Department of biology

((MICROBIOLOGY))

Stage 2

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Lecture 2

General characteristics of bacteria

By

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General characteristics of bacteria

- ❖ Bacteria are microscopic prokaryotic organisms whose cells lack a nucleus or nuclear membrane.
- ❖ The bacteria may found in different shapes.
- ❖ Bacteria have unique cell walls. reproduce by binary fission and exist in most environments on earth.
- ❖ Bacterial species vary in size.
  - The smallest bacterium *(Mycoplasma)* are about 0.3 µm in diameter. approximately the size of the largest viruses (poxviruses).
  - *Escherichia coli* bacterium of about 1.1 to 1.5 µm wide by 2.0 to 6.0 µm long.
  - Most spherical bacteria have diameters of 0.5 to 2.0 µm and rod-shaped cells are generally 0.2 to 2.0 µm wide and 1- l0 µm long.

Functions of Bacterial Cell Structures	
1. Plasma membrane	Selectively permeable barrier, mechanical boundary of cell, nutrient and waste transport, location of may metabolic processes (respiration).
2. Ribosomes	Protein synthesis.
3. Inclusion bodies	Storage of carbon, phosphate and other substances.
4. Nucleoid	Localization of genetic material (DNA).
5. Periplasmic space	Contains hydrolytic enzymes and binding proteins for nutrient processing and uptake.
6. Cell wall	Gives bacteria shape and protection from lysis in dilute solutions.
7. Capsules and slime layer	Resistance to phagocytosis, adherence to surface.
8. Fimbriae and pili	Attachment to surfaces, bacterial mating.
9. Flagella	Movement.
10. Endospore	Survival under harsh environmental conditions.

Classification of bacteria

❖ Bacteria are grouped by **four** main characteristics:

1. **Gram reaction**
2. **Atmospheric requirements**
3. **Shape**
4. **Endospore**

Gram reaction: can be classify to

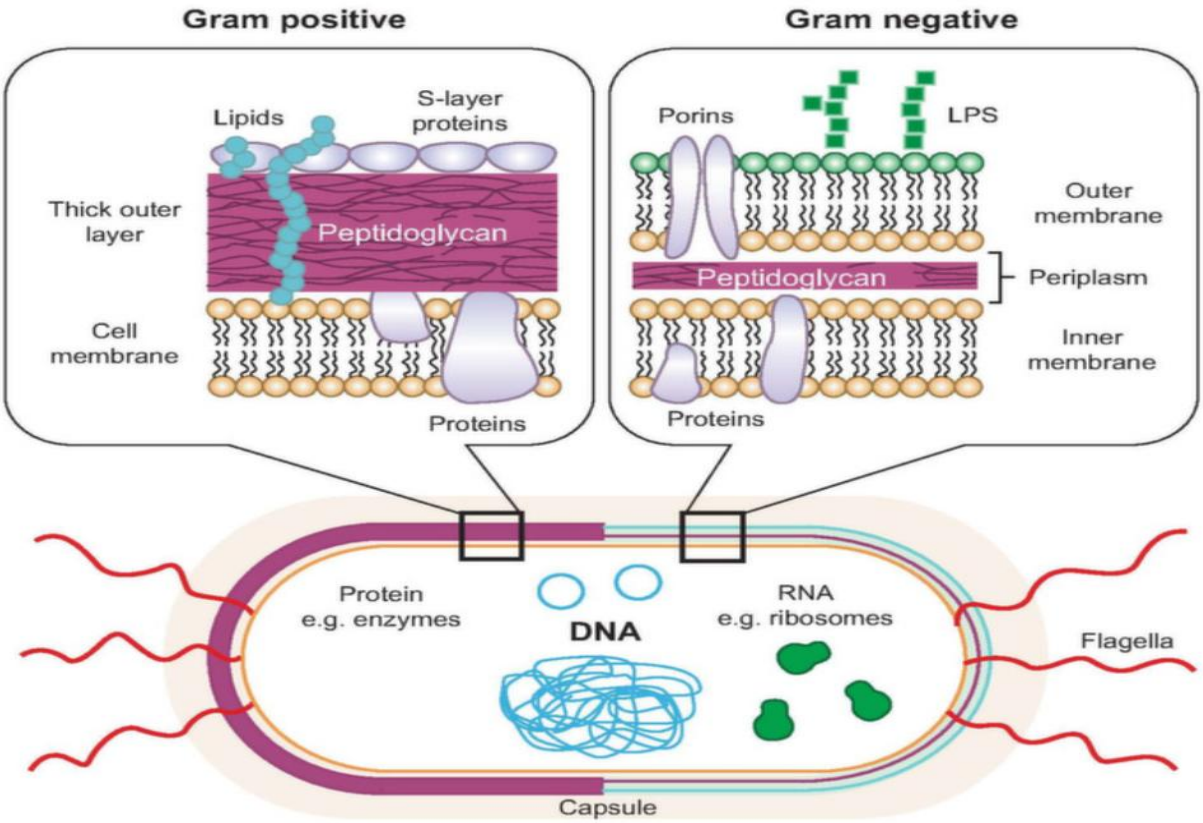
a. **Gram positive (+ve)**

b. **Gram negative (-ve)**

- Most bacteria are classified into two broad categories: Gram positive and Gram negative.
- These categories are based on their cell wall composition and reaction to the Gram stain test. The Gram staining method, developed by **Hans Christian Gram**, identifies bacteria based upon the reaction of their cell walls to certain dyes and chemicals.
- The differences between these bacteria are primarily related to their cell wall composition.
- **Gram positive bacteria** have cell walls composed mostly of a substance unique to bacteria known as **peptidoglycan**, or **murein.** These bacteria stain **purple** after Gram staining.
- **Gram negative bacteria** have cell walls with only a thin layer of peptidoglycan and an outer membrane with a lipopolysaccharide component not found in Gram positive bacteria. Gram negative bacteria stain **red or pink** after Gram staining.

Difference between Gram Positive and Gram Negative Bacteria			
S.No	**Characteristics**	**Gram positive Bacteria**	**Gram negative Bacteria**
1.	Cell wall	Single layered with 0.015µm-0.02µm	Triple layered with 0.0075µm–0.012µm thick
2.	Rigidity of cell wall	Rigid due to presence of Peptidoglycans	Elastic due to presence of lipoprotein-polysaccharide mixture
3.	Chemical composition	Peptidoglycans-80% Polysaccharide-20% Teichoic acid present	Peptidoglycans-3 to 12% rest is polysaccharides and lipoproteins. Teichoic acid absent
4.	Outer membrane	Absent	Present
5.	Periplasmic space	Absent	Present
6.	Susceptibility to penicillin	Highly susceptible	Low susceptible
7.	Nutritional requirements	Relatively complex	Relatively simple
8.	Flagella	Contain 2 basal body rings	Contain 4 basal body rings
9.	Lipid and lipoproteins	Low	High
10.	Lipopolysaccharides	Absent	Present

Difference between Gram positive and Gram negative bacteria cell wall



Gram positive bacteria

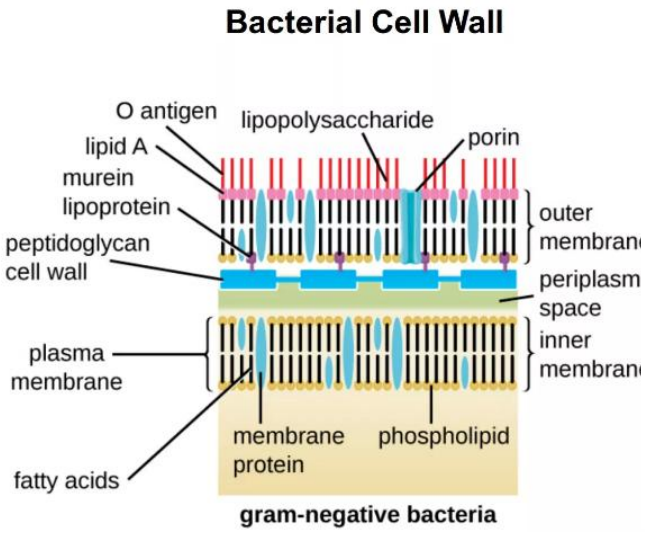
- Contains thick layers of peptidoglycan to support the cell membrane and provide a place of attachment for other molecules. The thick layers also enable Gram positive bacteria to retain most of the crystal violet dye during Gram staining causing them to appear purple.
- The cell walls also contain chains of **teichoic acid** that extend from the plasma membrane through the peptidoglycan cell wall. These sugar-containing polymers helps in maintaining cell shape and play a role in proper cell division.
- Some Gram positive bacteria have an additional component, **mycolic acid** that produce a waxy outer layer for additional protection for mycobacteria, such as **Mycobacterium tuberculosis**. Gram positive bacteria with mycolic acid are also called **acid-fast bacteria** because they require a special staining method, known as acid-fast staining, for microscope observation.
- Pathogenic Gram positive bacteria cause disease by the secretion of toxic proteins known as **exotoxins**.

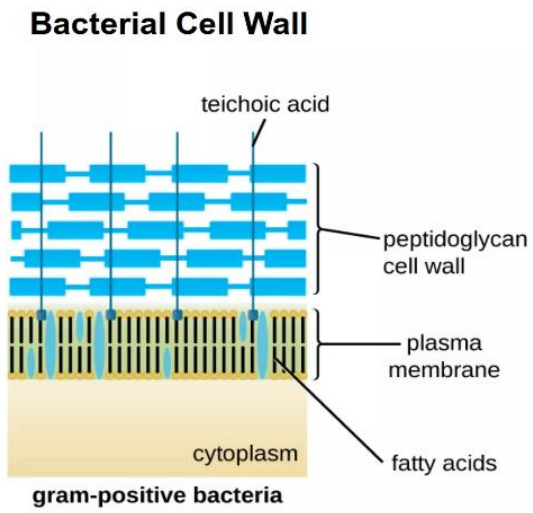
Gram Negative Bacteria

- The Gram negative bacterial cell wall is composed of a single thin layer peptidoglycan.
- The cell wall of Gram negative bacteria is more complex than that of Gram positive bacteria. Located between the plasma membrane and the thin peptidoglycan layer is a gel-like matrix called periplasmic space.
- Gram negative bacteria have an outer membrane layer that is external to the peptidoglycan cell wall. Membrane

proteins, murein lipoproteins, attach the outer membrane to the cell wall.

- Another unique characteristic of Gram negative bacteria is the presence of **lipopolysaccharide (LPS)** molecules on the outer membrane. LPS is a large glycolipid complex that protects bacteria from harmful substances in their environment. It is also a bacterial toxin (endotoxin) that can cause inflammation and septic shock in humans if it enters the blood.
- There are three components of the LPS: Lipid A, a core polysaccharide, and an O antigen. The **lipid A** component attaches the LPS to the outer membrane. Attached to the lipid A is the **core polyssaccharide.** It is located between the lipid A component and the O antigen. The **O antigen** component is attached to the core polyssaccharide and differs between bacterial species. It can be used to identify specific strains of harmful bacteria.
- Some Gram negative bacteria also produce exotoxins or endotoxin.





1. Atmospheric requirements:

a. Obligate aerobes and anaerobes

b. Facultative aerobes and anaerobes

c. Capnophiles

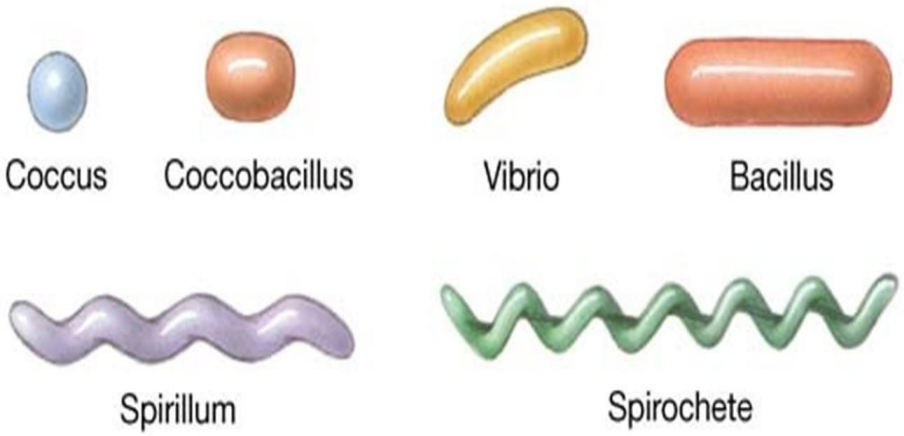
d. pH mediated (acidophile, alkaliphile, neutrophile)

e. Temperature mediated (Thermophilic, mesophilic, psycrophilic)

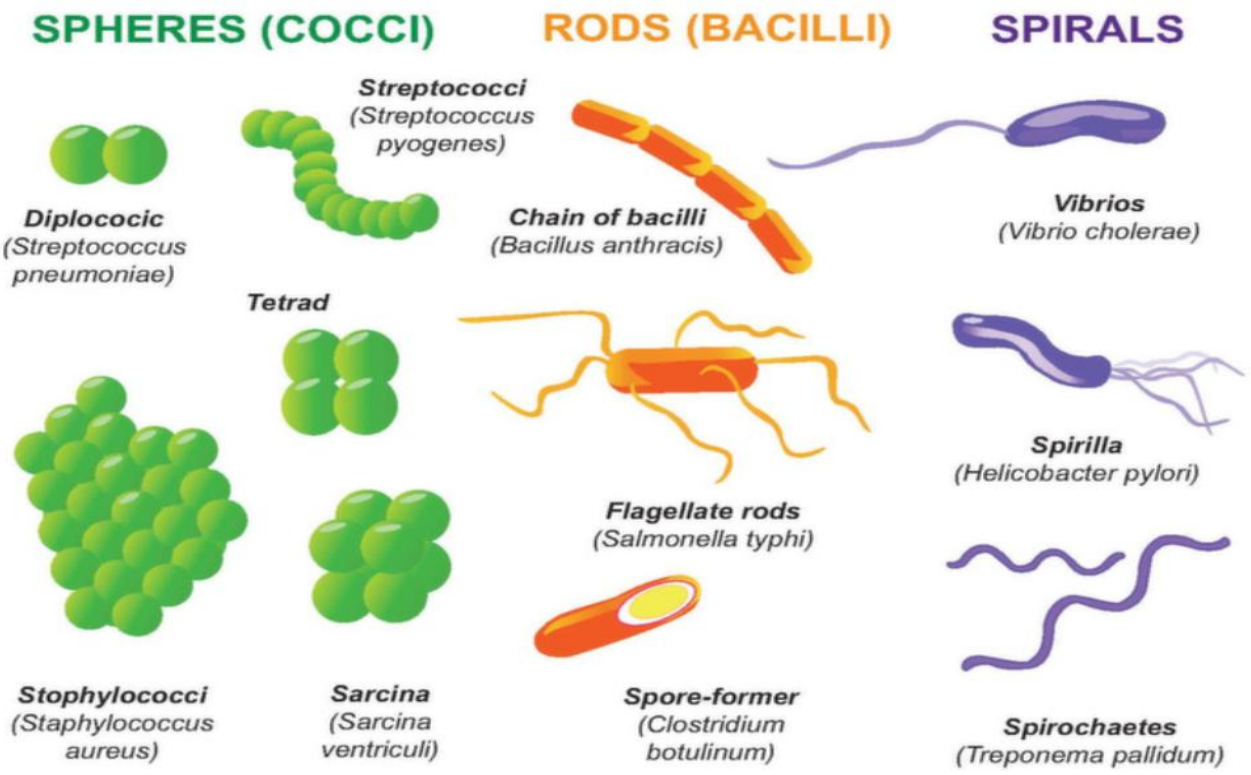
2. Shape:

Bacteria found in different shapes

- Cocci - Round or oval cells
- Bacilli - Rod shaped cells
- Spirilla - Non flexuous spiral forms
- Vibrio - Curved or comma-shaped rods
- Spirochetes- Slender and flexuous spiral forms
- Mycoplasma - Cell wall absent so bacteria found as round or oval cells
- Actinomycetes- Branched filamentous bacteria



- Some bacteria are arranged in groups are
  - Diplococci - Cocci arranged in pairs
  - Streptococci - Cocci arranged in chains
  - Staphylococci - Cocci arranged in clusters
  - Coccobacilli - Both length and width are approximately same in the bacteria
  - Streptobacilli - Bacilli arranged in chains
  - Chinese letter or Cuneiform pattern - resemble like Chinese letter
  - Tetrad - Cocci arranged as four cells
  - Sarcina - Cocci arranged as cluster of eight cells



4. Sporulation:

Bacteria can form different types of spores as survival or reproductive structures. The main types include:

1. Endospores:

Description: These are the most well-known bacterial spores. They form inside the bacterial cell (the mother cell) and are eventually released when the cell undergoes lysis.

Characteristics: Endospores are highly resistant to heat, radiation, chemicals, and desiccation. They are metabolically dormant, allowing the bacterium to survive in harsh conditions.

Examples: Commonly produced by genera such as Bacillus and Clostridium.

2. Exospores:

Description: Unlike endospores, exospores are formed externally on the surface of the bacterial cell. They typically result from a budding process or fragmentation of the parent cell.

Characteristics: Exospores are generally less resistant than endospores and often serve as a means of reproduction rather than long-term survival.

Examples: Some actinomycetes and certain cyanobacteria produce exospores.

3. Myxospores:

Description: These are formed by myxobacteria during a complex developmental cycle, often associated with social behavior and multicellular aggregation.

Characteristics: Myxospores are part of a communal survival strategy, allowing a group of cells to endure unfavorable conditions until the environment improves.

4. Cysts (Resting Cysts):

Characteristics: Cysts help bacteria survive in adverse conditions by reducing metabolic activity, though they might not possess the extreme resilience seen in endospores.

Examples: Certain free-living bacteria, such as Azotobacter, can form cysts.

Each type of spore serves as an adaptation to environmental stress, ensuring the survival of the bacterium until conditions become favorable for growth and reproduction.