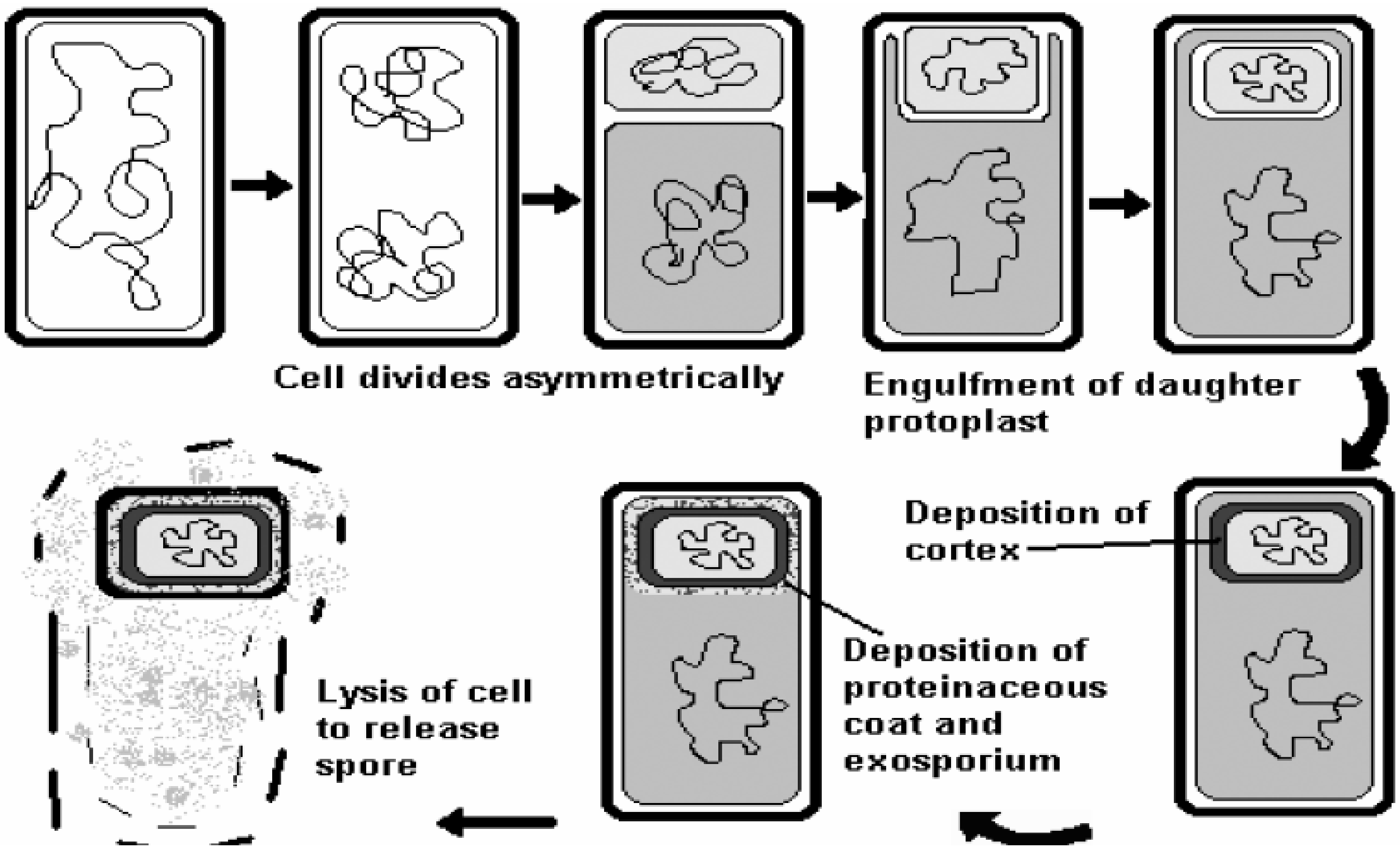
10)Spore :

- Bacterial spores are dormant forms of bacteria which are thick walled, highly refractile and resistant.
- During unfavorable conditions (*especially when carbon and nitrogen become unavailable*), spore-forming bacilli form spores
- Consists of different layers: from innermost to outermost are core, cortex, coat and exosporium respectively



Figs 2.21A to F: Position and shape of spores. **A.** Non-bulging, oval and terminal; **B.** Non-bulging, round, and subterminal; **C.** Non-bulging, oval and central; **D.** Bulging, round and terminal; **E.** Bulging, oval and terminal; **F.** Bulging, oval, and central

Sporulation



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The impermeability of the spore coat is thought to be responsible for the endospore's resistance to chemicals. The resistance of endospores is due to a variety of factors:

- Calcium-dipicolinate, abundant within the endospore, may stabilize and protect the endospore's DNA.
- Specialized DNA-binding proteins saturate the endospore's DNA and protect it from heat, drying, chemicals, and radiation.
- The cortex may osmotically remove water from the interior of the endospore and the dehydration that results is thought to be very important in the endospore's resistance to heat and radiation.
- DNA repair enzymes contained within the endospore are able to repair damaged DNA during germination.

Plasmid

The following is a reproduced textbook excerpt:

PLASMID

Plasmids are the extrachromosomal ds circular DNA molecules that exist in free state in the cytoplasm of bacteria (Fig. 6.4A) and also found in some yeasts.

- Not essential: Plasmids are not essential for life; bacteria may gain or lose plasmid during their lifetime.
- Numbers: They may be present singly or in multiple numbers—up to more than 40 plasmids per cell.
- Independent replication: Plasmids are capable of replicating independently. They can behave as replicon, possessing an origin of replication and other genes that help in replication.

Classification of Plasmids

Plasmids can be classified in many ways:

1. **Based on ability to perform conjugation:**
   - Conjugative plasmids: Some plasmids have an ability to transfer themselves to other bacteria by means of conjugation. These are called self transmissible or conjugative plasmids.
   - Non-conjugative plasmids: There are also called as nontransmissible plasmids. They cannot transfer themselves.
2. **Based on compatibility between the plasmids**, they can be grouped into:
   - Compatible plasmids: Different plasmids can exist in a single bacterial cell only if they are compatible to each other.
   - Incompatible plasmids: If two plasmids are not compatible, one or the other will be rapidly lost from the cell. They normally share the same replication or partition mechanisms, hence compete with each other.

3. **Based on function**, there are five main classes of plasmids:
   - **Fertility or F-plasmids:** They contain *tra*-genes, which code for the expression of sex pili that help in bacterial conjugation by forming the conjugation tube.
   - **Resistance (R) plasmids**: They contain genes that code resistance to various antibiotics.
   - **Col plasmids:** They contain genes that code for bacteriocins (antibiotic-like protein substances produced by bacteria that can kill other bacteria).
   - **Virulence plasmids:** They code for certain virulence factors and toxins that help in bacterial pathogenesis. Examples include:
     - Heat labile and heat stable toxin of *E. coli*
     - Siderophore production
     - Adherence antigens (K88 plasmid in *E. coli*)
   - **Metabolic plasmids:** They enable the host in various metabolic activities:
     - Digestion of unusual substances, e.g. toluene and salicylate, camphor, etc.
     - Urease synthesis
     - Nitrogen fixation

Atypical forms of bacteria

i) Cell wall deficient forms

ii) Pleomorphic bacteria

iii) Involution forms

- Many agents, such as antibiotics, lysozyme, and bacteriophages interfere or inhibit the synthesis of bacterial cell wall components, resulting in the formation of defective bacteria.

Cell wall deficient forms

1)**Protoplasts**

2)Spheroplasts

3)Mycoplasma

4) L-forms

Mycoplasma

- Have cell membrane which incorporates cholesterol compounds (sterols), similar to eukaryotic cells
- Cannot be detected by typical light microscopy
- Lacking a cell wall, these organisms are resistant to the effects of penicillins and other beta-lactam antibiotics, which act by disrupting the bacterial cell wall

Protoplasts

- These are defective unstable forms of bacteria with an intact cytoplasmic membrane but without any cell wall.
- In hypertonic media, these are produced from Grampositive cells on treatment with lysozyme.

Spheroplasts:

❖ These are defective forms derived from Gramnegative bacteria in the presence of EDTA (ethylenediaminetetraacetic acid).

❖ The EDTA disrupts the outer membrane allowing access of lysozyme and resulting in formation of spheroplasts.

❖ Spheroplasts are osmotically fragile and still retain outer membrane and entrapped peptidoglycan.

L-forms

- Named after Lister Institute, London, where the abnormal form of *Streptobacillus moniliformis* was first demonstrated
- Do not exhibit any regular size and shape
- May be spherical or disc shaped, about 0.01 micrometer in diameter
- In the lab they can grow into long, thin biofilm filaments that can reach 60-70 microns in length
- Produced more readily with exposure to penicillin than with lysozyme
- Some bacterial species produce L-forms spontaneously

Pleomorphic bacteria

- Pleomorphic bacteria may show considerable variation in size and shape
- It is called pleomorphism.
- Example: Proteus, Haemophilus

Involution form

- The involution forms are those that on ageing of culture show swollen and aberrant forms, especially in high salt concentration.
- Example: Yersinia pestis, Neisseria gonorrhoeae

THANK YOU !