

UNIT 2

MICROORGANISMS

- Microorganisms are organisms too small to be seen clearly by the unaided eyes.
 - They are organisms that are microscopic.
 - They are observed and studied using microscopes.
- Microbiology is the study of microbes.

Branches of microbiology

- **Bacteriology:** the study of bacteria.
- **Mycology:** the study of fungi.
- **Protozoology:** the study of protozoa.
- **Phycology/algology:** the study of algae.
- **Virology:** the study of viruses.

- The major groups of microorganisms are bacteria, archaea, fungi, algae, protozoa, and viruses.
- Cellular life forms are divided into three domains, namely Bacteria, Archaea, and Eukarya.
 - The Archaea & Bacteria are prokaryotic.

Eubacteria

- Eubacteria (“true bacteria”) are relatively simple in structure.
- They are prokaryotic unicellular organisms.
- They lack a nucleus and other membrane-bound organelles.
 - Both DNA and RNA are present in the bacterial cell.

General Characteristics

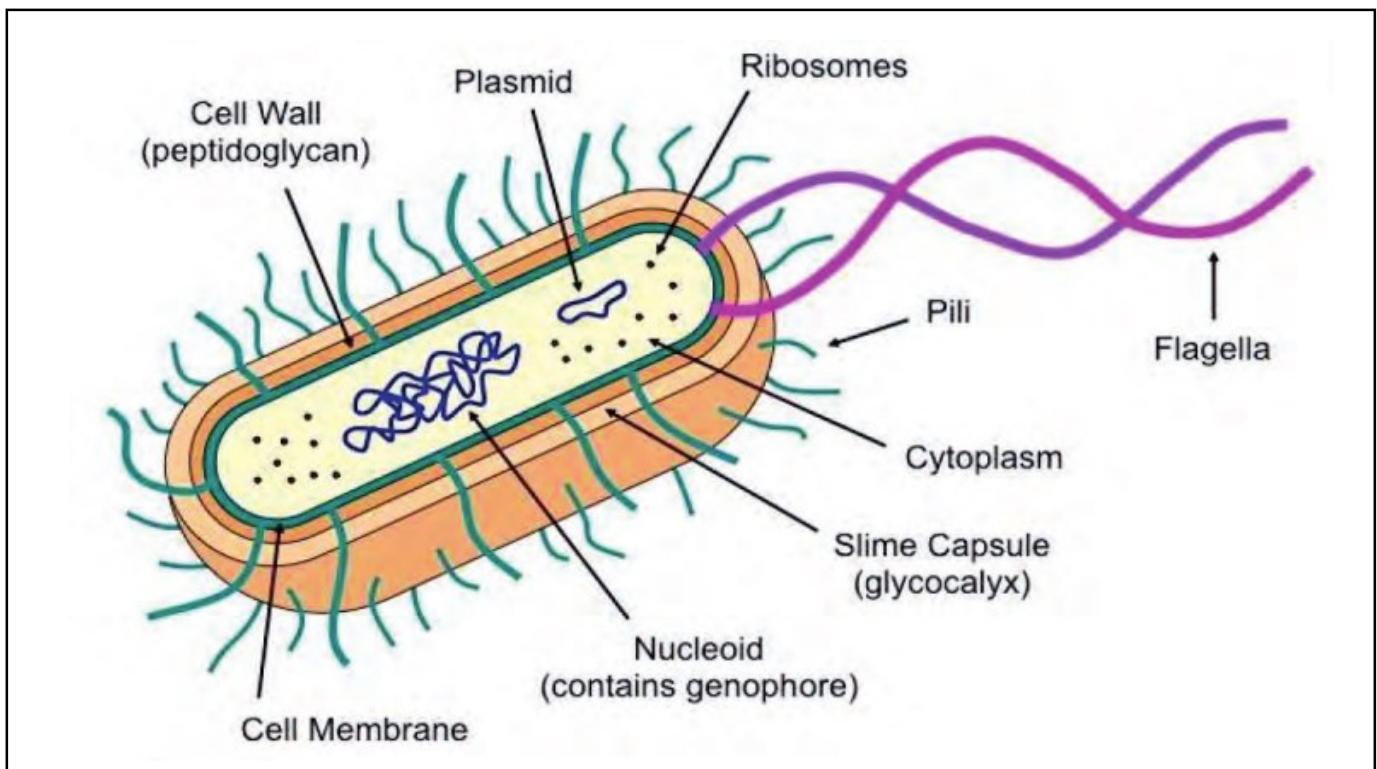
- Prokaryotes are ubiquitous.
 - They can be found everywhere on our planet.
- They are unicellular, prokaryotic microorganisms.
- They have a peptidoglycan cell wall outside the plasma membrane.

- They have great variation in the mode of nutrition.
 - They may be autotrophic or heterotrophic.
 - The heterotrophic ones may be parasite, saprophyte or symbiotic in nature.
- Few photosynthetic bacteria have a special type of chlorophyll called **bacterio-chlorophyll**.

- They reproduce asexually, usually by binary fission.
 - True sexual reproduction is absent in them.

Structure of Bacterial Cell

- They are much simpler in comparison to the eukaryotic cell.
- They exist as single cells or as cell clusters.



- a. Nucleoid:** Area of the cytoplasm that contains the prokaryote's single DNA molecule.
- b. Plasmid:** A small, extrachromosomal DNA that is physically separated from chromosomal DNA and can replicate independently.
- c. Ribosomes:** It is the site of protein synthesis.

- d. Cell membrane:** Surrounds the cell's cytoplasm and regulates the flow of substances in and out of the cell.
- e. Cell wall:** Outer covering that protects the bacterial cell and gives it shape.
- f. Slime capsule (glycocalyx):** It protects the bacteria cells from environmental dangers such as antibiotics and desiccation.

- g. Pili:** filamentous, extracellular structures that allow bacteria to adhere to biotic and abiotic surfaces. It is the appendage required for bacterial conjugation.
- h. Flagella:** Long, whip-like protrusion that aids cellular locomotion

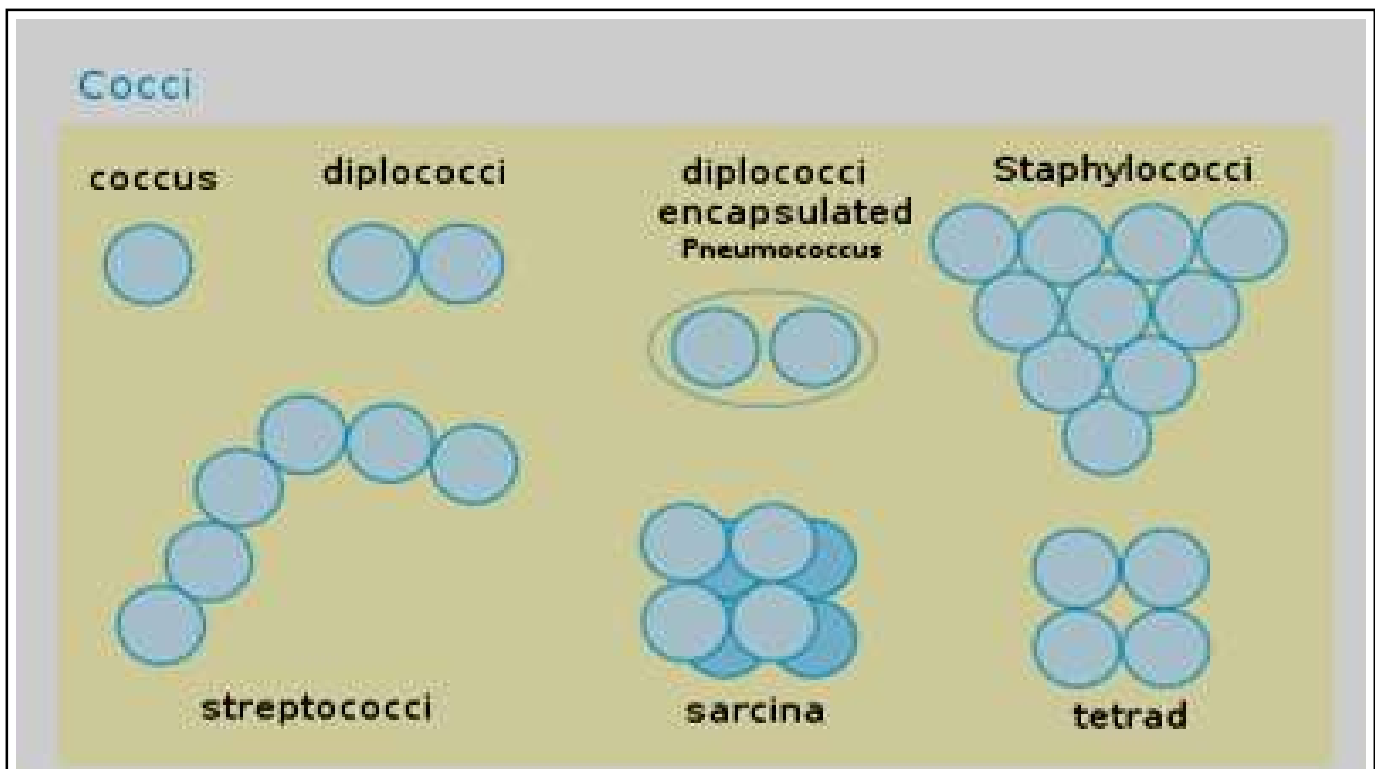
Bacterial Shapes

- Bacteria are classified into four groups according to their basic shapes:

a) Cocci (sing., Coccus)

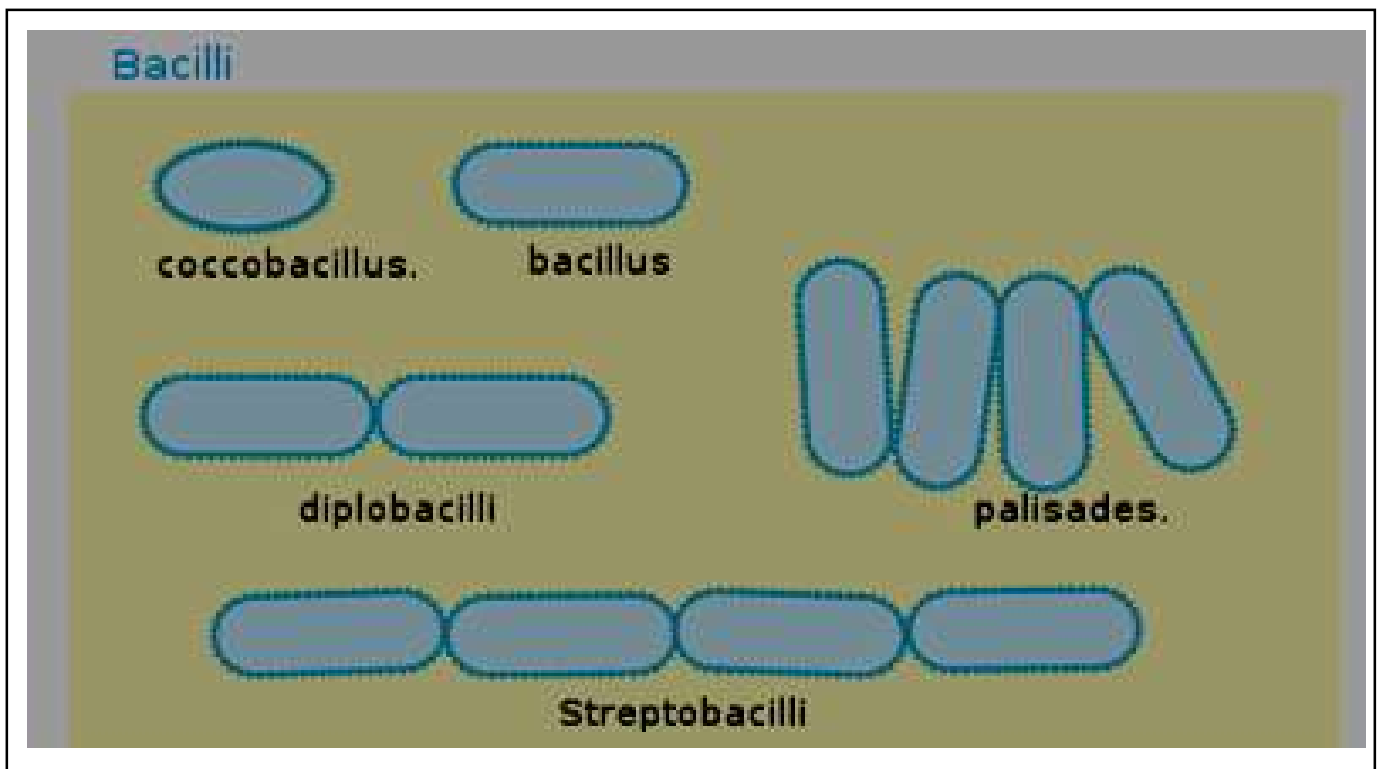
- Cocci are spherical or round-shaped bacteria.
- Most cocci bacteria do not have flagella and are non-motile.

- They can exist as single organisms (Monococcus) or in pairs (Diplococci), chains (Streptococci), grape-like clusters (Staphylococci), groups of four (Tetrads), or cuboidal packets (Sarcinae).
- A colony is a visible mass of micro-organisms all originating from a single mother cell, and constitutes a clone of bacteria all genetically alike.



b) Bacilli (sing., Bacillus)

- They are rod-shaped bacteria.
- They can combine to form diplobacilli (bacilli that occur as a pair), streptobacilli (bacilli arranged in chains) and palisade (arranged in a palisade, fence-like structure).



c) Spirochaetes

- They are spiral or helical in shape.
- Examples are *Campylobacter jejuni*, *Helicobacter pylori*, *Treponema pallidum*, etc.

d) Comma shaped (Vibrios)

- They are curved and appear like a comma.
- Examples are *Vibrio cholerae*, *Vibrio parahaemolyticus*, etc.



Vibrio cholera



Spirillum volutans



Treponema pallidum

Bacterial cell wall

- Bacterial cell walls are strong and relatively thick, to protect them from osmotic lysis and predation, and to give them shape.
- The bacterial cell wall consists of **peptidoglycan**.
 - Peptidoglycan is a rigid and complex structure of carbohydrates and amino acids.

- Gram staining differentiates bacteria by the chemical and physical properties of their cell walls.
- Gram staining is a method of staining used to classify bacterial species into two large groups: **gram-positive bacteria** and **gram-negative bacteria**.

- There are four basic steps of the Gram stain:
 1. Applying a primary stain (crystal violet) to a heat-fixed smear of a bacterial culture.
 2. The addition of iodine, which binds to crystal violet and traps it in the cell
 3. Rapid decolorization with ethanol or acetone
 4. Counterstaining with safranin.

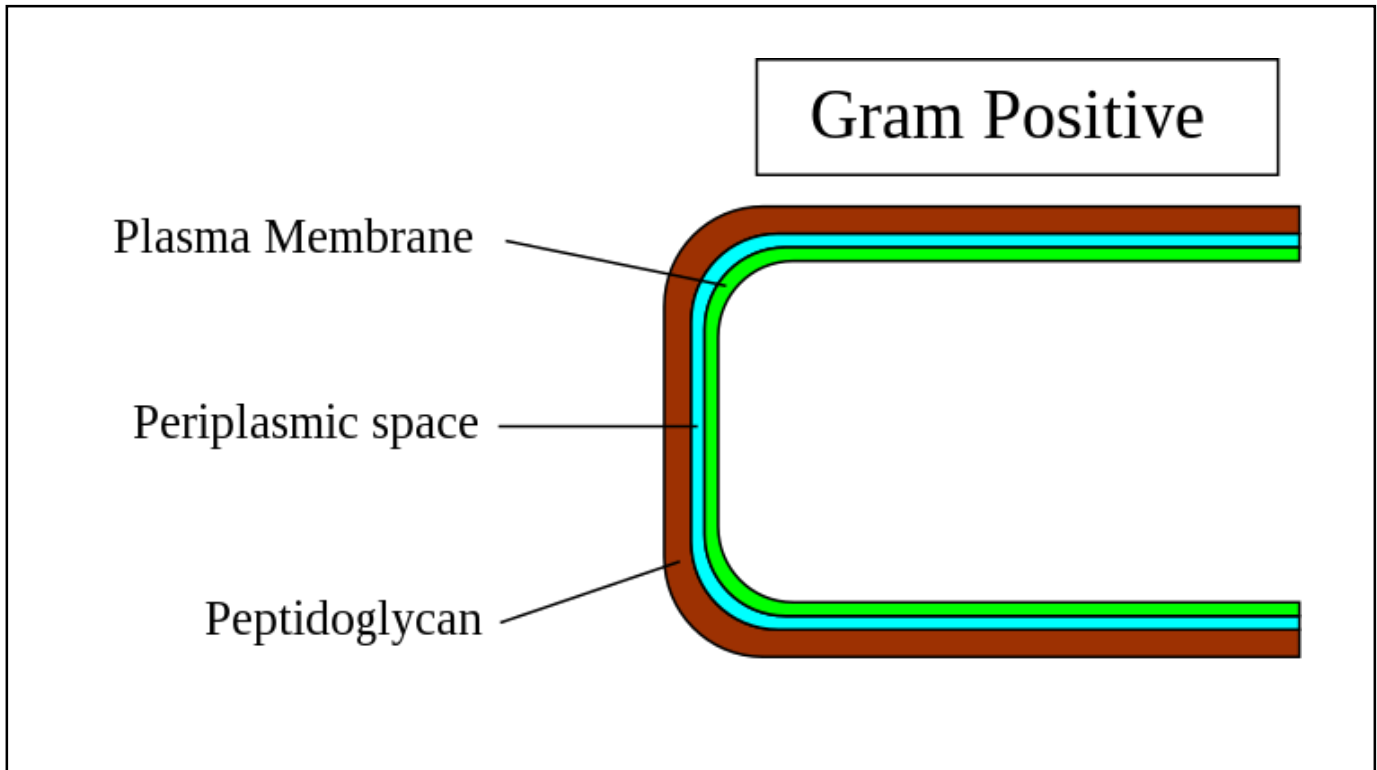
Summary of Gram stain

Application of	Reagent	Cell color	
		Gram-positive	Gram-negative
Primary dye	crystal violet	purple	purple
mordant	iodine	purple	purple
Decolorizer	alcohol/acetone	purple	colorless
Counter stain	safranin/carbol fuchsin	purple	pink or red

a) Gram-positive bacteria

- These are bacteria that give a positive result (purple appearance) in the Gram stain test.
- They take up the crystal violet stain used in the Gram stain test.
 - The thick layer of peptidoglycan retains the stain after it is washed away from the rest of the sample.
 - They have no outer lipid membrane.

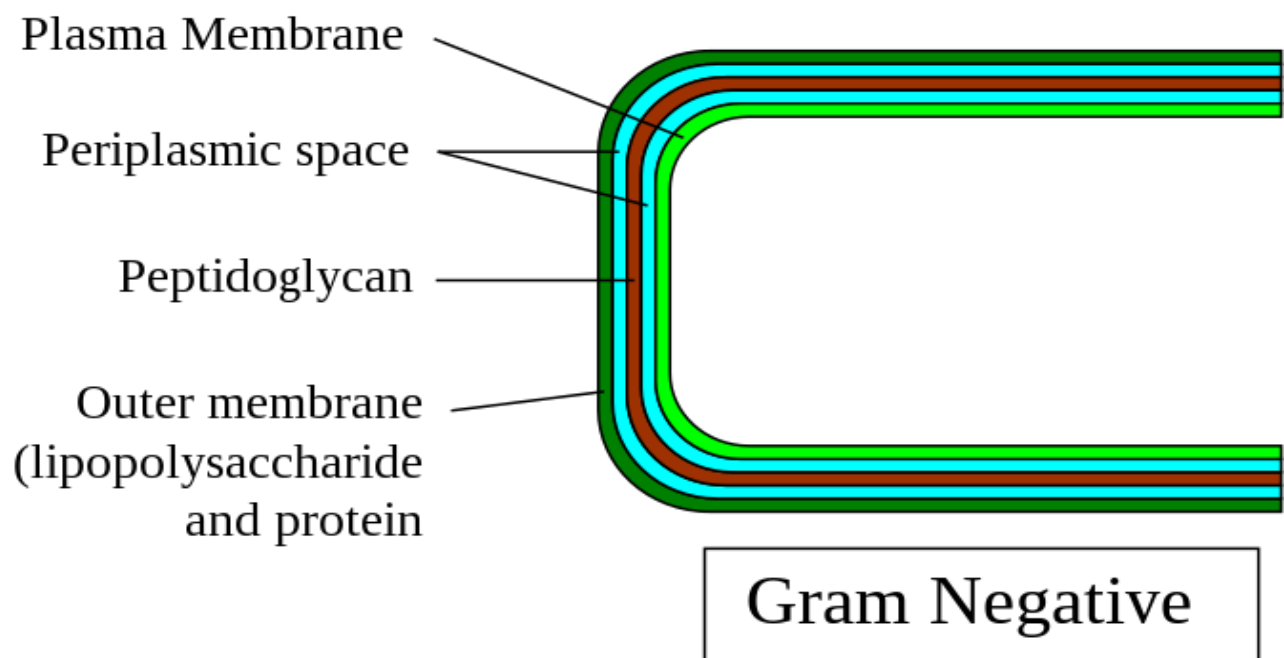
- Despite their thicker peptidoglycan layer, gram-positive bacteria are more receptive to certain cell wall-targeting antibiotics.
- Examples of gram-positive bacteria include all staphylococci, all streptococci and some listeria species.



b) Gram-negative bacteria

- They are bacteria that give a negative result (pink or red) following Gram staining.
- These bacteria lose the crystal violet stain in Gram's method of staining.
- They have a cell wall composed of a thin layer of peptidoglycan.

- They have outer membrane containing lipopolysaccharides.
- They are a significant medical challenge as their outer membrane protects them from many antibiotics.
- The gram-negative bacteria include *Escherichia coli*, *Pseudomonas aeruginosa*, *Chlamydia trachomatis*, and *Yersinia pestis*.



Nutritional Types of Bacteria

- Bacteria acquire energy and nutrients in many different ways.
- Based on source of carbon, bacteria can be classified into two major categories:
 1. **Autotrophs:** use inorganic carbon compounds as the carbon source.
 - ✓ Autotrophs that obtain their energy from sunlight are called **photo-autotrophs**.

- ✓ Autotrophs that harvest energy from inorganic chemicals are called **chemo-autotrophs**.
- 2. **Heterotrophs:** obtain their carbon from various organic substances.
 - ✓ Heterotrophs that obtain their energy from sunlight are called **photo-heterotrophs**.
 - ✓ Heterotrophs that harvest energy from organic molecules are called **chemo-heterotrophs**.

• Based on source of energy, bacteria can be classified as:

1. Phototrophs: use light as their energy source

✓ e.g. Cyanobacteria, Green sulfur bacteria, Purple sulfur bacteria and Purple non sulfur bacteria.

2. Chemotrophs: use energy from the oxidation of chemical compounds

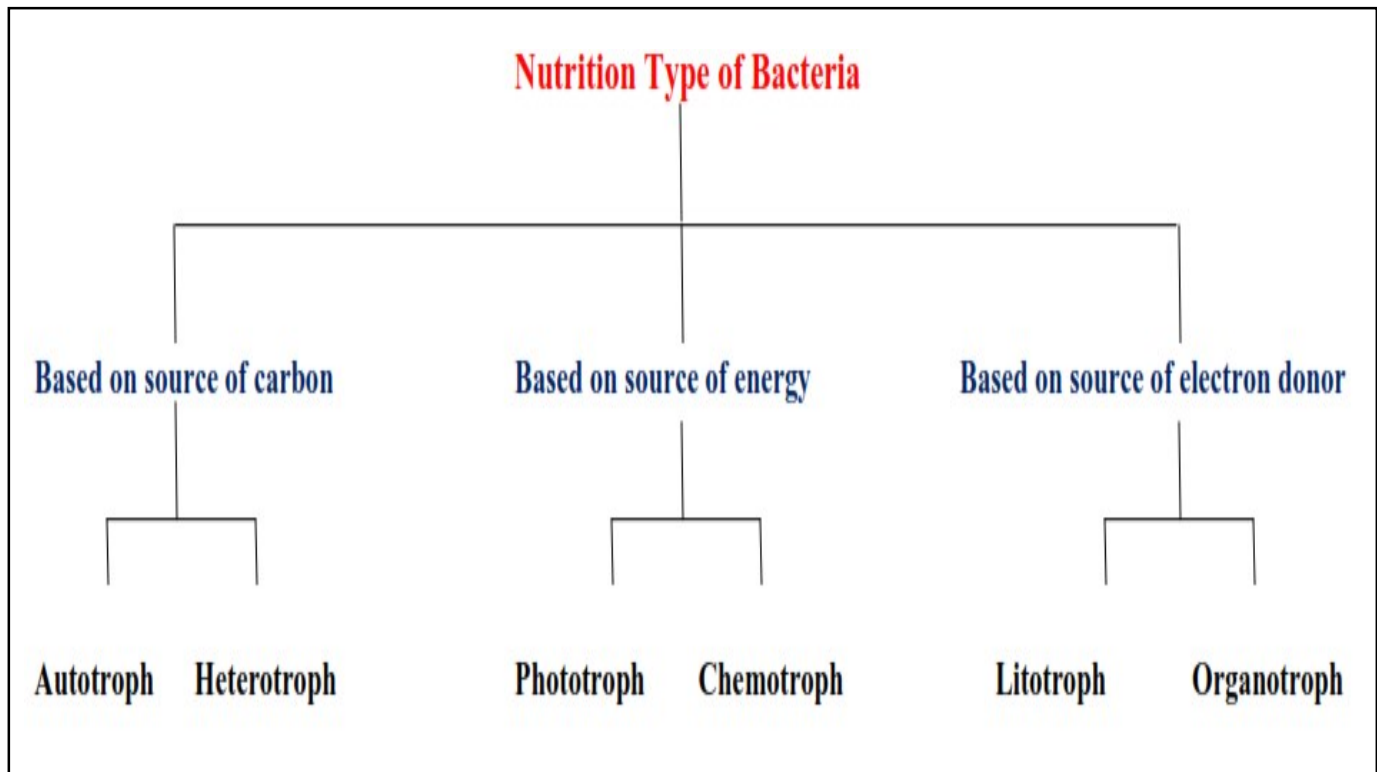
✓ e.g. Thiobacillus, Nitrifying bacteria, Iron bacteria and Hydrogen bacteria

• Based on sources for electrons, bacteria are grouped into two:

1. Lithotrophs: use reduced inorganic substances as their electron source.

✓ They include sulfide-, sulfur-, metal-, ammonium-, and nitrite-oxidizing bacteria.

2. Organotrophs: extract electrons from reduced organic compounds.



- The classification of bacteria based on nutrition is as follows:

1. Photolithoautotrophs

- They use light energy and have CO_2 as their carbon source.
- They extract electrons from H_2O (Photosynthetic bacteria & cyanobacteria), hydrogen, hydrogen sulfide, or elemental sulfur (purple and green sulfur bacteria).

2. Chemoorganoheterotrophs

- They use organic compounds as sources of energy, hydrogen, electrons and carbon
- Nearly all pathogenic microorganisms are chemoorganoheterotrophs.

3. Photoorganoheterotrophs

- They use organic matter as their electron donor and carbon source.
- They are common inhabitants of polluted lakes and streams.
- Some of them can grow as photolithoautotrophs with molecular hydrogen as an electron donor.

4. Chemolithoautotrophs

- They derive energy and electrons from the oxidation of reduced inorganic compounds.
- Carbon dioxide is their carbon source.

5. Chemolithoheterotrophs

- They use reduced inorganic molecules as their energy and electron source but derive their carbon from organic sources.
- They contribute greatly to the chemical transformations of elements.

Reproduction of Bacteria

- Bacteria can reproduce through both sexual and asexual means.
 - Asexual reproduction takes place through binary fission.
 - Sexual reproduction takes place through conjugation, transformation and transduction.

Asexual reproduction

- Binary fission is a process of asexual reproduction used by bacteria.
- It usually occurs after a period of growth in which the bacterial cell doubles in mass.
- Binary fission normally results in two identical daughter cells.

Steps of binary fission

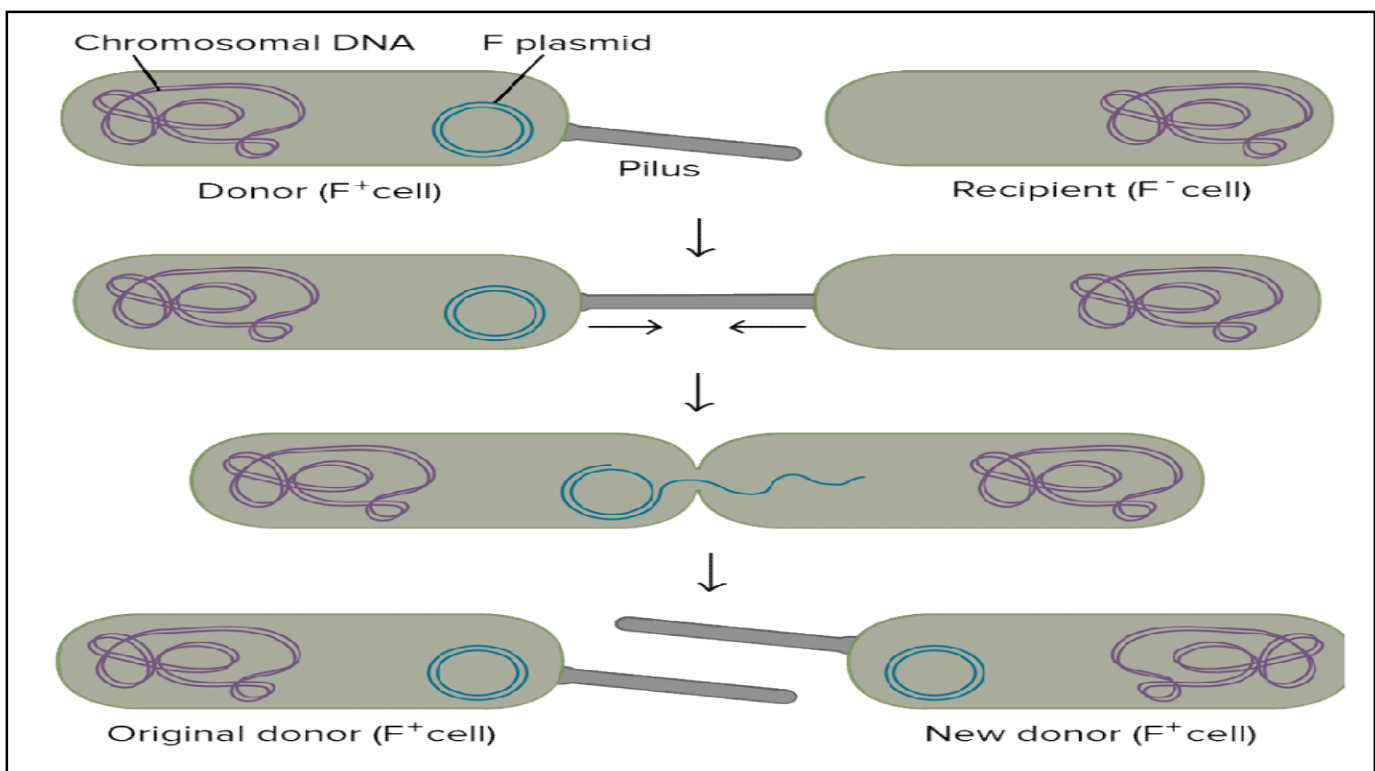
- A dividing bacterium copies its DNA.
 - Copying of DNA by replication enzymes begins at the origin of replication.
- Division of the cytoplasm takes place.
- The membrane pinches inward and a septum forms down the middle of the cell.
- The septum itself splits down the middle, and the two bacterial cells are released.

Sexual reproduction

a. Conjugation

- Two cells of different mating types come together, and genetic material is transferred from one to the other.
 - It involves contact between two cells.
 - In most cases, the genetic material to be transferred is in the form of a plasmid.

- Conjugative pili allow the transfer of DNA between bacteria.
- Donor cells typically act as donors because they have the fertility factor (or F factor).
 - If the F factor is transferred, the receiving cell turns into an F^+ donor.
- It has been most extensively studied in *E. coli*.



b. Transformation

- It is the uptake of DNA molecules through the cell wall from the external surroundings.

c. Transduction

- It is the process by which a virus transfers DNA from one bacterium to another.