Differential Equations

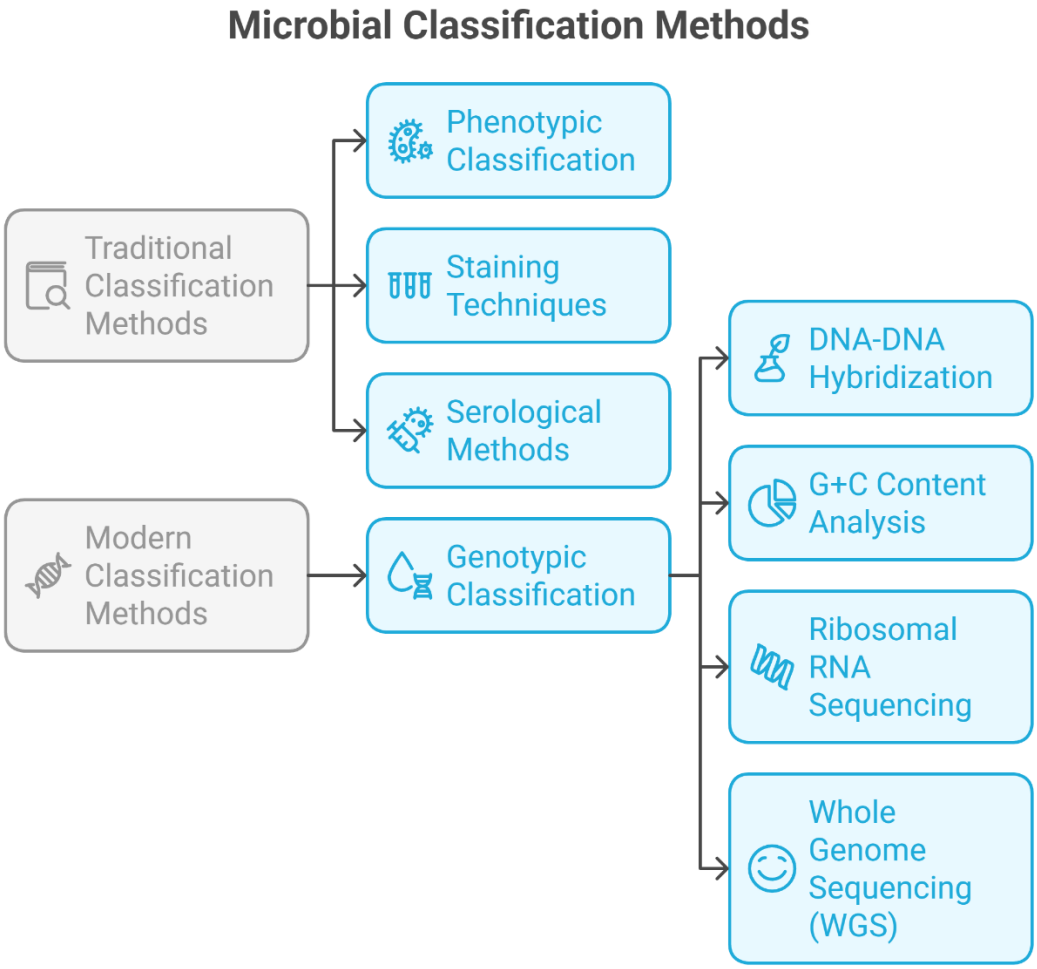
Different Methods of Classification of Microbes

What is Classification?

- **Classification** in microbiology refers to the systematic arrangement of microorganisms into groups or categories based on similarities and differences in characteristics such as morphology, genetics, metabolism, and ecological roles.

Goals of Classification

- To organize the diversity of microbial life.
- To aid in **identification** and **nomenclature**.
- To understand **evolutionary relationships**.
- To provide a framework for **diagnosis**, **research**, and **treatment** in medical microbiology.



Traditional (Classical) Classification Methods

A. Phenotypic Classification

- Based on observable physical and biochemical traits.
- Includes:

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- **Cell shape and size** (cocci, bacilli, spirilla).
- **Gram staining reaction** (Gram-positive vs Gram-negative).
- **Colony morphology** on culture media.
- **Motility** (presence of flagella).
- **Oxygen requirements** (aerobes, anaerobes).
- **Biochemical tests** (e.g., sugar fermentation, enzyme production).

B. Staining Techniques

- Used to differentiate microbes under the microscope.
- Examples:
  - **Gram stain**.
  - **Acid-fast stain** (e.g., for *Mycobacterium tuberculosis*).
  - **Endospore stain**.
  - **Capsule stain**.

C. Serological Methods

- Involves antigen-antibody reactions.
- Used to differentiate between species or strains (serotypes).
- Example: Widal test for *Salmonella typhi*.

Modern (Molecular) Classification Methods

Genotypic Classification

- Based on **genetic material (DNA or RNA)**.
- More accurate and reliable than phenotypic methods.

A. DNA-DNA Hybridization

- Measures the degree of genetic similarity.
- Useful for differentiating closely related species.

B. G+C Content Analysis

- Determines the **percentage of guanine and cytosine** in DNA.
- Species with significantly different G+C content are likely unrelated.

C. Ribosomal RNA Sequencing

- Especially **16S rRNA** (for bacteria and archaea).
- Highly conserved sequences; used to construct **phylogenetic trees**.
- Basis of **three-domain classification**: Bacteria, Archaea, and Eukarya.

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D. Whole Genome Sequencing (WGS)

- Provides complete genetic information.
- Enables **comparative genomics** and detailed evolutionary studies.

Taxonomic Hierarchy in Microbiology

- The system follows a hierarchical order:

Domain → Kingdom → Phylum → Class → Order → Family → Genus → Species

- Example:
  - ***Escherichia coli*:**
    - **Domain:** Bacteria
    - **Phylum:** Proteobacteria
    - **Class:** Gammaproteobacteria
    - **Order:** Enterobacterales
    - **Family:** Enterobacteriaceae
    - **Genus:** Escherichia
    - **Species:** coli

Study of Bacteria

Definition and General Features

- Bacteria are unicellular, prokaryotic, microscopic organisms that lack a membrane-bound nucleus and organelles.
- Their genetic material is located in a single, circular DNA molecule within the cytoplasm, in a region called the nucleoid.
- Despite their structural simplicity compared to eukaryotes, they can perform all essential life functions. Bacteria are typically 0.2–2.0 µm in diameter and 2–10 µm in length.

Morphology

A. Shape

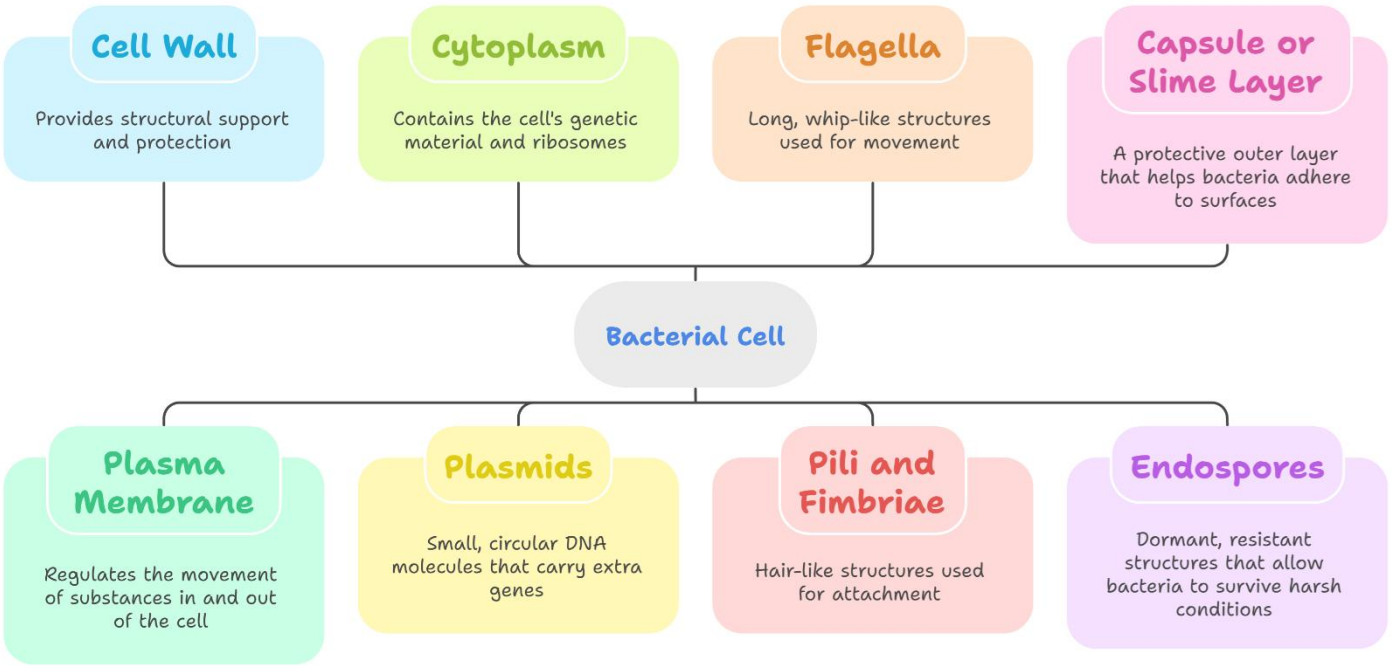
- **Cocci**: Spherical-shaped bacteria (e.g., *Staphylococcus*, *Streptococcus*).
- **Bacilli**: Rod-shaped bacteria (e.g., *Escherichia coli*).
- **Spirilla**: Spiral-shaped bacteria (e.g., *Spirillum*, *Helicobacter pylori*).
- **Vibrios**: Comma-shaped bacteria (e.g., *Vibrio cholerae*).
- **Filamentous**: Thread-like forms (e.g., *Actinomyces*).

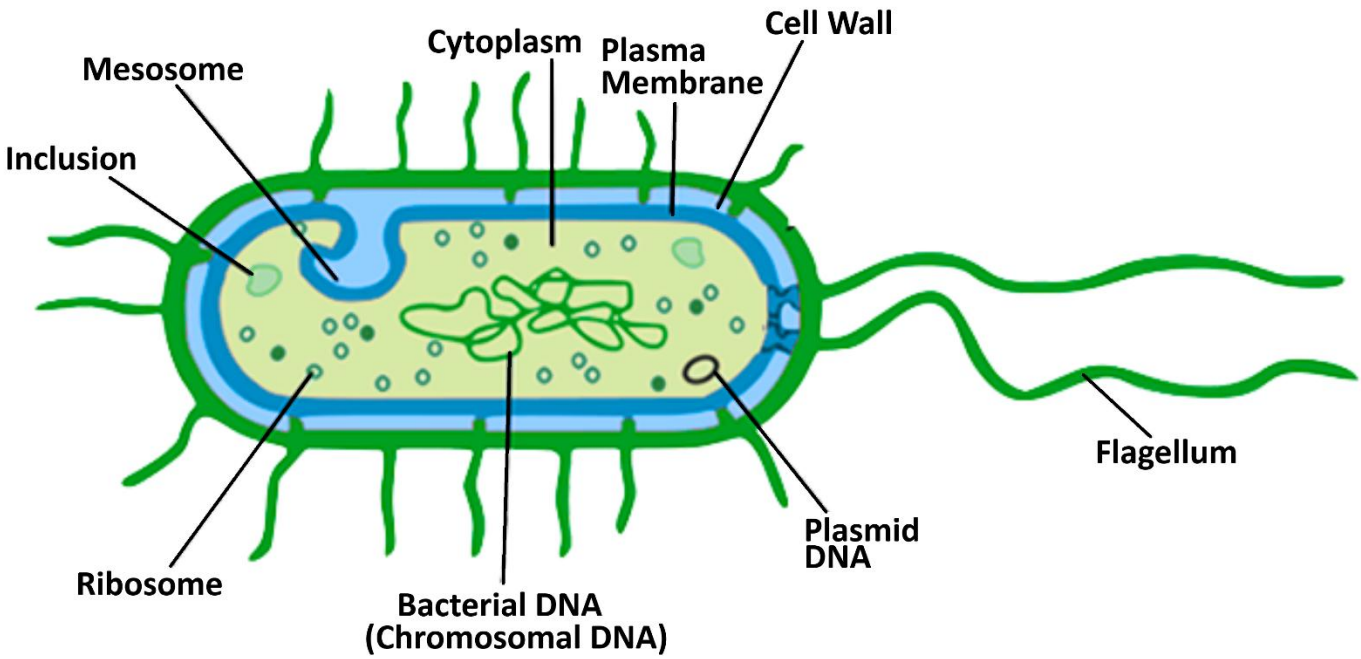
B. Arrangement

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- **Diplococci**: Cocci in pairs.
- **Streptococci**: Cocci in chains.
- **Staphylococci**: Cocci in clusters.

Cell Structure





A. Cell Wall

- Composed of **peptidoglycan (murein)**, which provides structural integrity and protection against osmotic lysis.
- Responsible for Gram staining characteristics:
  - **Gram-positive** bacteria have a thick peptidoglycan layer and stain purple.
  - **Gram-negative** bacteria have a thin peptidoglycan layer, an outer membrane containing lipopolysaccharides (LPS), and stain pink.

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B. Plasma (Cytoplasmic) Membrane

- Composed of a **phospholipid bilayer** with embedded proteins.
- Functions in **selective transport** and **energy generation** (since bacteria lack mitochondria).

C. Cytoplasm

- Contains:
  - **70S ribosomes** for protein synthesis.
  - **Enzymes** for metabolic activity.
  - **Inclusion bodies** for storage of nutrients.
  - **Nucleoid**, an irregularly shaped region that holds the bacterial chromosome (circular DNA not enclosed in a membrane).

D. Plasmids

- Extra-chromosomal, small, circular DNA molecules.
- Often carry genes for **antibiotic resistance** or other survival advantages.

E. Flagella

- Long, whip-like structures responsible for **motility**.
- May be arranged in different patterns: polar, peritrichous, etc.

F. Pili and Fimbriae

- **Pili**: Longer structures involved in **conjugation** (DNA transfer between bacteria).
- **Fimbriae**: Shorter, numerous projections used for **adhesion** to surfaces and host tissues.

G. Capsule or Slime Layer

- Composed of **polysaccharides**.
- Functions:
  - Protection from desiccation and host immune responses.
  - Adhesion to surfaces and tissues.
  - Evasion of phagocytosis.

H. Endospores

- Formed by some bacteria (e.g., *Bacillus*, *Clostridium*) under harsh environmental conditions.
- Dormant, highly resistant structures that allow long-term survival.

Classification

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