INTRODUCTION

Over the years, numerous classification systems have been introduced by scientists to categorize the vast diversity of living organisms. As you have learned in Chapter 1, one of the most widely accepted systems in biology was the five-kingdom classification proposed by the American ecologist **Robert H. Whittaker**. This system offered a broad and systematic framework for organizing organisms based on key characteristics and evolutionary relationships. According to this model, all prokaryotic organisms—those without a true nucleus—were grouped into a distinct kingdom known as **Monera**.

However, with the advancement of molecular biology and genetic research, especially over the past decade, scientists have uncovered significant limitations and inconsistencies in the five-kingdom classification. As discussed earlier in Chapter 1, a growing number of biologists now support a more refined system known as the **three-domain system**. This modern classification is better aligned with molecular data, particularly DNA and RNA sequencing, which provides deeper insight into the evolutionary lineage of organisms.

Recalling:
Robert H. Whittaker proposed the five-kingdoms of life i.e., Monera,Protista, Fungi, Plantae, andAnimalia. The first one includesprokaryotes and the other fourinclude eukaryotes.

Within this updated framework, bacteria are recognized as a unique group of prokaryotes and are placed in their own domain, the **Domain Bacteria**. This domain is distinct from the other two domains—**Archaea** and **Eukarya**—highlighting the fundamental genetic and biochemical differences among these major life forms.

In this chapter, we will explore the bacterial cell in detail, examining its structure and components. Furthermore, we will discuss the vital roles that bacteria play in ecosystems, human health, industry, and biotechnology, underscoring their importance in the natural world.

2.1 STRUCTURE OF BACTERIA

Q 1. Explain the position of bacteria in various classification systems.

Ans. Introduction:

Over the years, many schemes have been proposed for classifying organisms into kingdoms. Among these, the five-kingdom classification system, proposed by Robert H. Whittaker, is the one recommended in biology. This classification system organizes organisms in a comprehensive manner that reflects their evolutionary history.

Kingdom Monera

According to the five-kingdom classification, all prokaryotes are placed in a separate kingdom called **Monera**. This kingdom includes organisms that do not have membrane-bound organelles and lack a true nucleus.

Limitations of Five-Kingdom System

However, recent molecular studies have revealed serious flaws in this system regarding position of bacteria. Most biologists now support a new classification scheme, the **three-domain system**, which better aligns with molecular data.

Three-Domain System

In the three-domain system, bacteria are given a domain of their own, called **Domain Bacteria**. This system is more consistent with molecular biology findings and is widely accepted in modern taxonomy.

Structure of a Bacterial Cell.

Bacteria are a highly diverse group of organisms. All bacteria have a **unicellular prokaryotic organization**, meaning their cells lack membrane-bound organelles, including a defined nucleus. They have the **simplest cellular organization** among living organisms.

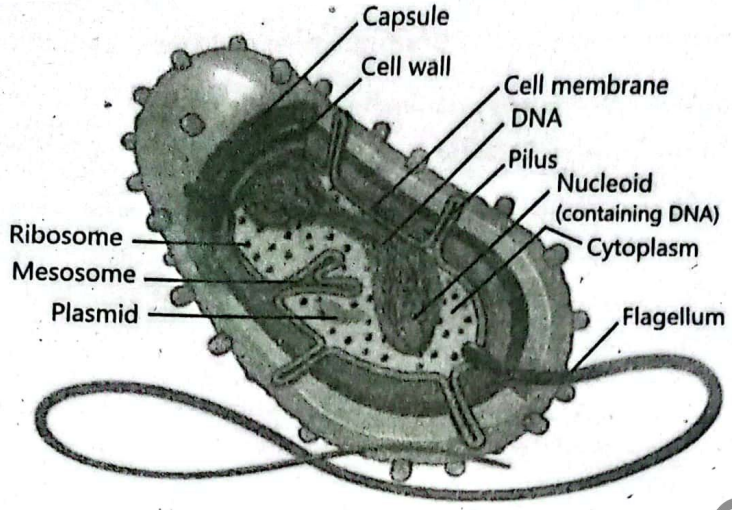


Fig. 2.1: Structure of a genferalized bacterium

The following are different parts of bacterial cell:

(i) Cell Wall

2. ? Discuss the structure and chemical composition of bacterial cell wall.

Ans. Structure and Chemical Composition of Bacterial Cell Wall

The **bacterial cell wall** is a rigid structure that lies outside the **plasma membrane** and provides shape, protection, and support to the bacterial cell. Its **main component** is a complex macromolecule called **peptidoglycan (murein)**.

Peptidoglycan Composition:

Peptidoglycan consists of **long chains of glycan (polysaccharides)**.

These chains are **cross-linked with short peptide fragments**.

The mesh-like structure provides mechanical strength to withstand internal osmotic pressure.

> Sir Hans Christian Gram devised the technique ofGram's staining. Gram-positive bacteria stainpurple because they retain violet dye. Gramnegativebacteria do not retain violet dye and sothey appear in original colour.

Additional Components:

In addition to peptidoglycan, some bacterial cell walls contain **lipids**.

The chemical composition and structure of the cell wall vary significantly between **Gram-positive and Gram-negative bacteria**, which can be distinguished by **Gram staining technique**.

Capsule:

Some bacteria produce an additional **external layer** known as a **capsule**, which:

- ✓ Is gelatinous and lies **outside the cell wall**.
- ✓ Provides **protection**, helps in **adherence to surfaces**, and can **evade immune responses**.
- ✓ Gives bacterial colonies a **sticky and slimy appearance**.

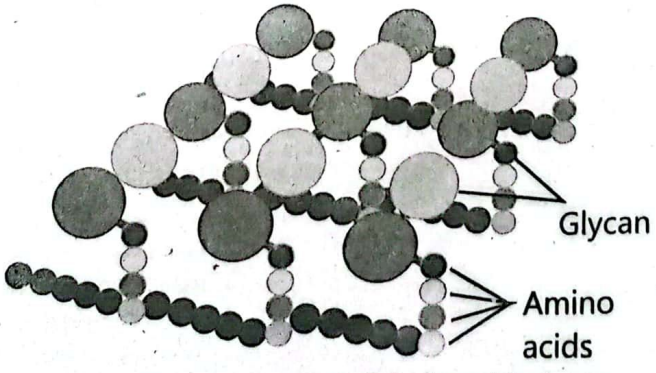


Fig. 2.2: The molecular model of peptidoglycan

3. Compare and contrast the cell wall of Gram-positive and Gram-negative bacteria

Ans. Comparison of Gram-Positive and Gram-Negative Bacterial Cell Walls

Feature	Gram-Positive Bacteria	Gram-Negative Bacteria
Peptidoglycan Layer	Thick (multi-layered)	Thin (single-layered)
Lipid Content	Low	High
Outer Membrane	Absent	Present (contains lipopolysaccharides)
Periplasmic Space	Small or absent	Large (between plasma membrane and outer wall)
Porin Proteins	Absent	Present in outer membrane
Teichoic Acids	Present (in peptidoglycan layer)	Absent
Gram Staining Result	Retains crystal violet (purple stain)	Does not retain crystal violet (appears pink)
Antibiotic Resistance	Generally more sensitive to antibiotics	More resistant due to outer membrane

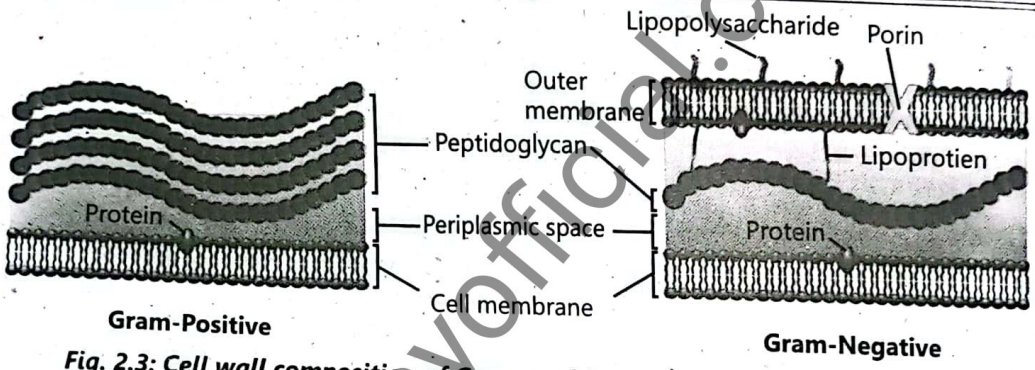


Fig. 2.3: Cell wall composition of Gram-positive and Gram-negative bacteria

Cell Membrane (Plasma Membrane)

4. Describe the cell membrane (plasma membrane) in bacteria. Also outline its diverse functions i the form of mesosomes.

Ans. The cell membrane, also known as the **plasma membrane**, is situated just beneath the cell wall. In bacteria th lack a cell wall, such as **Mycoplasmas** and **Sarcoplasmas**, the cell membrane forms the outermost boundary.

A significant feature of bacterial cell membranes is that they do not contain sterols such as cholesterol.

Mesosomes:Definition: In some regions, the cell membrane invaginates to form structures like vesicle tubules, or lamellae in the cytoplasm. These invaginated structures are called **mesosomes**.

Functions of mesosomes:

Mesosomes perform various functions such as:

- ✓ Participation in **DNA replication** and **cell division**.
- ✓ Functioning as **respiratory centers** of bacterial cells.

Cytoplasm and Genetic Material

5. Describe structure, chemical composition and functions of ribosomes, nucleoid and plasmids cytoplasm of bacteria

Ans. Unlike eukaryotic cells, bacterial cytoplasm **lacks a cytoskeleton** and **membrane-bound organelles**.

The **cytoplasm** of bacteria contains dissolved substances along with large structures such as:

a. **Ribosomes**
b. **Nucleoid**
c. **Plasmids**

a. Ribosomes in bacterial cells are:

Freely dispersed in the cytoplasmic matrix

Some are loosely attached to the plasma membrane Smaller than eukaryotic ribosomes

Plasmids also serve as important vectors, in geneticengineering. They are used to carry selected genes tobacteria for cloning or for the synthesis of specificproteins.

Sediment at **70S** (composed of a 50S larger subunit and a 30S smaller subunit)

Nucleoid: Near the center of the cytoplasm lies an **irregular-shaped dense area** known as the **nucleoid**. The nucleoid contains **bacterial DNA**, which is a **single, circular, double-stranded molecule**. This DNA:

Lacks histone proteins

Is often referred to as the **chromosome** of the bacterium

Plasmids: Some bacteria also possess additional circular DNA molecules called **plasmids**. These plasmids:

Are **double-stranded**, **extra-chromosomal**, and **self-replicating**

Can replicate **before or after cell division**.

Contain genes that provide bacteria with **resistance against unfavorable conditions**, such as resistance to antibiotics.

mQ's

1. **Who proposed the five-kingdom classification system?**
   A) Charles Darwin B) Robert H. Whittaker✓
   C) Carl Woese D) Aristotle
2. **In the five-kingdom system, prokaryotes are placed in which kingdom?**
   A) Protista B) Plantae
   C) Monera✓ D) Fungi
3. **Which classification system is more aligned with molecular studies?**
   A) Binomial nomenclature B) Five-kingdom system
   C) Two-kingdom system D) Three-domain system✓
4. **Bacteria belong to which domain in the three-domain system?**
   A) Archaea B) Eukarya
   C) Monera D) Bacteria✓
5. **What type of cellular organization do all bacteria have?**
   A) Multicellular eukaryotic B) Unicellular eukaryotic
   C) Unicellular prokaryotic✓
   D) Multicellular prokaryotic
6. **What is the major component of bacterial cell wall?**
   A) Cellulose B) Chitin
   C) Peptidoglycan✓ D) Lignin
7. **Peptidoglycan is composed of:**
   A) Amino acids and DNA B) Lipids and starch
   C) Glycan chains and peptide fragments✓
   D) Proteins and RNA
8. **What additional molecules are linked with peptidoglycan in bacterial cell walls?**
   A) Proteins B) Nucleic acids
   C) Lipids✓ D) Sterols
9. **Gram-positive bacteria have:**
   A) Thin peptidoglycan and high lipid content
   B) Thick peptidoglycan and low lipid content✓
   C) No peptidoglycan D) No lipid content at all
10. **What structural feature makes Gram-negative bacteria more resistant to antibiotics?**
    A) Capsule B) Ribosomes
    C) Outer membrane✓ D) Thick cell wall
11. **What protein acts as a pore in Gram-negative bacteria?**
    A) Actin B) Myosin
    C) Porin✓ D) Tubulin
12. **What is the function of the capsule in some bacteria?**
    A) DNA replication B) Cell division
    C) Sticky nature of colonies✓
    D) Photosynthesis
13. **In bacteria that lack a cell wall, which structure forms the outermost layer?**
    A) Cytoplasm B) Capsule
    C) Cell membrane✓ D) Nucleoid
14. **Which of the following is absent in bacterial cell membranes?**
    A) Peptidoglycan
    B) Sterols (e.g., cholesterol)✓
    C) Ribosomes D) Porins
15. **What are mesosomes?**
    A) Pigments in bacteria
    B) Invaginations of cell wall
    C) Invaginations of plasma membrane✓
    D) Cell wall components
16. **Which of the following is a function of mesosomes?**
    A) Digestion B) Photosynthesis
    C) DNA replication and respiration✓
    D) Motility
17. **What is absent in bacterial cytoplasm?**
    A) Ribosomes B) Cytoskeleton✓
    C) Mesosomes D) Nucleoid
18. **What is the sedimentation rate of bacterial ribosomes?**
    A) 60S B) 80S
    C) 70S✓ D) 90S
19. **What type of DNA is found in the nucleoid of bacteria?**
    A) Single-stranded circular
    B) Double-stranded circular✓
    C) Double-stranded linear
    D) Single-stranded linear
20. **What are plasmids?**
    A) Parts of ribosomes B) Non-replicating proteins
    C) Extra-chromosomal, self-replicating DNA✓
    D) Cell wall components

1. What is the cellular organization of bacteria?

Ans. Bacteria have a unicellular prokaryotic organization lacking membrane-bound organelles and a well-defined nucleus.

2. How is the cell wall of a bacterial cell structured?

Ans. The cell wall is a rigid layer around the plasma membrane, mainly composed of peptidoglycan (murein), which includes long glycan chains cross-linked with short peptide fragments. The cell wall also contains lipids linked to peptidoglycan.

3. How does the cell wall differ between Gram-positive and Gram-negative bacteria?

Ans. 1. Gram-positive bacteria have a thick layer of peptidoglycan and less lipid content.
2. Gram-negative bacteria have a thin layer of peptidoglycan, an outer membrane made of lipopolysaccharides and lipoproteins, and more periplasmic space.

4. What is the function of the outer membrane in Gram-negative bacteria?

Ans. It makes them resistant to many antibiotics and contains porin proteins that act as pores for specific molecules.

5. What is the capsule in bacteria and what is its function?

Ans. The capsule is a gelatinous layer outside the cell wall that gives a sticky character to bacterial colonies.

6. Where is the cell membrane located in bacteria?

Ans. It is located just beneath the cell wall and forms the outermost layer in bacteria lacking a cell wall (e.g., Mycoplasmas and Sarcoplasmas).

7. Do bacterial cell membranes contain sterols?

Ans. No, bacterial membranes do not contain sterols like cholesterol.

8. What are mesosomes and their functions?

Ans. Mesosomes are invaginations of the cell membrane that form vesicles, tubules, or lamellae in the cytoplasm. They are involved in DNA replication, cell division, and serve as respiratory centers.

Cytoplasm and Genetic Material

9. What components are found in bacterial cytoplasm?

Ans. The cytoplasm contains dissolved substances, nucleoid, ribosomes, and mesosomes. It lacks cytoskeleton and membrane-bound organelles.

10. Describe the ribosomes in bacteria.

Ans. Bacterial ribosomes are smaller than eukaryotic ones, sediment at 70S (comprising 50S and 30S subunits), and are either dispersed in the cytoplasm or loosely attached to the plasma membrane.

11. What is the nucleoid and what does it contain?

Ans. The nucleoid is an irregular-shaped dense area near the center of the cytoplasm containing a single, circular, double-stranded DNA molecule.

12. What is special about bacterial DNA?

Ans. It lacks attached histones and is often referred to as the bacterial chromosome.

13. What are plasmids and what are their roles?

Ans. Plasmids are circular, double-stranded extra-chromosomal DNA molecules that can self-replicate. They carry genes that help bacteria resist unfavorable conditions like antibiotics.

2.2 ENDOSPORE FORMATION IN BACTERIA

6. Define endospores. What are their characteristics?

Ans. Endospores

Definition: Endospores are thick-walled, metabolically inactive (dormant) structures developed in bacteria

Characteristics of Endospores

1. Endospores are thick-walled, metabolically inactive (dormant) structures.
2. They can remain in a dormant state for extended periods.
3. When favorable conditions return, they germinate to form active bacterial cells once again.
4. Endospores offer a remarkable survival strategy to withstand harsh environmental conditions.
5. They are specialized, highly resistant, and dormant cells.
6. These structures allow bacteria to endure periods of extreme stress such as:

(i) Heat (ii) Desiccation (iii) Radiation (iv) Nutrient depletion

Q 7. Explain the process of endospore formation in bacteria.

Ans. Sporulation – The Process of Endospore Formation

The formation of endospores is known as **sporulation**. This is a complex process triggered by **unfavorable environmental conditions**. Sporulation occurs in several sequential steps:

1. DNA Replication
2. When the bacterium senses a hostile environment, it begins the process by replicating its DNA.
3. Septum Formation
4. The cell membrane forms a septum, which isolates one copy of the newly replicated DNA along with a small portion of the cytoplasm.
5. Engulfment of the DNA
6. The cell membrane then grows around the new DNA and the isolated cytoplasm, enclosing it in a double membrane.
7. Disintegration of the Vegetative Cell DNA
8. The DNA of the original (vegetative) cell begins to disintegrate, and the cell starts to dehydrate, which is crucial for the endospore's resistance to environmental damage.
9. Peptidoglycan Layer Formation
10. A new peptidoglycan layer is formed between the two membranes that surround the newly isolated DNA and cytoplasm.
11. Spore Coat Formation
12. A protective spore coat develops around the inner core, providing additional resistance to physical and chemical damage.
13. Maturation of the Endospore
14. The structure matures into a fully developed endospore, ready to withstand adverse conditions.
15. Release of Endospore
16. The vegetative cell eventually breaks down, releasing the mature endospore into the environment.

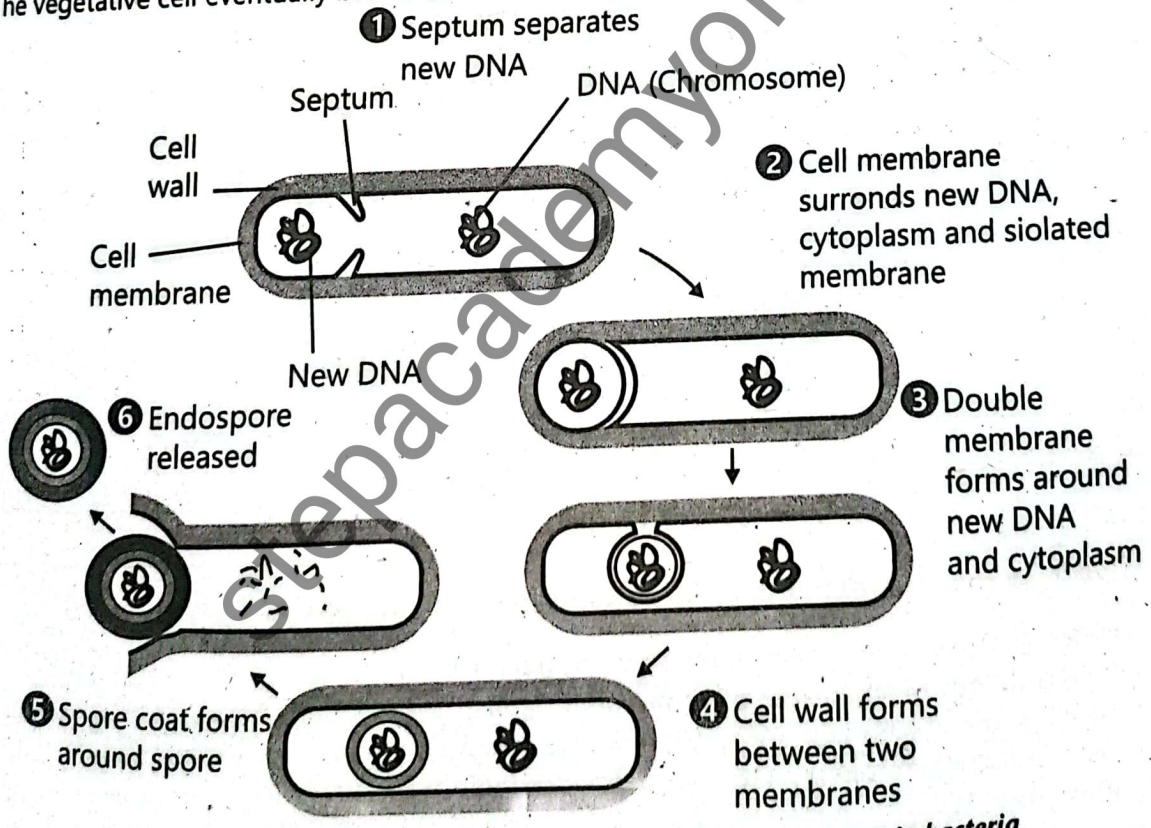


Fig. 2.4: Process of endospore formation (sporulation) in bacteria

Germination of Endospores

Once **favorable conditions** return, the endospore **germinates**. During germination, the endospore absorbs water, enzymes become active, metabolism resumes, and the dormant structure transforms back into a new **vegetative cell**, ready for normal growth and reproduction.

MCQs

1. **What are endospores in bacteria?**
   A. Metabolically active cells
   B. Resting, thick-walled, dormant cells ✓
   C. Cells that perform photosynthesis
   D. Thin-walled reproductive cells
2. **The process by which bacteria form endospores is called:**
   A. Germination B. Binary fission
   C. Sporulation ✓ D. Replication
3. **During sporulation, the first step is:**
   A. Septum formation B. DNA replication ✓
   C. Spore coat formation
   D. Peptidoglycan layer formation
4. **What surrounds the new DNA during endospore formation?**
   A. A single cell wall B. A protein layer
   C. Two membranes ✓ D. One lipid membrane
5. **What happens to the DNA of the vegetative cell during endospore formation?**
   A. It duplicates B. It becomes active
   C. It disintegrates ✓
   D. It is transferred to the endospore
6. **When do endospores germinate?**
   A. During nutrient depletion
   B. When conditions are unfavorable
   C. Under favorable conditions ✓
   D. At high temperature

SQ

1. What are endospores and why do bacteria form them?

Ans. Endospores are specialized, thick-walled, metabolically inactive (dormant) "resting" cells formed by many bacteria to survive extended periods of harsh or unfavorable environmental conditions.

2. What is the process of endospore formation called?

Ans. The process by which bacteria form endospores is called **sporulation**.

3. Outline the steps involved in sporulation (Endospore formation).

Ans.
1. When a bacterium encounters unfavorable conditions, it replicates its DNA.
2. The cell membrane forms a septum to isolate the new DNA along with a small portion of cytoplasm.
3. The membrane then grows around the new DNA, cytoplasm, and septum, enclosing them in two membranes.
4. The DNA of the vegetative cell disintegrates and the cell begins to dehydrate.
5. A new peptidoglycan layer forms between the two membranes.
6. A protective spore coat is developed around the structure.
7. The whole structure matures into an endospore.
8. The vegetative cell ruptures, releasing the endospore into the environment.
9. The endospore remains dormant until favorable conditions return.

4. What happens to the endospore when conditions become favorable again?

Ans. When favorable conditions return, the endospore **germinates** and develops into a new vegetative bacterial cell.

2.3 MOTILITY IN BACTERIA

Q 8. Describe the different types of motility patterns observed in bacteria.

OR Explain different methods of movement in bacteria.

Ans. Bacteria have evolved various **mechanisms of movement** to help them navigate through their environments. These motility patterns allow bacteria to explore surfaces, move towards nutrients, or escape harmful substances. Bacterial motility is especially important for survival, colonization, and infection.

Motility Patterns in Bacteria:

1. **Flagellar Movement**

   The most common form of movement in **bacilli and spirilla** is through **flagella**, which are whip-like appendages.

   Mechanism: Bacteria swim by rotating their flagella. When a bacterial population moves together using flagella, the movement is called **swarming**.

Direction: A **counterclockwise rotation** of the flagellum pushes the cell forward with the flagellum trailing behind.

Medium: This movement primarily occurs in **liquid environments**.

2. **Twitching or Crawling**

Some bacteria use **pili** to move over solid surfaces.

Mechanism: The pili extend, **attach to a solid surface**, and then **retract**, pulling the cell forward.

Function: This method is effective for movement on surfaces and is known as **twitching** or **crawling**.

3. **Gliding Motility**

Gliding is similar to twitching but involves a different mechanism.

Mechanism: Bacteria secrete a slimy substance, which facilitates smooth and continuous movement over solid surfaces.

Usage: This form of motility is used by bacteria that lack flagella.

4. **Sliding**

Sliding is a passive movement that results from the pushing force of dividing bacterial cells.

Mechanism: As cells multiply, they expand outward, pushing other cells along a surface.

Nature: It is not an active form of motility but contributes to the spreading of colonies.

5. **Brownian Movements**

Some bacteria (e.g., *Streptococcus*) thatlack flagella or pili may still exhibit movement.

Mechanism: They undergo random, uncontrolled movements due to the collision of particles in the surrounding fluid.

Note: This is not true motility but a physical phenomenon called **Brownian movement**.

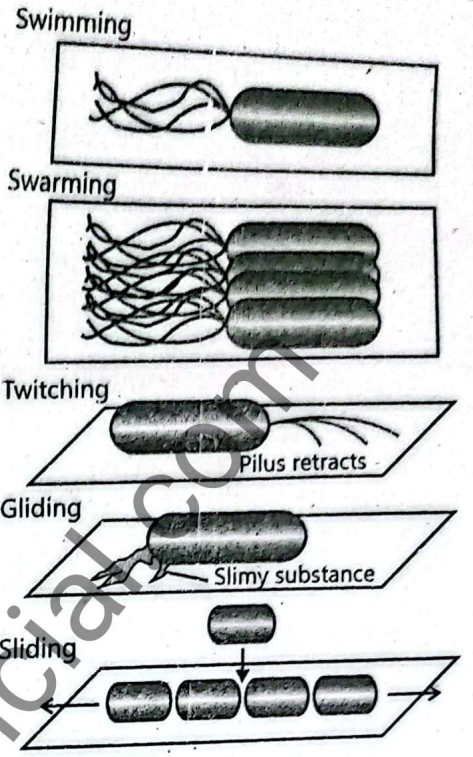


Fig. 2.5: Motility in bacteria

6. **Movement by Axial Filament**

Certain bacteria, such as **spirochaetes**, have a unique structure called the **axial filament**, which helps them move.

Structure: The axial filament is a **modified flagellum** located in the **periplasmic space** (between the cell membrane and the outer membrane).

Mechanism: It consists of **two sets of flagella-like fibrils** anchored at both ends of the cell.

Function: The axial filament allows **flexing, spinning, creeping, and swimming** movements, making spirochaetes highly motile in viscous environments.

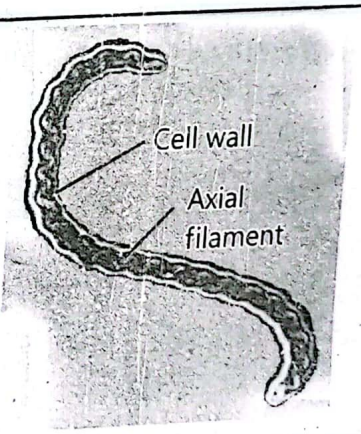


Fig. 2.6: Axial filament in a spirochaete

MCQs

1. **What type of movement is caused by flagella?**
   A. Crawling B. Swarming ✓
   C. Gliding D. Flexing
2. **What rotation of flagella pushes the bacterial cell forward?**
   A. Clockwise B. Lateral
   C. Counterclockwise ✓ D. Irregular
3. **What structure is used in twitching or crawling motility?**
   A. Flagella Axial filament
   C. Pili ✓ Ciiia
4. **Which motility involves he secretion of a slimy substance?**
   A. Twitching B Sliding
   C. Gliding ✓ D. Swimming
5. **What type of movement results from the pushing force of dividing cells?**
   A. Twitching B. Sliding ✓

C. Brownian D. Spinning

6. **Brownian movement in bacteria is:**
A. Flagellar-driven B. Controlled and directional
C. Caused by pili
D. Random and uncontrolled ✓

7. **Which bacteria move using an axial filament?**
A. Bacilli B. Spirilla
C. Spirochaetes ✓ D. Cocci

8. **Axial filament is located:**
A. Outside the cell B. In the cytoplasm
C. In the nucleus
D. In the periplasmic space ✓

SQ

1. What is the purpose of motility in bacteria?

Ans. Bacteria use various types of motility to **navigate and explore natural habitats**, helping them survive and thrive.

Flagellar Movements

2. How do most bacilli and spirilla bacteria move?

Ans. Most bacilli and spirilla bacteria move using **flagella**, enabling them to swim in liquid media.

3. What is 'swarming' in bacteria?

Ans. Swarming is a type of collective flagellar movement where a **bacterial population moves together** across a surface or medium.

4. How does the rotation of flagella help in movement?

Ans. The **counter-clockwise rotation** of a flagellum **pushes the bacterial cell forward**, with the flagellum trailing behind.

Twitching or Crawling

5. What is twitching or crawling and how is it performed?

Ans. It is surface movement mediated by **pili**, which attach to solid surfaces and retract, pulling the bacterial cell forward.

Gliding

6. What is gliding movement in bacteria?

Ans. In gliding, bacteria secrete a **slimy substance** that helps them move smoothly over solid surfaces, similar to twitching.

Sliding

7. What causes sliding movement in bacteria?

Ans. Sliding occurs due to the **expansion force** produced by dividing cells that push one another across surfaces.

Brownian Movements

8. What is Brownian movement and which bacteria show it?

Ans. Brownian movement is a **random, uncontrolled movement** caused by particle motion in fluid. It is seen in bacteria like **Streptococcus**, which lack flagella or pili.

Movement by Axial Filament

9. What is axial filament and which bacteria use it for movement?

Ans. Axial filament is a **modified flagellum** found in bacteria like **spirochaetes**. It runs lengthwise in the periplasmic space and is anchored at both poles, enabling **flexing, swimming, creeping, and spinning movements**.

2.4 FLAGELLA

9. What are flagella in bacteria? Describe types of bacteria on the basis of number and arrangement of flagella

Ans. Introduction:

Flagella are long, whip-like appendages that help bacteria move. They are the most important locomotory structures for motile bacteria. Besides motility, flagella also play a role in **chemotaxis**, enabling bacteria to detect and respond to chemical signalsin their environment.

Types of Bacteria Based on Number and Arrangement of Flagella

Bacteria can be classified based on the **number and arrangement of flagella** on their surface:

1. **Atrichous**
   - Bacteria **without any flagella** are called atrichous.
   - These bacteria are **non-motile**.

2. **Monotrichous**
   - Bacteria with a **single flagellum at one pole** are called Monotrichous.
   - This arrangement allows directional movement.
3. **Lophotrichous**
   - Bacteria with a **tuft of flagella at one pole** are called Lophotrichous.
   - The bundle of flagella rotates together for effective propulsion.
4. **Amphitrichous**
   - Bacteria with **one or more flagella at each of the two poles** are called Amphitrichous.
   - Allows movement in both directions.
5. **Peritrichous**
   - Bacteria with **flagella distributed all over the cell surface** are called Peritrichous.
   - The coordinated rotation of multiple flagella enables rapid movement.

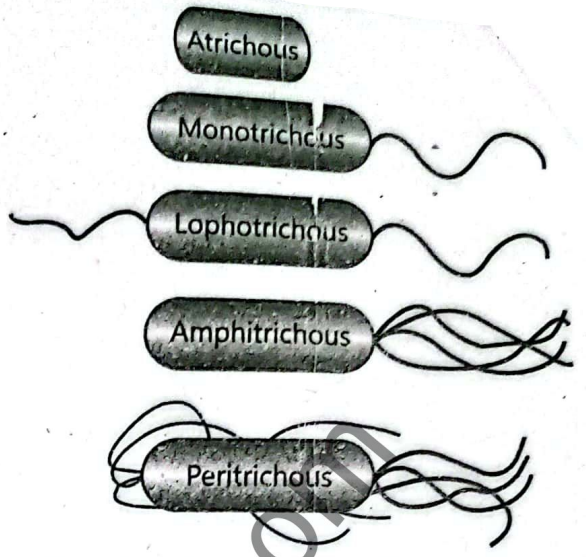


Fig. 2.7: The different arrangements of bacterial flagella

10. Explain the structure of bacterial flagellum.

Ans. Structure of Bacterial Flagella

The structure of bacterial flagella is different from that of eukaryotic flagella. Unlike eukaryotic flagella, which are based on a **9+2 microtubule arrangement**, bacterial flagella are composed of a protein called **flagellin**.

Three Main Parts of a Bacterial Flagellum:

1. **Basal Body**
   - Anchors the flagellum to the cell membrane and cell wall.
   - Consists of **rotating rings**:
     - **Gram-positive bacteria** have **one pair of rings**.
     - **Gram-negative bacteria** have **two pairs of rings**.
2. **Hook**
   - A **curved structure** that connects the **basal body** with the **filament**.
   - Acts as a **universal joint**, allowing the filament to rotate and generate thrust.
3. **Filament**
   - The **long, whip-like part** that extends from the cell.
   - Composed of **flagellin protein**.
   - Rotates to produce motion.

> Some bacteria have pili (singular; pilus). These arenon-helical, filamentous appendages and are smallerand thinner than flagella. Pili are used for attachmentof bacteria to various surfaces. They are also involvedin the mating process (conjugation) between cells.

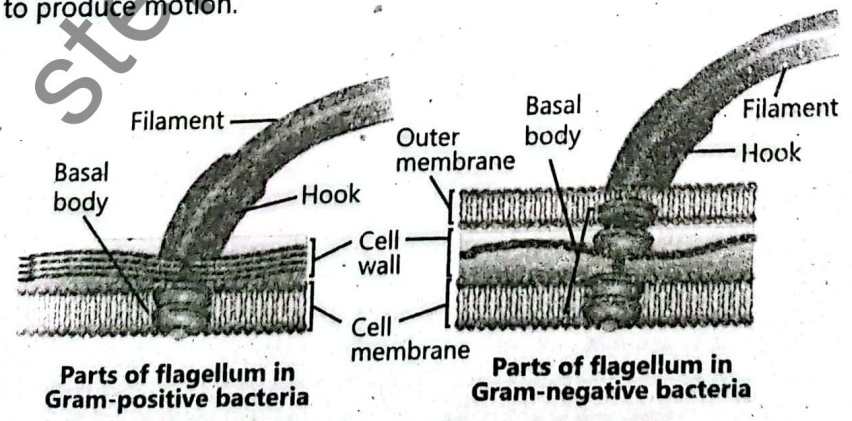


Fig. 2.8: The structure of bacterial flagella

Conclusion

Flagella are essential structures for many bacteria, providing them with the ability to move toward favorable environments and away from harmful ones. Their structure and arrangement differ among species, reflecting adaptations to different ecological niches.

MCQs

1. **What type of bacteria do not possess any flagella?**
   A. Peritrichous B. Monotrichous
   C. Atrichous ✓ D. Lophotrichous
2. **Bacteria with a single flagellum at one pole are called:**
   A. Amphitrichous B. Monotrichous ✓
   C. Peritrichous D. Lophotrichous
3. **Lophotrichous bacteria have:**
   A. Flagella all over
   B. A tuft of flagella at one pole ✓
   C. No flagella D. Flagella on both poles
4. **Amphitrichous bacteria possess flagella:**
   A. Only on one pole B. On all sides
   C. On both poles ✓ D. Only internally
5. **What surrounds the entire surface of peritrichous bacteria?**
   A. Pili B. Axial filaments
   C. Slime layer D. Flagella ✓
6. **What protein makes up bacterial flagella?**
   A. Tubulin B. Actin
   C. Flagellin ✓ D. Myosin

SQ

1. **What are the functions of flagella in bacteria?**

Ans. Flagella primarily **enable movement** and also help in **detecting and responding to chemical signals** in the environment.

2. **Differentiate betweenatrichous and monotrichous bacteria?**

Ans. Atrichous bacteria are those that **do not possess any flagella** while monotrichous bacteria have a **single polar flagellum**.

3. **Differentiate between lophotrichous and amphitrichous bacteria?**

Ans. Lophotrichous bacteria have a **tuft of flagella at one pole** while amphitrichous bacteria have **flagella at both poles** of the cell.

4. **What are peritrichous bacteria?**

Ans. Peritrichous bacteria have **flagella distributed all around** the cell surface.

Structure of Bacterial Flagella

5. **How is the structure of bacterial flagella different from eukaryotic flagella?**

Ans. Bacterial flagella are made of **flagellin protein** and do **not follow the 9+2 microtubule arrangement** seen in eukaryotes.

6. **How is the bacterial flagellum anchored in the cell?**

Ans. It is anchored by **rotating rings** (one pair in Gram-positive and two pairs in Gram-negative bacteria) embedded in the **cell membrane and cell wall**.

7. **What is the role of the hook in bacterial flagella?**

Ans. The **hook** is a **curved structure** that connects the **basal body** to the **filament**, allowing flexibility and rotation for movement.

2.5 BACTERIA; ECOLOGY & DIVERSITY

11. Discuss the ancient and ubiquitous nature of prokaryotes.

Ans. Ancient and Ubiquitous Organisms

The fossil record provides strong evidence that **prokaryotes**—specifically **archaea and bacteria**—were the earliest forms of life on Earth. They were already **abundant around 3.5 billion years ago** and dominated Earth for **the next two billion years**, long before the emergence of eukaryotic organisms. Today, **prokaryotes inhabit almost every environment** where life is possible. Bacteria, in particular, are found in **water, soil, air, food**, and within the **bodies of plants and animals**. They are **more numerous than all eukaryotic organisms combined** and possess remarkable abilities to **survive extreme conditions**, such as high temperature, salinity, acidity, or radiation.

> Perhaps most interesting of all is the recent discovery that the bulk of our modern petroleumdeposits were formed by masses of decayedcyanobacteria.

12. Describe the major groups of bacteria as proposed by Margulis and Schwartz.

Ans. Bacterial Diversity and Classification

Biologists **Margulis and Schwartz** proposed a comprehensive classification system that divided all prokaryotes into **16 phyla**. The discussion below focuses on **important bacterial groups**, especially from the **domain Bacteria**, which exhibit a broad range of structural and ecological characteristics.

> Colourful blooms may occur in polluted water as aresult of the rampant growth of cyanobacteria. Thecolours of such blooms result from thephotosynthetic pigments of cyanobacteria

1. **Omnibacteria**
   - These are **rigid, rod-shaped (bacilli)**, **Gram-negative**, and **heterotrophic** bacteria.
   - They are usually **aerobic** and **motile with flagella**.
   - They **do not form spores** and include several **important pathogens**, such as *Escherichia coli*.
   - This group also includes **vibrios**, another rod-shaped form.
2. **Cyanobacteria**
   - These are **photosynthetic bacteria** that contain **chlorophyll-a** and accessory pigments like **carotenoids**, **blue**, and **red phycobilins**.
   - They have played a **critical role in increasing free oxygen** in the Earth's atmosphere.
   - Some cyanobacteria can **fix atmospheric nitrogen** using specialized cells called **heterocysts**.
   - They are found in **soil (as mats)**, **lichens on rock surfaces**, and **marine sediments**.

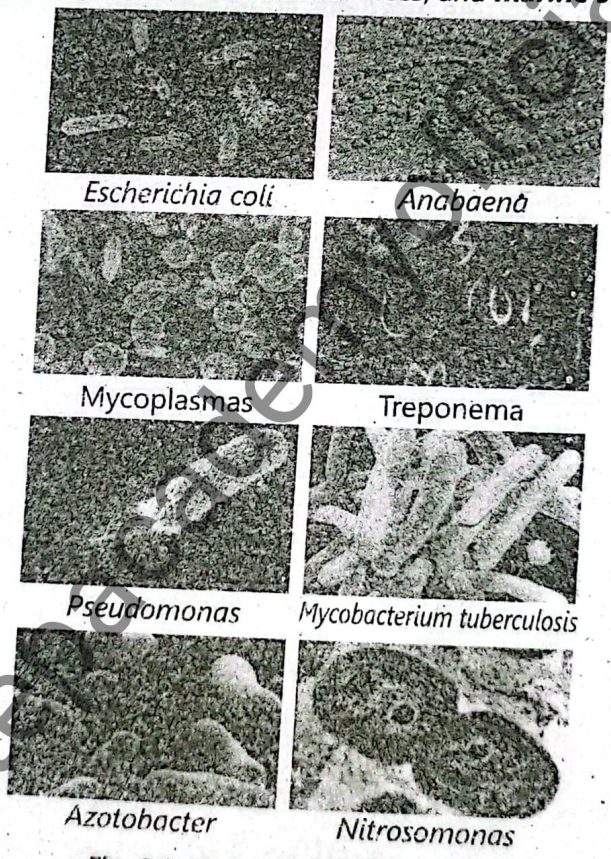


Fig. 2.9: Major groups of bacteria

3. **Mycoplasmas and Spiroplasmas**
   - These bacteria are unique because they **lack cell walls**, making them **resistant to antibiotics** like penicillin, which target cell wall synthesis.
   - Some **mycoplasmas** are pathogens in mammals and can cause **pneumonia in humans**.
   - **Spiroplasmas** infect plants, causing diseases such as **lethal yellowing of coconuts**.
4. **Spirochaetes**
   - These are **long spiral-shaped (spirilla)**, **Gram-negative** bacteria.
   - They possess **2 to over 100 flagella**, allowing a variety of movements.
   - A key example is *Treponema*, the bacterium that causes **syphilis**, a **serious sexually transmitted disease**.

5. **Pseudomonads**
   - These are **straight or curved rod-shaped, Gram-negative** bacteria with **polar flagella**.
   - They live in **soil and water** and are capable of **breaking down organic compounds**.
   - Some are **autotrophic**, but many are **plant pathogens** and also participate in **denitrification**.
   - *Pseudomonas aeruginosa* is commonly found in soil, water, and on vegetables; it is **harmless to healthy individuals** but can cause **serious infections in immunocompromised people**.

6. **Actinomycetes**
   - These bacteria have a **filamentous (chain-like)** structure and can produce **resistant spores**.
   - Some live in **root nodules** of flowering plants and are **nitrogen fixers**.
   - Certain actinomycetes form **dental plaque**, which damages tooth enamel.
   - **Pathogenic members** include *Mycobacterium leprae* (causes **leprosy**) and *Mycobacterium tuberculosis* (causes **tuberculosis**).
   - They are also the source of many **antibiotics**, such as **tetracycline, erythromycin, chloramphenicol**, and **neomycin**.

7. **Nitrogen-fixing Aerobic Bacteria**
   - This group contains **Gram-negative, flagellated bacteria** that are **economically important**.
   - They are involved in **converting atmospheric nitrogen into nitrates**, enhancing soil fertility.
   - A major example is **Azotobacter**, commonly found in **soil and water**.

8. **Chemosynthetic Bacteria**
   - These bacteria obtain energy by **oxidizing inorganic compounds** such as **ammonia (NH_3), sulfur, or iron**.
   - They utilize this energy to **synthesize their own food**.
   - *Nitrosomonas* and *Nitrobacter* are examples that oxidize ammonia to produce **nitrites and nitrates**, playing an **essential role in the nitrogen cycle**.

Table: Characteristics of Some Groups of Bacteria

Name of Group	Form	Motility	Nutrition	Ecological Role
Omnibacteria	R	N, F	H	Pathogens and decomposers
Cyanobacteria	R, C, M	G, N	P	Carbon and nitrogen fixers
Mycoplasmas and Spiroplasmas	No wall	N	H	Pathogens
Spirochaetes	S	F	H	Decomposers and pathogens
Pseudomonads	R	F	H, C	Decomposers and plant pathogens
Actinomycetes	M, R	N	H	Pathogens and nitrogen fixers
Nitrogen-fixing aerobes	R, N	N, F	H	Free-living and mutualistic nitrogen fixers
Chemosynthetic bacteria	R, C	F	C	Oxidize nitrogen and sulphur compounds, play role in nitrogen cycle

Legend:
- **Form**: R = rods (bacilli), C = cocci, S = spirilla, M = chains/aggregations
- **Motility**: F = flagellated, N = non-motile, G = gliding
- **Nutrition**: H = heterotrophic, C = chemosynthetic, P = photosynthetic

MCQs ✓

1. **According to fossil records, prokaryotes first appeared on Earth about:**
   A) 2 billion years ago B) 1.5 billion years ago
   C) 3.5 billion years ago ✓ D) 4.5 billion years ago

2. **Prokaryotes include which two domains?**
   A) Protista and Fungi B) Archaea and Bacteria ✓
   C) Plantae and Bacteria D) Fungi and Archaea

3. **Omnibacteria are generally:**
   A) Photosynthetic
   B) Gram-positive and spore-forming
   C) Rod-shaped, heterotrophic, and Gram-negative ✓
   D) Spirilla and non-motile

4. **Cyanobacteria are important because they:**
   A) Cause plant diseases
   B) Decompose organic matter
   C) Fix oxygen in the soil
   D) Increased oxygen in Earth's atmosphere ✓

5. **The pigments found in cyanobacteria include all EXCEPT:**
A) Chlorophyll-a B) Phycobilins
C) Carotenoids D) Anthocyanins ✓

6. **What are heterocysts?**
A) Photosynthetic organelles in bacteria
B) Antibiotic-resistant genes
C) Nitrogen-fixing cells in cyanobacteria ✓
D) Pigment granules in fungi

7. **Which bacteria group lacks a cell wall?**
A) Cyanobacteria
B) Mycoplasmas and Spiroplasmas ✓
C) Spirochaetes D) Pseudomonads

8. **Which disease is caused by Treponema?**
A) Tuberculosis B) Leprosy
C) Syphilis ✓ D) Pneumonia

9. **Which group includes Pseudomonas aeruginosa?**
A) Omnibacteria B) Pseudomonads ✓
C) Actinomycetes D) Spirochaetes

10. **Actinomycetes are known for:**
A) Causing syphilis
B) Fixing carbon in the atmosphere
C) Producing antibiotics ✓
D) Forming heterocysts

11. **Which disease is caused by Mycobacterium leprae?**
A) Pneumonia B) Syphilis
C) Leprosy ✓ D) Tuberculosis

12. **Azotobacter is an example of:**
A) Actinomycetes
B) Nitrogen-fixing aerobic bacteria ✓
C) Spiroplasmas D) Chemosynthetic bacteria

13. **Which bacteria derive energy from oxidation of inorganic compounds?**
A) Cyanobacteria B) Mycoplasmas
C) Chemosynthetic bacteria ✓
D) Actinomycetes

14. **Nitrosomonas belongs to which bacterial group?**
A) Spirochaetes
B) Chemosynthetic bacteria ✓
C) Omnibacteria D) Mycoplasmas

15. **Which bacteria cause diseases in plants like lethal yellowing in coconuts?**
A) Actinomycetes B) Spiroplasmas ✓
C) Pseudomonads D) Mycoplasmas

16. **Which bacteria are known for filamentous growth and spore production?**
A) Omnibacteria B) Cyanobacteria
C) Actinomycetes ✓ D) Pseudomonads

17. **Which bacteria contribute to the decomposition of organic compounds in soil and water?**
A) Cyanobacteria B) Spirochaetes
C) Pseudomonads ✓ D) Mycoplasmas

18. **What is the ecological role of spirochaetes?**
A) Nitrogen fixation only
B) Photosynthesis and decomposition
C) Decomposition and pathogenesis ✓
D) Oxygen production

19. **Which group includes bacteria that are resistant to penicillin?**
A) Cyanobacteria
B) Mycoplasmas and Spiroplasmas ✓
C) Spirochaetes D) Actinomycetes

20. **What is the role of Nitrobacter in the ecosystem?**
A) Decomposing organic matter
B) Fixing atmospheric oxygen
C) Oxidizing ammonia to nitrites
D) Oxidizing nitrites to nitrates ✓

SQ

1. **What do fossil records reveal about prokaryotes?**
Ans. Fossil records show that prokaryotes, including archaea and bacteria, were abundant about 3.5 billion years ago. They evolved early and remained the only life forms on Earth for the next 2 billion years.

2. **Where are prokaryotes found today?**
Ans. Prokaryotes are found wherever there is life, including water, soil, air, food, and inside the bodies of plants and animals.

3. **How do bacteria compare in number to eukaryotes?**
Ans. Bacteria outnumber all eukaryotic organisms and can survive in extreme environments.

4. **Who proposed the classification of prokaryotes into phyla, and how many were there?**
Ans. Margulis and Schwartz proposed a classification system dividing prokaryotes into 16 phyla.

5. **What are omnibacteria and what are their features?**
Ans. Omnibacteria are rigid, rod-shaped, Gram-negative, heterotrophic bacteria. They are mostly aerobic, motile with flagella, do not produce spores, and include pathogens such as *Escherichia coli*. Vibrios are also part of this group.

6. What are cyanobacteria and why are they important?

Ans. Cyanobacteria are photosynthetic bacteria containing chlorophyll-a and pigments like carotenoids and phycobilins. They played a major role in raising Earth's atmospheric oxygen and can fix atmospheric nitrogen in special cells called heterocysts.

7. Where are cyanobacteria commonly found?

Ans. Cyanobacteria are found in soil as mats, on rock surfaces in lichens, and in marine sediments.

8. What distinguishes mycoplasmas and spiroplasmas from other bacteria?

Ans. They lack cell walls, making them resistant to antibiotics like penicillin. Mycoplasmas cause diseases like pneumonia, while spiroplasmas cause plant diseases such as lethal yellowing of coconuts.

9. What are spirochaetes and what disease do they cause?

Ans. Spirochaetes are long, spiral-shaped (spirilla), Gram-negative bacteria with multiple flagella. *Treponema*, a spirochaete, causes syphilis—a serious sexually transmitted disease.

10. What are pseudomonads and what is their ecological role?

Ans. Pseudomonads are Gram-negative, rod-shaped bacteria with polar flagella. They are found in soil and water, can degrade organic compounds, and include plant pathogens. Some, like *Pseudomonas aeruginosa*, may cause infections in immunocompromised people.

11. What is the significance of *Pseudomonas aeruginosa*?

Ans. It occurs in soil, water, and raw vegetables. While usually harmless, it can cause serious infections in individuals with weakened immune systems.

12. What are actinomycetes and what makes them unique?

Ans. Actinomycetes have a filamentous structure and can produce resistant spores. Some fix nitrogen in root nodules, others cause dental plaque or diseases like leprosy and tuberculosis. They are also a source of antibiotics such as tetracycline, erythromycin, and neomycin.

13. Which actinomycetes are pathogenic and what do they cause?

Ans. *Mycobacterium leprae* causes leprosy, and *Mycobacterium tuberculosis* causes tuberculosis.

14. What are nitrogen-fixing aerobic bacteria?

Ans. These are Gram-negative, flagellated bacteria found in soil and water that convert atmospheric nitrogen into nitrates. *Azotobacter* is a key example.

15. What are chemosynthetic bacteria and how do they obtain energy?

Ans. Chemosynthetic bacteria derive energy by oxidizing inorganic compounds of nitrogen, sulfur, or iron. They use this energy to make food and play a vital role in the nitrogen cycle.

16. Name two chemosynthetic bacteria and describe their role.

Ans. *Nitrosomonas* and *Nitrobacter* oxidize ammonia (NH_3) into nitrites and nitrates, contributing to nitrogen cycling in ecosystems.

17. What is the role of cyanobacteria in nitrogen fixation?

Ans. Cyanobacteria fix atmospheric nitrogen in specialized cells called heterocysts, enriching soil fertility.

18. How do pseudomonads contribute to the nitrogen cycle?

Ans. Some pseudomonads participate in denitrification, converting nitrates into nitrogen gas, thus completing the nitrogen cycle.

19. What structural feature do mycoplasmas lack, and what advantage does this give them?

Ans. Mycoplasmas lack a cell wall, making them naturally resistant to antibiotics like penicillin that target cell wall synthesis.

20. What kind of pigmentation is found in cyanobacteria?

Ans. Cyanobacteria contain chlorophyll-a, carotenoids, and blue and red phycobilins, allowing them to perform photosynthesis.

2.6 IMPORTANCE OF BACTERIA

Q 13. Explain the importance of bacteria in the environment and human life.

Ans. Bacteria play an essential role in both ecological and economic systems, contributing significantly to the balance of life on Earth. They serve beneficial purposes in numerous ways, including as recyclers of nature, makers of useful products, environmental cleaners, biopesticides, and tools for research and technology.

Recyclers of Nature

Bacteria are integral to biogeochemical cycles, which are processes where essential elements move between organisms and the environment. For instance, nitrifying bacteria such as *Nitrosomonas*, *Nitrobacter*, and *Azotobacter* contribute to the nitrogen cycle, ensuring nitrogen is converted into forms usable by plants and animals. Additionally, denitrifying bacteria like *Pseudomonas* convert nitrogen back into gas, completing the cycle. Decomposer bacteria help break down dead organic matter, playing a crucial role in the carbon, hydrogen, and oxygen cycles. Photosynthetic bacteria, such as cyanobacteria, help increase free oxygen in the atmosphere.

Makers of Useful Products

Bacteria have long been used in the production of fermented foods, including cheese, yogurt, pickles, soy sauce, and wine. Bacteria like *Lactobacillus* play a central role in these processes, often in combination with yeasts and molds. Moreover, bacteria are critical in producing pharmaceutical products such as antibiotics and other chemicals used in both medicine and agriculture. They are also used in animal leather preparation by breaking down specific compounds in skins.

Environmental Cleaners

Bacteria help clean up the environment through bioremediation, a process where microorganisms degrade pollutants into harmless substances. They are used to decompose city sewage, digest hydrocarbons in oil spills, and clean up industrial toxic wastes, showcasing their ability to break down harmful chemicals and organic compounds.

Biopesticides

Bacteria like *Bacillus thuringiensis* are used in biological pest control, replacing harmful chemical pesticides. These bacteria are environmentally friendly, as they target pests without harming humans, wildlife, or beneficial insects, contributing to safer agricultural practices.

Research and Technology Tools

Due to their rapid growth and ease of manipulation, bacteria are vital in genetic engineering, molecular biology, and biochemistry. Researchers use bacteria to study gene functions, create mutations in bacterial DNA, and produce therapeutic proteins like insulin, growth hormones, and antibodies. This ability to modify bacteria allows scientists to apply similar techniques to more complex organisms.

MCQs

1. **Which of the following is a significant role of nitrifying bacteria?**
   A) Decompose dead organic matter
   B) Convert ammonia into nitrites and nitrates ✓
   C) Digest hydrocarbons from oil spills
   D) Produce antibiotics

2. **What is the role of denitrifying bacteria in the nitrogen cycle?**
   A) Convert nitrogen gas into ammonia
   B) Convert nitrates into nitrogen gas ✓
   C) Break down hydrocarbons in oil spills
   D) Produce oxygen through photosynthesis

3. **Which bacteria is commonly used in bioremediation to clean oil spills?**
   A) Lactobacillus
   B) Bacillus thuringiensis
   C) Nitrosomonas
   D) Petroleum-degrading bacteria ✓

4. **Which of the following is a product produced by bacteria used in the pharmaceutical industry?**
   A) Insulin ✓
   B) Cyanobacteria
   C) Hydrocarbons
   D) Nitrates

5. **What is the primary function of bacteria in the process of photosynthesis?**
   A) Produce antibiotics
   B) Increase free oxygen in the atmosphere ✓
   C) Decompose organic matter
   D) Synthesize vitamins

SQ

1. Why are bacteria considered important organisms?

Ans. Bacteria are considered important because they affect life on Earth both beneficially and harmfully. They are ecologically and economically valuable. Bacteria are involved in nutrient cycling, food production, environmental cleaning, biological pest control, and biotechnology. They are also used in medicine and research.

2. What is meant by 'Recyclers of Nature' in relation to bacteria?

Ans. Bacteria are termed "recyclers of nature" because they participate in all major biogeochemical cycles. Nitrifying bacteria like *Nitrosomonas*, *Nitrobacter*, and *Azotobacter* help in the nitrogen cycle, while *Pseudomonas* performs denitrification. Decomposer bacteria break down dead organic matter, playing a crucial role in the carbon-hydrogen-oxygen cycle. Photosynthetic bacteria like cyanobacteria contribute to increasing atmospheric oxygen.

3. How do bacteria help in the production of useful products?

Ans. Bacteria, such as *Lactobacillus*, in combination with yeasts and molds, are used in the fermentation of foods like cheese, pickles, soy sauce, vinegar, wine, and yogurt. In the pharmaceutical and agrochemical industries, bacteria help produce antibiotics and other chemicals. They are also used in treating animal skins for leather production.

4. What is the role of bacteria in environmental cleaning?

Ans. Bacteria help in bioremediation, the removal or degradation of environmental pollutants. They can decompose city sewage, digest petroleum hydrocarbons to clean oil spills, and break down industrial toxic wastes into harmless products.

5. How are bacteria used as biopesticides?

Ans. Certain bacteria, like *Bacillus thuringiensis*, are used in biological pest control as biopesticides. These are environmentally friendly alternatives to chemical pesticides and are safe for humans, wildlife, pollinators, and beneficial insects.

6. Why are bacteria considered useful tools in research and technology?

Ans. Bacteria grow rapidly and can be easily manipulated, making them ideal for use in molecular biology, genetics, and biochemistry. Scientists alter bacterial DNA to study gene and enzyme functions. Human genes can be inserted into bacteria to produce therapeutic proteins like insulin, growth hormones, and antibodies.

2.7 NORMAL FLORA

Q 14. Define the term normal flora. State the benefits which we get from normal bacterial flora.

Ans. Definition:

The normal flora refers to the community of microorganisms that naturally inhabit the surface tissues of the human body, such as the skin and mucous membranes. These microorganisms, particularly bacteria, play a crucial role in maintaining human health by offering various benefits to the host.

Composition of Normal Flora

Normal flora consists mainly of bacteria, though it may also include some fungi, protists, and methanogenic archaea. These microorganisms typically colonize areas like the skin, eyes, mouth, nose, and gastrointestinal tract, providing a protective and beneficial function.

Benefits to the Human Body

The relationship between humans and their normal flora is mutualistic, meaning both the body and the microorganisms benefit from this association.

1. Synthesis of Vitamins
2. Certain bacteria in the alimentary canal, such as enteric bacteria and lactic acid bacteria, produce vitamins like Vitamin K, Vitamin B12, and other B-vitamins. These vitamins are excreted by the bacteria in excess of their needs and are absorbed by the human body, contributing to its nutritional requirements.
3. Prevention of Pathogen Colonization
4. Normal flora acts as a barrier to harmful pathogens. The bacteria on the skin and in the gastrointestinal tract compete with pathogens for attachment sites and nutrients. This competition prevents pathogens from gaining a foothold, reducing the likelihood of infection.
5. Inhibition or Killing of Pathogens
6. Intestinal bacteria produce substances, such as antimicrobial peptides, that inhibit or kill pathogenic bacteria. By doing so, they contribute to the body's natural defense mechanisms, preventing infection and maintaining a healthy microbial balance.
7. Immune System Stimulation
8. Normal flora also helps in stimulating the body's immune system. These bacteria act as antigens, triggering the production of low levels of antibodies. These antibodies can cross-react with certain pathogens, offering protection against infections by preventing pathogen invasion or reducing its severity.

Normal Flora as a Defense Mechanism

Normal flora is instrumental in maintaining the body's overall health and preventing infections. Their presence and activities help ensure the body's internal balance, protect against harmful microorganisms, and promote the synthesis of essential nutrients.

15. How do bacteria contribute to the nitrogen cycle? Explain the roles of nitrifying and denitrifying bacteria.

Ans. (a) Role of Bacteria in Nitrogen Cycle

Bacteria play a critical role in the nitrogen cycle, which is essential for converting nitrogen into forms that are usable by plants and animals. Nitrifying bacteria and denitrifying bacteria are two important groups that facilitate key steps in this cycle.

Nitrifying Bacteria

Nitrifying bacteria are responsible for converting ammonia into nitrites and then into nitrates, which are forms of nitrogen that plants can absorb and utilize. Examples of nitrifying bacteria include *Nitrosomonas*, which converts ammonia (NH_3) to nitrite (NO_2^-), and *Nitrobacter*, which converts nitrites to nitrates (NO_3^-). *Azotobacter* also contributes to the fixation of atmospheric nitrogen into usable forms.

Denitrifying Bacteria

Denitrifying bacteria, such as *Pseudomonas*, perform the opposite role by converting nitrates (NO_3^-) into nitrogen gas (N_2), which is released back into the atmosphere. This process completes the nitrogen cycle and helps maintain the balance of nitrogen in the environment.

(b) The Role in Ecosystem Sustainability

Through their actions in the nitrogen cycle, bacteria ensure that nitrogen, an essential element for all living organisms, is continuously recycled and made available in usable forms. Without the work of nitrifying and denitrifying bacteria, nitrogen would become limited, affecting plant growth and, consequently, the entire food chain.

16. Describe the process of bioremediation and explain how bacteria contribute to cleaning up the environment.

Ans. Bioremediation is a process that uses microorganisms, primarily bacteria, to degrade or remove pollutants from the environment, making them less harmful or completely non-toxic. This process is an eco-friendly method to clean up environmental contaminants, including organic pollutants, heavy metals, and toxic chemicals.

Bacterial Role in Bioremediation

Bacteria are highly efficient at breaking down a wide variety of organic compounds, including hydrocarbons from oil spills, sewage, and industrial waste. Some bacteria can digest petroleum products, which are difficult to break down, and convert them into simpler, less toxic substances. These bacteria can be used in cleaning up oil spills, making them an important tool in environmental conservation.

Application in Sewage Treatment

Bacteria are used in wastewater treatment plants to decompose organic matter in city sewage. By breaking down waste materials, bacteria help transform sewage into harmless products like water and gases, thus preventing pollution of water bodies and ensuring the sustainability of ecosystems.

Cleaning Toxic Industrial Waste

Certain bacteria can detoxify industrial waste products, including heavy metals and chemicals, by breaking them down into non-toxic compounds. This makes bacteria essential in mitigating the harmful effects of industrial pollution.

Bioremediation in Oil Spill Cleanups

In the case of oil spills, bacteria that consume petroleum hydrocarbons are deployed to the affected areas. These bacteria help digest the oil, reducing its environmental impact and restoring affected ecosystems.

MCQs

1. **What role do normal flora bacteria play in preventing pathogen colonization?**
   A) They produce toxins that kill pathogens
   B) They compete for attachment sites and nutrients ✓
   C) They synthesize vitamins only
   D) They stimulate the production of antibodies

2. **Which of the following vitamins are produced by bacteria in the human body?**
   A) Vitamin C and Vitamin E
   B) Vitamin A and Vitamin D
   C) Vitamin K and Vitamin B12 ✓
   D) Vitamin B1 and Vitamin B3

3. **What is the main benefit of normal flora bacteria to humans?**
   A) They help produce energy
   B) They synthesize essential vitamins ✓
   C) They clean up oil spills
   D) They increase carbon dioxide levels in the body

4. **What does the term "normal flora" refer to?**
   A) Harmful bacteria
   B) The community of microorganisms living in the human body ✓
   C) Bacteria that cause diseases
   D) Bacteria used in pharmaceutical industries

5. **Which bacterium is commonly used as a biopesticide in agriculture?**
   A) Bacillus thuringiensis ✓
   B) Nitrosomonas
   C) Azotobacter
   D) Pseudomonas

6. **What is the process called when bacteria degrade harmful pollutants in the environment?**
   A) Bioremediation ✓
   B) Photosynthesis
   C) Nitrogen fixation
   D) Fermentation

7. **Which of the following is a function of the bacteria in the human intestine?**
   A) Produce antibiotics
   B) Kill pathogens directly
   C) Synthesize vitamins ✓
   D) Stimulate the immune response

8. **How do normal flora bacteria contribute to immunity in humans?**
   A) They inhibit the growth of all bacteria
   B) They produce substances that kill all pathogens
   C) They stimulate the production of cross-reactive antibodies ✓
   D) They prevent all forms of infection

9. **Which of the following bacteria is involved in the production of fermented foods?**
   A) Lactobacillus ✓
   B) Bacillus thuringiensis
   C) Azotobacter
   D) Pseudomonas

10. **Which bacteria are involved in the decomposition of dead organic matter?**
    A) Decomposer bacteria ✓
    B) Nitrifying bacteria
    C) Photosynthetic bacteria
    D) Denitrifying bacteria

11. **What is the role of bacteria in the carbon-hydrogen-oxygen cycle?**
    A) They increase oxygen levels in the atmosphere
    B) They decompose dead organic matter ✓
    C) They fix nitrogen into usable forms
    D) They synthesize oxygen

12. **Which of the following bacteria is involved in the nitrogen cycle and converts nitrogen gas into ammonia?**
    A) Azotobacter ✓
    B) Pseudomonas
    C) Nitrobacter
    D) Bacillus thuringiensis

13. **How do bacteria help in the preparation of leather goods?**
    A) They digest the skin to remove contaminants ✓
    B) They ferment the skin into a usable material
    C) They are involved in tanning processes
    D) They produce enzymes that soften the leather

14. **Which type of bacteria is used to break down petroleum products in oil spills?**
    A) Denitrifying bacteria
    B) Petroleum-degrading bacteria ✓
    C) Nitrifying bacteria
    D) Photosynthetic bacteria

15. **What type of bacteria are used in the creation of biopesticides?**
    A) Gram-positive soil-dwelling bacteria ✓
    B) Antibiotic-producing bacteria
    C) Nitrogen-fixing bacteria
    D) Photosynthetic bacteria

SQ

1. **What is meant by 'normal flora' in the human body?**

Ans. Normal flora refers to the community of microorganisms regularly found on the surface tissues of the human body, such as skin and mucous membranes. Internal tissues like blood and brain are usually free of microbes. Normal flora includes bacteria, a few fungi and protists, and some methanogenic archae with bacteria being the most prominent.

2. **What are the benefits of bacterial flora in the human body?**

Ans. The benefits of bacterial flora include:

1. Synthesis of vitamins: Bacteria in the alimentary canal produce and excrete excess vitamins like Vitamin K, Vitamin B12, and certain B-vitamins, which are absorbed by the body.

2. **Preventing colonization by pathogens:** Normal flora compete with pathogens for nutrients and attachment sites, reducing infection chances.

3. **Inhibiting or killing pathogens:** Intestinal bacteria produce substances that can kill or inhibit harmful bacteria.

4. **Stimulating cross-reactive antibodies:** Normal flora acts as antigens, triggering an immune response. The antibodies produced can cross-react with and protect against pathogens.

3. **Which bacteria help in the nitrogen cycle and what is their role?**

Ans. *Nitrosomonas*, *Nitrobacter*, and *Azotobacter* are nitrifying bacteria that convert nitrogen compounds into usable forms in the nitrogen cycle. *Pseudomonas* is a denitrifying bacterium that helps complete the nitrogen cycle by converting nitrates back into nitrogen gas.

4. **Give examples of foods and products made with the help of bacteria.**

Ans. Foods like cheese, yogurt, soy sauce, pickles, vinegar, and wine are made using bacteria such as *Lactobacillus*. Bacteria also help in producing antibiotics, pharmaceutical chemicals, and are used in preparing animal hides for leather products.

5. **What is bioremediation, and how do bacteria contribute to it?**

Ans. Bioremediation is the process of using organisms to remove pollutants from the environment. Bacteria contribute by decomposing city sewage, digesting hydrocarbons in oil spills, and breaking down toxic industrial wastes into harmless substances.

6. **Describe the bacterium Bacillus thuringiensis and its importance.**

Ans. *Bacillus thuringiensis* is a Gram-positive, soil-dwelling bacterium used as a biopesticide. It controls pests biologically without harming humans, wildlife, or beneficial insects, making it an environmentally friendly pest control method.

7. **How do bacteria assist in biotechnology and genetic engineering?**

Ans. Bacteria are used in genetic engineering because they grow quickly and are easy to manipulate. Scientists insert human genes into bacteria to produce therapeutic proteins like insulin and antibodies, and use bacteria to study gene and enzyme functions.

8. **What kind of relationship exists between humans and their normal flora?**

Ans. The relationship between humans and their normal flora is mutualistic. Bacteria benefit by receiving nutrients, stable temperature, protection, and transport. In return, they provide the host with vitamins, immune stimulation, and protection against pathogens.

9. **How do enteric and lactic acid bacteria benefit the human body?**

Ans. Enteric bacteria secrete vitamins like Vitamin K and B12, while lactic acid bacteria produce other B-vitamins. These are absorbed by the body and contribute to human nutrition.

10. **What is the role of normal flora in immune system stimulation?**

Ans. Normal flora behaves like antigens, triggering the immune system to produce low levels of antibodies. These antibodies can cross-react with pathogens, providing protection against infections.

11. **Why do pathogens have fewer chances of invading tissues in presence of normal flora?**

Ans. Normal flora competes with pathogens for attachment sites and nutrients on surface tissues. This competitive exclusion makes it harder for pathogens to establish infections.

12. **What substances are produced by intestinal bacteria to combat pathogens?**

Ans. Intestinal bacteria produce various substances such as bacteriocins and acids that inhibit or kill pathogenic bacteria, contributing to the host's defense system.

13. **In what industrial process is bacterial treatment of animal skin used?**

Ans Bacteria are used in the commercial preparation of animal skins for making leather goods. They help in cleaning and softening the skins by breaking down unwanted materials.

14. **What type of bacteria is used for cleaning up oil spills and how?**

Ans. Certain bacteria can digest hydrocarbons found in petroleum. These bacteria are used in bioremediation to clean up oil spills by breaking down the oil into less harmful substances.

2.8 VIRUS

Q 17. What are viruses and how are they classified in terms of their structure?

Ans. Definition and Characteristics:

Viruses are extremely small infectious agents that lack cellular organization but exhibit characteristics of living organisms. They are only visible under an electron microscope due to their extremely small size, ranging from 20 nm to 250 nm, making them significantly smaller than most bacteria.

Herpes virus (causes cold sores,chickenpox etc.) contains 162capsomeres in its capsid.Adenovirus (causes common cold)contains 252 capsomeres in its

Basic Structure:

The structure of a virus consists of a central core containing nucleic acid, either DNA or RNA. Surrounding the nucleic acid is a protein coat called a **capsid**, made up of protein subunits called **capsomeres**.

Envelope and Shape:

In some viruses, particularly animal viruses, the nucleocapsid is further covered by a lipid-rich membrane known as an **envelope**, which is derived from the host cell. Non-enveloped viruses are referred to as **naked viruses**. Viruses also vary in their shape—animal and plant viruses are typically **polyhedral or helical**, whereas **bacteriophages** may have cubic, icosahedral, helical, or complex forms.

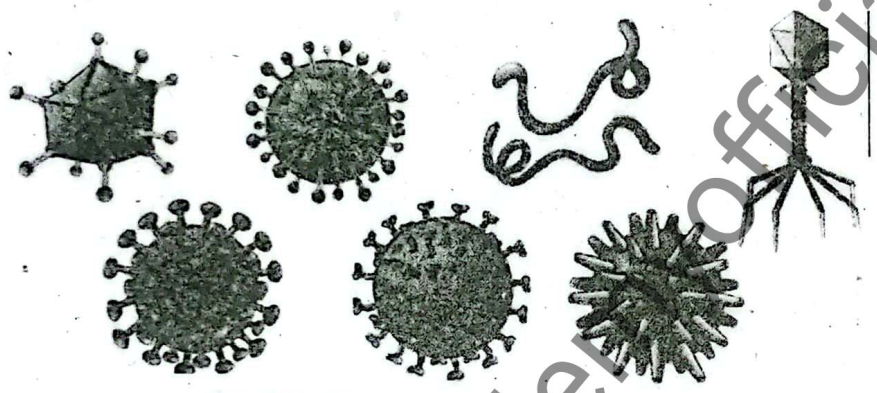


Fig. 2.10: Diversity in viruses' shapes

Bacteriophages are used as carriers in genetic engineering. The gene of interest is inserted into the DNA of bacteriophage, which carries it to thetarget bacterial cell. When virus incorporates its DNA into bacterial chromosome, the gene of interest also becomes a part of bacterial DNA. Such transgenic bacteria (transgenic: whose genome has DNA of some other organism) can be grown to get copies of the gene of interest and to get the required protein

Q 18. Explain the structure and function of bacteriophages.

OR Explain the structure of a model bacteriophage and HIV.

Ans. Definition:

Bacteriophages, or **phages**, are viruses that specifically infect bacteria and are among the most complex types of viruses.

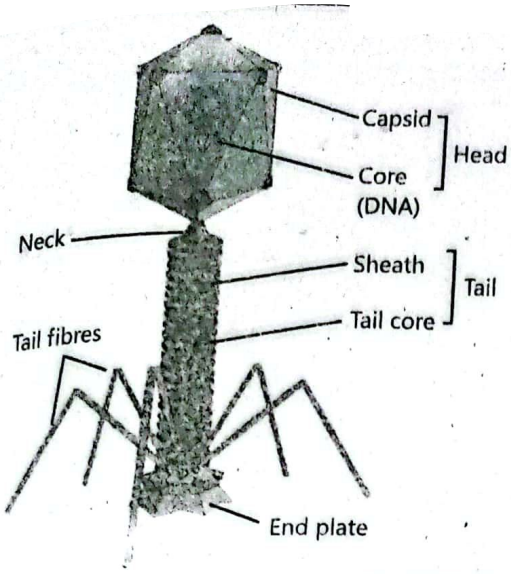
Structural Components:

A bacteriophage has a **head and a tail**.

The **head** is elongated pyramidal or hexagonal and is made of proteins, containing the viral genome (typically double-stranded DNA).

The **tail** includes an inner core and an outer sheath made from proteins.

A **neck** connects the head and sheath, while an **end plate** with **six tail fibers** at the base allows the phage to attach to bacterial cells.



Experts have concluded that HIV originated in the jungles of Africa among wild chimps. Evidence suggests that a form of this virus entered human species and became HIV by way of monkey bites or ingesting monkey meat and brains

Fig. 2.11: Structure of a bacteriophage (T4 phage)

Function:

The tail fibers enable the virus to attach to the bacterial wall and inject its genetic material, initiating infection. This structure is highly specialized for infecting bacterial cells.

19. Describe the structure of HIV and its role in causing AIDS.

Ans. Classification and Features:

HIV (Human Immunodeficiency Virus) is a **retrovirus**, characterized by its **RNA genome** and the enzyme **reverse transcriptase**.

Structure:

HIV has a **lipid-rich envelope** derived from the host cell membrane, embedded with **glycoprotein spikes** essential for binding to immune cells. Inside, it contains RNA and reverse transcriptase.

Mechanism of Action:

Upon entry into the host cell, reverse transcriptase converts viral RNA into **DNA**, which is then integrated into the host's genome. This allows the virus to replicate and eventually weaken the immune system, causing **AIDS (Acquired Immunodeficiency Syndrome)**.

Historical Context:

HIV was first reported in **1981** and identified as the cause of AIDS in **1984**. It is a **host-specific virus** that affects humans and certain primates (without causing AIDS in them).

20. How does HIV infect the human immune system and what makes it a host-specific virus?

Ans. Target Cells:

HIV specifically targets **CD4+ T cells**, key players in the immune response.

Infection Process:

The virus binds to the **CD4 receptor** using its glycoprotein spikes, enters the cell, and uses reverse transcriptase to convert its RNA into DNA. This DNA integrates into the host genome and begins producing new viruses.

Immune System Impact:

As HIV replicates, it **destroys CD4+ cells**, weakening the immune system and leading to AIDS.

Host Specificity:

While HIV can infect other primates, it only causes **AIDS in humans**, making it a **host-specific** virus adapted to target and harm human immune cells.

Q 21. What are the characteristics of retroviruses, and how do they differ from other types of viruses like bacteriophages?

Ans. Retroviruses (e.g., HIV):

- Contain **RNA** as genetic material
- Have **reverse transcriptase** to convert RNA into DNA
- Are **enveloped** viruses
- Infect **animal cells**, particularly immune cells
- Cause diseases such as **AIDS**

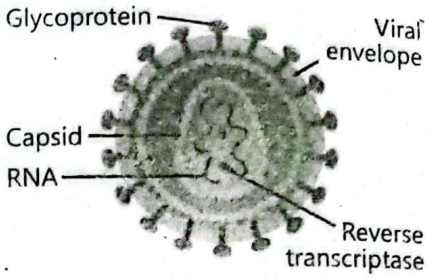


Fig. 2.12: Structure of HIV

Bacteriophages:

- Contain **DNA** as genetic material
- Lack reverse transcriptase
- Are **non-enveloped**
- Have a complex structure with **head and tail**
- Infect **bacteria** only

Summary of Differences:

The main difference lies in their **genetic material**, **replication method**, **target cells**, and **structural complexity**. Retroviruses use reverse transcription and infect human cells, while bacteriophages rely on direct DNA injection into bacteria.

MCQs

1. **What is the size range of viruses?**
   a) 10 nm to 500 nm b) 20 nm to 250 nm ✓
   c) 50 nm to 500 nm d) 100 nm to 1000 nm
2. **What is the central core of a virus made up of?**
   a) Protein b) RNA or DNA ✓
   c) Lipids d) Carbohydrates
3. **What is the protein coat of a virus called?**
   a) Capsid ✓ b) Envelope
   c) Nucleocapsid d) Ribosome
4. **What are the protein subunits that make up a virus's capsid called?**
   a) Capsomeres ✓ b) Enzymes
   c) Receptors d) Nucleotides
5. **Which of the following viruses have an envelope?**
   a) Naked viruses b) Animal viruses ✓
   c) Bacteriophages d) Plant viruses
6. **What are non-enveloped viruses also known as?**
   a) Naked viruses ✓ b) Protein viruses
   c) DNA viruses d) Retroviruses
7. **What is the shape of most animal and plant viruses?**
   a) Helical or polyhedral ✓ b) Rod-shaped
   c) Spherical d) Complex
8. **What type of viruses are bacteriophages?**
   a) Animal viruses b) Plant viruses
   c) Bacterial viruses ✓ d) Retroviruses
9. **Which structure of a bacteriophage helps it attach to bacterial cells?**
   a) Head b) Tail fibers ✓
   c) Envelope d) Nucleocapsid
10. **What is the core of a T4 bacteriophage made of?**
    a) RNA
    b) Double-stranded DNA ✓
    c) Protein d) Lipids
11. **What is the structure of the envelope in HIV composed of?**
    a) Proteins b) Nucleic acids
    c) Lipids and glycoproteins ✓
    d) Carbohydrates
12. **What enzyme is characteristic of retroviruses like HIV?**
    a) Polymerase b) Reverse transcriptase ✓
    c) Ligase d) RNA polymerase
13. **What is the primary target of HIV in the human body?**
    a) Liver cells b) Red blood cells
    c) CD4+ T cells ✓ d) Muscle cells
14. **How does HIV replicate inside host cells?**
    a) By transcription of its RNA
    b) By reverse transcription of RNA into DNA ✓
    c) By splitting the host cell into two
    d) By using host DNA directly
15. **What is the disease caused by HIV?**
    a) Influenza b) AIDS ✓
    c) Hepatitis d) Tuberculosis
16. **What distinguishes retroviruses from other viruses?**
    a) They have RNA genomes and reverse transcriptase ✓
    b) They do not have a capsid
    c) They do not infect humans
    d) They replicate through a process called transcription
17. **What is the main function of the glycoprotein spikes on the HIV envelope?**
    a) Replication of the virus
    b) To help the virus bind to host cells ✓
    c) To protect the viral genome
    d) To replicate the viral RNA
18. **What is the main structural difference between enveloped and non-enveloped viruses?**

a) Enveloped viruses have a protein coat; non-enveloped do not
b) Enveloped viruses have a lipid membrane; non-enveloped do not ✓
c) Non-enveloped viruses are spherical in shape
d) Enveloped viruses have RNA as their genetic material

19. How are T4 bacteriophages typically structured?
a) Only a head
b) A head and a tail ✓
c) A spherical shape
d) Only an envelope

20. When was HIV first identified as the cause of AIDS?
a) 1975
b) 1981
c) 1984 ✓
d) 1986

SQ

1. What are viruses?

Ans. Viruses are extremely small infectious agents that do not possess cellular organization but show characteristics of living organisms. They can only be seen under an electron microscope and are much smaller than most bacteria.

2. What is the structure of a virus?

Ans. A virus consists of a central core containing nucleic acid (either DNA or RNA), surrounded by a protein coat called a capsid. The capsid is made up of protein subunits called capsomeres. In some animal viruses, the nucleocapsid is covered by an envelope, a lipid-rich membrane derived from the host cell.

3. What is the function of the capsid in a virus?

Ans. The capsid gives a definite shape to the virus and protects the nucleic acid inside. It is made up of protein subunits known as capsomeres.

4. What are naked viruses?

Ans. Naked viruses are viruses that do not have an envelope. They only consist of the nucleocapsid, which is the combination of the central core and the protein capsid.

5. What is the structure of bacteriophages?

Ans. Bacteriophages are viruses that attack bacteria. They have a complex structure with a head and a tail. The head is typically hexagonal or pyramidal in shape and contains a protein capsid surrounding a long strand of double-stranded DNA. The tail is made up of an inner core and an outer sheath and helps the phage attach to the bacterial wall through tail fibers.

6. What is the function of tail fibers in a bacteriophage?

Ans. The tail fibers of a bacteriophage help the virus attach to the bacterial wall, enabling the virus to infect the bacteria.

7. What is the structure of HIV?

Ans. Human Immunodeficiency Virus (HIV) is a retrovirus that contains RNA as its genetic material. It is surrounded by a lipid-rich envelope with glycoprotein spikes. The virus has a spherical form and is about 100 nm in diameter. It also contains the enzyme reverse transcriptase, which plays a crucial role in the virus's replication process.

8. What is the significance of reverse transcriptase in HIV?

Ans. Reverse transcriptase is an enzyme found in retroviruses like HIV. It catalyzes the process of reverse transcription, where a single-stranded RNA is transcribed into DNA. This DNA is then used to form a double helix, allowing the virus to replicate.

9. What disease does HIV cause?

Ans. HIV causes Acquired Immunodeficiency Syndrome (AIDS), a disease that weakens the immune system, making the patient susceptible to other infections. AIDS is fatal without a functioning immune system.

10. When was AIDS first reported and in which group of patients?

Ans. AIDS was first reported in 1981, and initially, it was found in homosexual patients. Later, it was discovered in non-homosexual patients who had received blood or blood products from AIDS patients.

11. What year was HIV identified as the cause of AIDS?

Ans. HIV was identified as the cause of AIDS in 1984. The virus responsible for the disease was later named Human Immunodeficiency Virus (HIV) in 1986.

12. Can HIV infect monkeys?

Ans. Yes, HIV can multiply in monkeys but does not cause AIDS in them. HIV is a host-specific virus, meaning it primarily affects humans.

SOLVED EXERCISE

MULTIPLE CHOICE QUESTIONS

Tick (✓) the correct answer.

1. **Which of the following component is not found in all kinds of bacteria?**
   (a) Ribosomes (b) Cellmembrane (c)Nucleoid (d) Capsule✓
2. **The bacterial chromosome is typically:**
   (a)Linear,double-strandedDNA (b) Circular, single-strandedRNA
   (c) Circular,double-strandedDNA✓ (d)Linear, single-strandedDNA
3. **In bacterial cells,respiration occurs at:**
   (a)Mitochondria (b) Cell membrane✓ (c) Ribosomes (d)Endoplasmicreticulum
4. **Which group of bacteria is known as a good source of antibiotics?**
   (a)Omnibacteria (b) Spirochaetes(c)Pseudomonads (d) Actinomycetes✓
5. **What is the primary function of flagella in bacterial cells?**
   (a)DNA replication (b) Cell division (c)Motility✓ (d) Proteinsynthesis
6. **Which typeof motility in bacteria is mediated by pili?**
   (a) Brownianmovement (b) Glidingmotility (c) Twitchingmotility✓ (d) Swarmingmotility
7. **Which of the following bacterial structures is responsible for detecting and responding to chemicals?**
   (a) Capsule (b) Pili✓ (b) Flagella (d) Ribosomes
8. **Which one of the following are not Nitrifying bacteria?**
   (a) Nitrosomonas (b) Nitrobacter (c) Azotobacter✓ (d) Pseudomonas
9. **The enzyme responsible for converting HIVRNA into DNA is:**
   (a) RNApolymerase (b) Reverse transcriptase✓ (c) DNÀhelicase (d) Integrase
10. **The HIV capsid contains:**
    (a) Single-strandedDNAand reverse transcriptase (b) Single-strandedRNAandreverse transcriptase✓
    (c) Double-strandedDNAandintegrase (d) Double-strandedRNAandRNApolymerase

SHORT ANSWER QUESTIONS

1. **Write about the structural components of a bacterial cell wall and their arrangement.**

Ans. See short question 1 from Short Questions and Answers Section 2.1

2. **Write the composition of the peptidoglycan layer in bacterial cell walls.**

Ans. See sort question 2 from Short Questions and Answers Section 2.1

3. **What are mesosomes? What are their functions?**

Ans. See short question 8 from Short Questions and Answers Section 2.1

4. **How can plasmids be used in genetic engineering?**

Ans. Plasmids are small, circular DNA molecules that can be used as vectors to transfer genes into host cells. In genetic engineering, scientists insert a gene of interest into a plasmid and then introduce it into bacteria to produce proteins or replicate the gene.

5. **Define sporulation.**

Ans. Sporulation is the process by which certain bacteria form endospores to survive in harsh environmental conditions. It involves a series of complex steps that lead to the formation of a highly resistant, dormant cell.

6. **What is the function of the bacterial capsule?**

Ans. The bacterial capsule provides protection against phagocytosis by host immune cells. It also helps bacteria adhere to surfaces and form biofilms.

7. **Write the role of pili in bacterial cells. How do they differ from flagella?**

Ans. Pili are hair-like structures that help bacteria attach to surfaces and exchange genetic material during conjugation. Unlike flagella, which are used for motility, pili are mainly involved in adhesion and genetic exchange.

8. **What are plasmids, and how do they contribute to enabling bacteria to resist unfavourable conditions?**

Ans. Plasmids are extra-chromosomal DNA molecules found in bacteria that carry genes for traits like antibiotic resistance. These genes help bacteria survive in hostile environments, such as in the presence of antibiotics.

9. **Write about the role of endospores in bacterial survival.**

Ans. Endospores are highly resistant structures formed by some bacteria to withstand extreme conditions like heat, radiation, and desiccation. They allow the bacterial cell to remain dormant until favorable conditions return.

10. **What is the significance of lipopolysaccharides and lipoproteins in Gram-negative bacteria?**

Ans. Lipopolysaccharides (LPS) in the outer membrane of Gram-negative bacteria act as endotoxins and contribute to structural integrity. Lipoproteins help anchor the outer membrane to the peptidoglycan layer, maintaining cell envelope stability.

11. **How do spirochetes achieve motility?**

Ans. Spirochetes move by using axial filaments, also called endoflagella, which are located between their cell membrane and outer sheath. These filaments rotate, causing the entire cell to twist in a corkscrew motion for movement.

12. **Differentiate between twitching and gliding movements in bacterial motility.**

Ans. Twitching motility is a jerky movement on surfaces caused by the extension and retraction of type IV pili. Gliding motility is a smooth, continuous movement without the use of flagella or pili, often involving surface adhesion and slime secretion.

13. **How do bacteria without flagella achieve motility?**

Ans. Bacteria without flagella may move using pili in twitching motility or through gliding mechanisms involving surface proteins and slime layers. Some also use changes in cell shape or surface tension to move across surfaces.

14. **What is the difference between swimming motility and swarming motility in bacteria?**

Ans. Swimming motility occurs in liquid environments and involves individual bacteria using flagella to move. Swarming motility occurs on solid surfaces and involves coordinated movement of bacterial groups, often forming wave-like patterns.

LONG QUESTIONS

Q1. Compare and contrast the cell wall of Gram-positive and Gram-negative bacteria.

Ans. See Long Question number 3.

Q2. Explain different methods of movement in bacteria.

Ans. See Long Question number 8.

Q3. Explain the structure of bacterium flagellum.

Ans. See Long Question number 10.

Q4. State the formation of endospore in bacteria.

Ans. See Long Question number 7.

Q5. Briefly describe the ecological and economic importance of bacteria.

Ans. See Long Question number 13.Q

Q6. Explain the use of bacteria in research and technology.

Ans. See Long Question number 13.

Q7. Define the term normal flora. State the benefits which we get from normal bacterial flora.

Ans. See Long Question number 14.

Q8. Explain the structure of a model bacteriophage and HIV.

Ans. See Long Question number 18.

INQUISITIVE QUESTIONS

1. **Why do bacteria have ribosomes even though they do not have membrane-bound organelles?**

Ans. Bacteria lack membrane-bound organelles like the nucleus, mitochondria, or endoplasmic reticulum, but they still require ribosomes because protein synthesis is essential for all forms of life. Ribosomes are not membrane-bound structures; instead, they are macromolecular complexes made of rRNA and proteins that float freely in the cytoplasm.

In bacteria, ribosomes play a crucial role in translating genetic information from messenger RNA (mRNA) into functional proteins, which are needed for growth, metabolism, and cellular processes. Despite their simplicity, bacterial ribosomes are highly efficient and adapted to function in the absence of compartmentalization found in eukaryotic cells.

2. If bacteria do not have mitochondria, how do they generate energy for survival?

Ans. Bacteria generate energy through cellular respiration and fermentation processes that take place in the cytoplasm and across the cell membrane. The bacterial cell membrane functions similarly to the mitochondrial membrane, where enzymes involved in the electron transport chain are located. This allows bacteria to produce ATP, the energy currency of the cell, without the need for mitochondria.

3. Why do certain bacteria exhibit twitching motility using pili instead of flagella?

Ans. Some bacteria use pili for twitching motility because it allows them to move across solid surfaces where flagella-based swimming would not be effective. Type IV pili extend and then retract, pulling the cell forward in a jerky motion. This form of movement is especially useful in biofilm formation and surface colonization.

4. Give reasons in favour of the statement "Prevention is better than cure" and present your arguments in the class.

Ans. Prevention helps avoid the occurrence of diseases and is often more cost-effective than treating an illness after it occurs. It reduces the burden on healthcare systems and improves the overall quality of life. Vaccination, hygiene, and healthy lifestyle choices are examples of preventive measures that can stop diseases before they start.

5. Correlate the social and cultural values of a country with the prevalence of AIDS.

Ans. Social and cultural values, such as openness about sexual health, education, and stigma around HIV, significantly influence the prevalence of AIDS in a country. In societies where awareness and safe practices are promoted, the spread of AIDS tends to be lower. Conversely, in cultures where discussing sexual health is taboo or lack of education and fear of discrimination may lead to higher transmission rates.

Self-Assessment Unit 2

Max. Marks: 28 **Time allowed 60 Mins**

Q1. Each of the following question has four options. Select the correct answer. (10x1=10)

1. **Which of the following component is not found in all kinds of bacteria?**
   (a) Ribosomes (b) Cell membrane (c) Nucleoid (d) Capsule
2. **The bacterial chromosome is typically:**
   (a) Linear, double-stranded DNA (b) Circular, single-stranded RNA
   (c) Circular, double-stranded DNA (d) Linear, single-stranded DNA
3. **In bacterial cells, respiration occurs at:**
   (a) Mitochondria (b) Cell membrane (c) Ribosomes (d) Endoplasmic reticulum
4. **Which group of bacteria is known as a good source of antibiotics?**
   (a) Omnibacteria (b) Spirochaetes (c) Pseudomonads (d) Actinomycetes
5. **What is the primary function of flagella in bacterial cells?**
   (a) DNA replication (b) Cell division (c) Motility (d) Protein synthesis
6. **Which type of motility in bacteria is mediated by pili?**
   (a) Brownian movement (b) Gliding motility (c) Twitching motility (d) Swarming motility
7. **Which of the following bacterial structures is responsible for detecting and responding to chemicals?**
   (a) Capsule (b) Pili (b) Flagella (d) Ribosomes
8. **Which one of the following are not Nitrifying bacteria?**
   (a) Nitrosomonas (b) Nitrobacter (c) Azotobacter (d) Pseudomonas
9. **The enzyme responsible for converting HIV RNA into DNA is:**
   (a) RNA polymerase (b) Reverse transcriptase (c) DNA helicase (d) Integrase
10. **The HIV capsid contains:**
    (a) Single-stranded DNA and reverse transcriptase (b) Single-stranded RNA and reverse transcriptase
    (c) Double-stranded DNA and integrase (d) Double-stranded RNA and RNA polymerase

Q2. Write short answers to the following questions. **(5x2=10)**

1. Write about the structural components of a bacterial cell wall and their arrangement.
2. What are mesosomes? What are their functions?
3. Define sporulation.
4. Write the role of pili in bacterial cells. How do they differ from flagella?
5. What is the function of the bacterial capsule?

Q3. Write detailed answer to the following question. **(4+4=8)**

1. Compare and contrast the cell wall of Gram-positive and Gram-negative bacteria.
2. Explain different methods of movement in bacteria.