Unit 2: Bacteria and Viruses

Short Questions - Complete Answers

Short Question Answers (Exercise)

Q1. Write about the structural parts of a bacterial cell wall and how they are arranged.

The bacterial cell wall is a stiff (rigid) covering around the plasma membrane. Its main building block is a special large molecule called peptidoglycan (also known as murein). It is made of long sugar-chain strands (glycan), cross-linked together by short chains of amino acids (peptides). The amount of peptidoglycan varies between different bacteria. The wall also contains fats (lipids), which are attached to the peptidoglycan.

Q2. Write the makeup of the peptidoglycan layer in bacterial cell walls.

The makeup of the cell wall is quite different in Gram-positive and Gram-negative bacteria.

- Gram-positive bacteria have a thick layer of peptidoglycan and a smaller amount of fat (lipid).
- Gram-negative bacteria have a thin layer of peptidoglycan and a larger amount of fat (lipid).

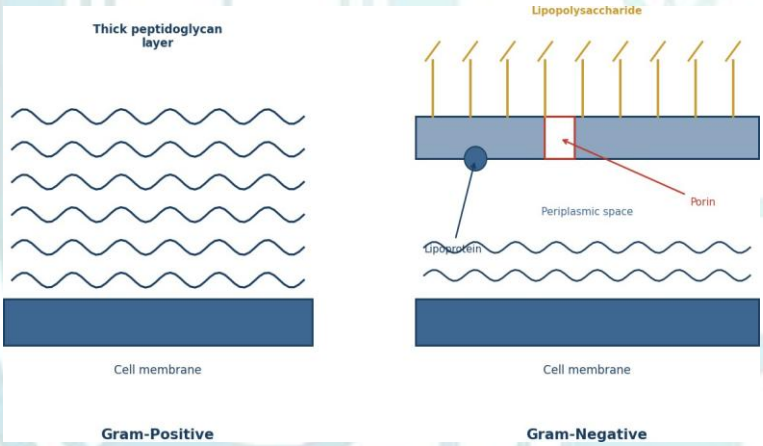

Fig: Cell wall makeup of Gram-positive and Gram-negative bacteria

Q3. What are mesosomes? What do they do?

At certain points in bacteria, the cell membrane folds inward and forms pouches, tubes, or sheet-like structures in the cytoplasm. These folded structures are called mesosomes. They take part in copying DNA and in cell splitting (division), and they also act as centres for breathing (respiration).

Q4. How can plasmids be used in genetic engineering?

Plasmids act as important carriers (vectors) in genetic engineering. They are used to carry chosen genes into bacteria, either to make copies of the gene or to produce specific proteins. Scientists also insert human genes into bacteria to make useful medical proteins, such as insulin, growth hormones, or antibodies.

Q5. Define sporulation.

The process by which bacteria form spores (endospores) is called sporulation. An endospore stays inactive (dormant) until good conditions return. When conditions become favourable again, the endospore sprouts (germinates) to form a new, active, growing cell.

Q6. What is the job of the bacterial capsule?

Some bacteria make a capsule outside their cell wall. It is a jelly-like (gelatinous) layer that gives bacterial colonies a sticky quality. It protects the bacteria from being eaten by immune cells (phagocytosis), stops them from drying out, and helps them stick to surfaces.

Q7. Write the role of pili in bacterial cells. How do they differ from flagella?

Some bacteria have pili (singular: pilus). These are straight, thread-like extensions that are smaller and thinner than flagella.

- Pili are used to attach bacteria to different surfaces.
- They also play a part in the mating process (conjugation), where cells swap genetic material. Flagella, on the other hand, allow bacteria to move around, sense chemical signals, and respond to them.

Q8. What are plasmids, and how do they help bacteria resist unfavourable conditions?

Some bacteria contain circular, double-stranded pieces of extra (non-chromosomal) DNA, called plasmids. They can copy themselves and may replicate before or after the cell divides. They carry genes that give bacteria the ability to resist harsh or unfavourable conditions, such as antibiotics.

Q9. Write about the role of endospores in bacterial survival.

Many bacteria can survive long stretches of harsh conditions by forming special "resting" cells, called endospores. Endospores have thick walls and are metabolically inactive (dormant). The process of forming endospores is called sporulation. An endospore stays inactive until good conditions return, then it sprouts (germinates) into a new, active cell.

Q10. What is the importance of lipopolysaccharides and lipoproteins in Gram-negative bacteria?

The cell wall of Gram-negative bacteria has an extra outer layer (membrane) made of lipopolysaccharides and lipoproteins. This outer membrane makes Gram-negative bacteria resistant to many antibiotics. It contains a protein called porin, which acts like a tiny channel that lets certain molecules pass through.

Q11. How do spirochetes achieve movement?

Spirochaetes have a changed (modified) flagellum, known as the axial filament. It is anchored at one end and runs lengthwise through the periplasmic space (the gap between the cell membrane and outer membrane). It is made of two sets of flagella-like threads (fibrils), anchored at the two ends of the cell. It helps spirochaetes bend, swim, creep, and spin.

Q12. Tell apart twitching and gliding movements in bacterial motility.

Twitching	Gliding
A type of movement that lets bacteria move over surfaces	Similar to twitching.
Driven by pili, which grip the nearby solid surface and pull the bacterial cell forward	Pulling (retracting) and releasing the bacterial cell walls them glide smoothly

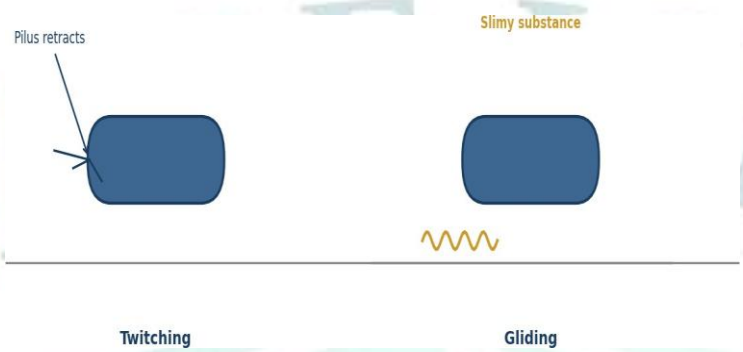

Fig: Twitching (pilus retraction) vs. gliding (slime trail)

Q13. How do bacteria without flagella manage to move?

Some bacteria (e.g., Streptococcus) that lack flagella or pili move because of the random, uncontrolled jostling of particles in the surrounding fluid. This is called Brownian movement.

Q14. What is the difference between swimming motility and swarming motility in bacteria?

Swimming Motility	Swarming Motility
The movement of individual bacteria in a liquid setting	They swim using their flagella in a coordinated manner to move across a solid surface as a group.

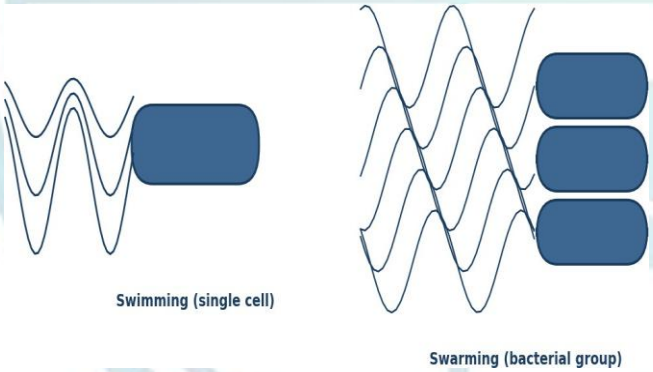

Fig: Swimming (single cell) vs. swarming (group movement)

SLO Based Short Question Answers

Structure of Bacteria

Q15. Discuss the recent classification status of bacteria.

Under the five-kingdom system, proposed by Robert Whittaker, all prokaryotes (organisms without a nucleus) were placed in one separate kingdom, called Monera. But over the last decade, gene studies have shown clear weaknesses in the five-kingdom system. Most biologists now favour replacing it with a newer system, called the three-domain system, which lines up better with the data gained from molecular studies. In this newer system, bacteria are given their own domain - domain Bacteria.

Q16. What is the periplasmic space? How does it differ in various bacteria?

The gap between the peptidoglycan layer and the cell membrane of bacteria is called the periplasmic space. Gram-negative bacteria have a larger periplasmic space than Gram-positive bacteria.

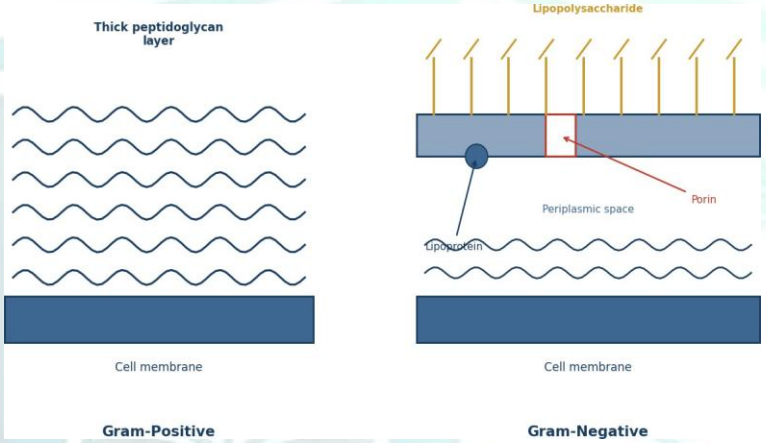

Fig: Cell wall makeup of Gram-positive and Gram-negative bacteria

Q17. Why are Mycoplasmas and Spiroplasmas resistant to penicillin?

Penicillin is an antibiotic that works by blocking cell-wall growth in bacteria. There are two groups of bacteria that lack a cell wall altogether - Mycoplasmas and Spiroplasmas. Because they have no cell wall, their outer covering is just a membrane, which is why they are resistant to penicillin.

Q18. How is the cell membrane and cytoplasm of bacteria different from those of eukaryotes?

Cell Membrane of Bacteria

The bacterial cell membrane does not contain sterols (i.e., cholesterol) in its make-up, while eukaryotic cell membranes do have cholesterol in their lipid layer.

Cytoplasm of Bacteria

A bacterial cell lacks an internal skeleton (cytoskeleton), membrane-bound compartments (organelles), and a nucleus in its cytoplasm. The only structure they have is the ribosome, but these are smaller than eukaryotic ribosomes. Eukaryotic cytoplasm, by contrast, contains a cytoskeleton, membrane-bound organelles, and a nucleus.

Bacteria, Ecology and Diversity

Q19. For how long have bacteria and archaea been living on Earth? Where are they found?

Fossil records show that prokaryotes - archaea and bacteria - were plentiful 3.5 billion years ago. They evolved and remained alone on Earth for the next 2 billion years. Today, prokaryotes (archaea and bacteria) are found

wherever there is life. Bacteria are found in water, air, soil, food, and in the bodies of animals and plants. They outnumber all eukaryotes and can survive in extreme habitats.

Q20. Name the major groups of domain Bacteria.

1. Omnibacteria
2. Cyanobacteria
3. Mycoplasmas and Spiroplasmas
4. Spirochetes
5. Pseudomonas
6. Actinomycetes
7. Nitrogen-fixing bacteria
8. Chemosynthetic bacteria

Q21. Describe the traits of Omnibacteria.

These are stiff, rod-shaped, heterotrophic (feeding on organic matter), Gram-negative bacteria. Many important disease-causing bacteria (pathogens) belong to this group. Most of them have flagella. They do not form spores. They are usually aerobic (need oxygen). Escherichia coli and vibrios are examples of such bacteria.

Q22. Briefly describe the main traits of Mycoplasmas and Spiroplasmas. How do they differ from other bacteria?

These two groups differ from all other bacteria in that they lack cell walls, making them the smallest bacteria known. Because they lack cell walls, they are also resistant to penicillin and other antibiotics that work by blocking cell-wall growth.

- Some Mycoplasmas cause diseases in mammals, e.g., certain kinds of pneumonia in humans.
- Spiroplasmas cause serious plant diseases, e.g., the deadly (lethal) yellowing disease of coconut palms.

Q23. Tell apart cyanobacteria and nitrogen-fixing bacteria.

Cyanobacteria	N2-Fixing Bacteria
These are photosynthetic bacteria. They contain chlor	Nitrogen-fixing bacteria live in soil and water and obtain nitrogen

Q24. Compare spirochetes with pseudomonas.

Spirochaetes	Pseudomonas
Spirochaetes are long, spiral-shaped (spirilla) bacteria	Pseudomonas are rod-shaped bacteria. They are Gram-negative and have a tuft of flagella.

Q25. How do chemosynthetic bacteria get energy to survive?

Chemosynthetic bacteria get energy by oxidizing (chemically breaking down) inorganic compounds of nitrogen, sulphur, and iron. They use this energy to build (synthesize) their own food. Nitrosomonas and Nitrobacter belong to this group. They break down nitrogen compounds (NH_3, ammonia) to gain energy. The ammonia is, in turn, changed into nitrite and then nitrate. This way, they play a vital part in the nitrogen cycle.

Q26. Name the group of bacteria that are disease-causing and also decomposers.

1. Omnibacteria
2. Spirochetes

3. Pseudomonas

Q27. Name the group of bacteria that fix nitrogen.

1. Cyanobacteria
2. Actinomycetes

Q28. Which bacteria cause the following diseases? (i) Leprosy (ii) Tuberculosis (iii) Syphilis (iv) Lethal yellowing disease of coconuts

- (i) Leprosy is caused by Mycobacterium leprae.
- (ii) Tuberculosis is caused by Mycobacterium tuberculosis.
- (iii) Syphilis is caused by Treponema pallidum.
- (iv) Lethal yellowing disease of coconuts is caused by Spiroplasmas.

Q29. Name the antibiotics that come from actinomycetes.

- Tetracycline
- Chloramphenicol
- Erythromycin
- Neomycin

Q30. Which bacteria play major roles in completing the nitrogen cycle?

Nitrifying Bacteria	Denitrifying Bacteria
Nitrosomonas	Pseudomonas
Nitrobacter	
Azotobacter	

Importance of Bacteria

Q31. Some bacteria are called "The makers of useful products." Justify this.

Many bacteria, e.g., Lactobacillus, working together with yeasts and moulds, have been used for thousands of years to prepare fermented foods such as cheese, pickles, soy sauce, vinegar, wine, and yogurt. In the drug-making (pharmaceutical) and farm-chemical (agrochemical) industries, bacteria are highly important for producing key chemicals. Some bacteria are used to make antibiotics. The commercial treatment of animal skins to make leather goods also relies on bacteria.

Q32. Describe the role of bacteria as environmental cleaners.

Many bacteria can break down organic matter with ease. Such bacteria are used to remove or break down pollutants - a process called bioremediation - from the environment.

- For example, bacteria are used to break down city sewage into harmless products.
- Some bacteria can digest the hydrocarbons found in petroleum. These bacteria are used to clean up oil spills.
- Bacteria are also used for the bioremediation of toxic industrial waste.

Q33. Which bacteria matter for biological pest control? / Justify the role of bacteria as biopesticides.

Bacteria are used in place of chemical pesticides for biological pest control. This commonly involves Bacillus thuringiensis, a Gram-positive, soil-dwelling bacterium. These biopesticides are eco-friendly and have little to no effect on humans, wildlife, pollinators, and most other helpful insects.

Q34. Which quality of bacteria makes them useful for biological research?

Bacteria grow quickly, and scientists can work with (manipulate) them very easily, e.g., Escherichia coli. Because of this, bacteria are used in the fields of molecular biology, genetics, and biochemistry.

- Scientists cause mutations in bacterial DNA and study the resulting changes in traits (characteristics).
- This way, they work out the job (function) of genes and enzymes in bacteria.
- This knowledge is then applied to study the same genes and enzymes in more complex organisms. Scientists also insert human genes into bacteria and produce medical proteins, e.g., insulin, growth hormones, or antibodies.

Normal Flora

Q35. Define normal flora. Which organisms make up humans' normal flora?

- The mix of organisms regularly found at any body location (anatomical site) is called the normal flora.
- In a healthy animal, the internal tissues - e.g., blood, brain, muscle - are usually free of microorganisms. On the other hand, the surface tissues - e.g., skin and mucous membranes - are constantly in touch with the environment and become home to (colonized by) certain microbial species.
- The normal flora of humans is made up of bacteria, a few fungi, protists, and some methane-making (methanogenic) archaea. Bacteria are the most common and obvious microbial part of the normal flora.

Q36. Comment: Humans and their normal flora have a mutually beneficial relationship.

The relationship between humans and their normal flora is mutually beneficial (mutualistic). In the human body, the normal flora gets nutrients, a stable setting, steady warmth, protection, and transport. In turn, the body also gets many benefits from the normal bacteria; for example:

1. Making (synthesis) of vitamins (Vitamin K, Vitamin B12)
2. Stopping colonization by disease-causers (pathogens)
3. Blocking or killing pathogens
4. Boosting the making of cross-reactive antibodies

Q37. Describe how normal flora boosts the making of cross-reactive antibodies.

The normal flora acts like foreign markers (antigens); they trigger an immune response. Small amounts of antibodies made against the normal flora are known to also react against certain disease-causers (cross-react with pathogens), and this way help prevent infection or invasion.

Q38. Discuss the role of normal flora in making vitamins and stopping pathogens from entering.

1. Making of vitamins: Bacteria in the gut (alimentary canal) produce vitamins. They release vitamins that are more than they themselves need. From the gut, these vitamins are absorbed and spread through the body. For example, gut bacteria release Vitamin K and Vitamin B12, and lactic-acid bacteria produce certain B-vitamins.

2. Stopping colonization by pathogens: The bacteria of the normal flora compete with disease-causers for spots to attach to and for nutrients. So, pathogens have less chance of entering body tissues.

3. Blocking or killing pathogens: The gut bacteria make a range of substances that block or kill disease-causing bacteria.

Virus

Q39. Tell apart capsid and capsomeres.

Capsid	Capsomeres
In viruses, the core is covered by a protein coat, calle	tl

Q40. What are naked viruses? Briefly describe how viruses generally look.

In some animal viruses, the nucleocapsid is wrapped in another covering called the envelope. It is a fat-rich (lipid-rich) membrane, taken from the host cell. Viruses without an envelope are known as naked viruses.

General Appearance

There is great variety in how viruses look.

- Animal and plant viruses may be polyhedron-shaped (having many sides) or helical (spiral).
- Bacterial viruses (bacteriophages) may be cube-shaped, icosahedral (having 20 faces), helical, or complex (having a many-sided head and a rod-shaped tail).

Q41. Discuss the role of bacteriophages in genetic engineering.

Bacteriophages are used as carriers in genetic engineering. The gene of interest is inserted into the DNA of a bacteriophage, which then carries it to the target bacterial cell. When the virus's DNA joins the bacterial chromosome, the gene of interest also becomes part of the bacterial DNA. Such altered (transgenic) bacteria - meaning their genetic makeup carries DNA from another organism - can then be grown to produce copies of the gene of interest and the protein that is needed.

Q42. Sketch the structure of a T4 bacteriophage.

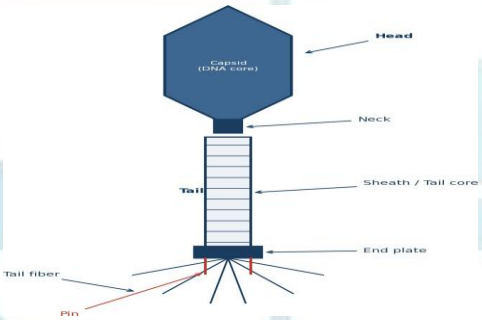

Fig: Structure of a T4 bacteriophage - head, neck, tail (sheath and core), tail fibers, end plate, and pins

Q43. Briefly describe the tail of a bacteriophage.

The tail of a bacteriophage is made of an inner core and an outer sheath, both built from different proteins. A neck joins the sheath to the head, and an end plate sits on the other side of the sheath. Six tail fibers are attached to the end plate.

Job

They help the phage attach to the bacterial wall. These parts are also made of proteins.

Q44. What do you know about retroviruses?

Retroviruses contain RNA and a capsid. The most distinctive trait of retroviruses is the presence of a specific enzyme, reverse transcriptase. This enzyme drives the process of reverse transcription, in which a single strand of RNA is turned (transcribed) into a strand of DNA. The enzyme then uses that DNA strand to build a complete double helix of DNA.

Q45. Comment on the entry of HIV into humans.

Experts have concluded that HIV first arose in the jungles of Africa, among wild chimps. Evidence suggests that an earlier form of this virus entered the human species by way of monkey bites or by people eating monkey meat or brains.

Q46. Sketch the structure of HIV.

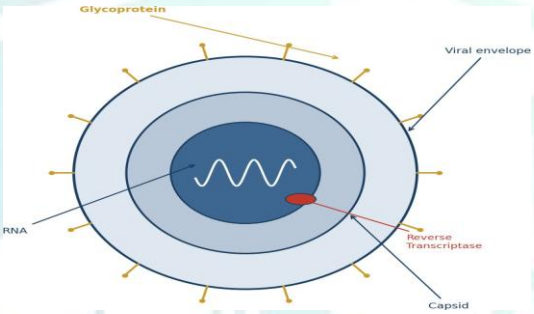

Fig: Structure of HIV - glycoprotein spikes, viral envelope, capsid, RNA, and reverse transcriptase

Q47. Give a brief account of the discovery of AIDS.

The disease was first reported in 1981, and the patients were found to be homosexual men. Later on, AIDS was also discovered in non-homosexual patients who had received blood or blood products from other AIDS patients. In 1984, it was discovered that the agent causing AIDS was a virus. In 1986, the virus that causes AIDS was given the name Human Immunodeficiency Virus (HIV). It is host-specific: it can multiply in monkeys but does not cause AIDS in them.

Long Questions (Exercise) - Quick Reference

These questions point back to the fuller explanations already given under the short/SLO questions above.

#	Question	See Answer To
1	Compare and contrast the cell wall of Gram-positive and Gram-negative bacteria.	Q2
2	Explain different methods of movement in bacteria.	Q11-Q14
3	Explain the structure of a bacterium's flagellum.	Q7, Q11
4	State the formation of an endospore in bacteria.	Q5, Q9
5	Briefly describe the ecological and economic importance of bacteria.	Q31-Q34
6	Explain the use of bacteria in research and technology.	Q34
7	Define the term normal flora. State the benefits we get from normal bacterial flora.	Q35-Q38
8	Explain the structure of a model bacteriophage and HIV.	Q42-Q43, Q46

Inquisitive Questions

Q1. Why do bacteria have ribosomes even though they do not have membrane-bound organelles?

Bacteria lack membrane-bound organelles because they have no internal membranes to enclose them. Their only organelle is one that is not wrapped in any membrane - the ribosome (the sole organelle of prokaryotes). The main job of ribosomes is the same as in eukaryotes: building proteins (protein synthesis). Even so, bacterial ribosomes are smaller (70S) than eukaryotic ribosomes (80S).

Q2. If bacteria do not have mitochondria, how do they generate energy for survival?

Although bacteria lack mitochondria, they still get energy through cellular respiration - especially using the electron transport chain and ATP synthase, which sit in their plasma membrane (in eukaryotes, these are found in the mitochondrial membrane instead).

Q3. Why do certain bacteria show twitching movement using pili instead of flagella?

Twitching motility, also called crawling motility, is used by bacteria to move over surfaces. It is driven by pili, which grip the nearby solid surface and pull back (retract). This pulls the bacterial cell forward in a crawling, or twitching, fashion.

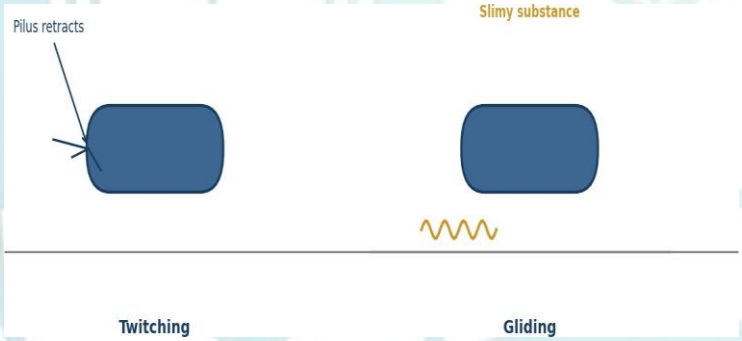

Fig: Twitching motility - pilus grips the surface and retracts

Q4. Give reasons in favour of the statement "Prevention is better than cure," and present your arguments in class.

1. Preventive actions help reduce the risk of spreading harm and disease to others, e.g., isolating people with catching (contagious) diseases like mumps, measles, and COVID-19.
2. It helps avoid outcomes that cannot be fully reversed, e.g., long-term (chronic) diseases.
3. It supports long-term wellbeing - regular screening tests, for instance, help catch deadly diseases like cancer or emphysema early, raising the chances of survival.
4. It lowers physical, emotional, or money-related (financial) strain, and is also cheaper than treatment, which is often very costly nowadays.

Q5. Connect the social and cultural values of a country with how common AIDS is.

AIDS is a sexually transmitted disease with many other ways of spreading (like unscreened blood transfusions, body fluids, or infected surgical tools), and it remains incurable today. How common it is (its prevalence) is

strongly shaped by a country's social and cultural values. The following social and cultural factors can add to how common AIDS becomes:

1. Lack of education and poor awareness about how it spreads.
2. Religious opposition (to prevention methods).
3. Traditional healing (false spiritual cures) delaying proper HIV treatment.
4. Weak healthcare systems, i.e., lack of testing and treatment.
5. Multiple marriage practices (polygamy), in the case of infected men.
6. Lack of circumcision (since male circumcision lowers female-to-male HIV spread).
7. Weak protection for high-risk groups (such as drug users).