Bacteria, viruses and infection

Comparing bacteria and viruses, how TB and HIV infect and cause disease, entry routes, barriers, and the non-specific responses of the body.

Bacteria and viruses

	Bacteria	Viruses
Cells	Prokaryotic **cells**, living	**Not cells**, non-living outside a host
Genetic material	Circular DNA (and plasmids)	DNA **or** RNA (not both)
Structure	Cell wall, membrane, ribosomes	Nucleic acid in a protein coat, the **capsid**; some have an **envelope** (a lipid membrane from the host) with attachment proteins
Reproduction	Binary fission	Only inside a **host cell**, using its machinery
Treatment	**Antibiotics**	Antibiotics are **ineffective**

Examples of viruses

- **Ebola virus**: an enveloped RNA virus, filamentous in shape.
- **Tobacco mosaic virus (TMV)**: a rod-shaped RNA virus with a helical capsid, no envelope, infects plants.
- **HIV**: an enveloped retrovirus with RNA and **reverse transcriptase**, with attachment proteins (gp120) and a capsid.
- **Lambda phage (λ phage)**: a **bacteriophage** with a head (capsid) containing DNA, and a tail, which infects bacteria.

Lytic and latent infection

- **Lytic cycle**: the virus enters the host cell, uses the cell's machinery to **replicate**, and new viruses are released by **lysis** (bursting) of the cell.
- **Latent (lysogenic) cycle**: the viral nucleic acid is **integrated into the host genome** and remains **dormant**, copied when the host cell divides, until triggered to enter the lytic cycle. HIV can be latent in T cells.

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Tuberculosis (TB)

Caused by the bacterium ***Mycobacterium tuberculosis***, spread in **droplets** from coughs.

- Bacteria are taken up by **macrophages** in the lungs but **resist digestion**, and multiply inside them.
- The immune response forms **tubercles** (nodules) that wall in the bacteria; the infection may become **latent**.
- If the immune system is weakened, the bacteria become active and **destroy lung tissue**, causing coughing blood, weight loss and fever, and can lead to death.
- Risk is higher in people with **HIV**, with a poor diet, or in crowded conditions. The bacteria are becoming **antibiotic-resistant**.

HIV

Human immunodeficiency virus infects **helper T cells** (CD4 cells).

1. The virus's **attachment protein** binds to the **CD4 receptor** on a helper T cell and the envelope fuses with the cell membrane.
2. The RNA and enzymes enter the cell. **Reverse transcriptase** makes **DNA** from the viral RNA, and the DNA is **integrated** into the host genome.
3. The host cell makes new viral proteins and RNA, and new viruses **bud off** (taking an envelope from the host membrane).
4. The number of helper T cells **falls**, so the immune system cannot work properly and fewer B cells are activated. Without them, the patient develops **AIDS** and is vulnerable to **opportunistic infections** (e.g. TB and pneumonia) and some cancers, which can result in death.

How pathogens enter the body

Major routes:

- the **gas exchange system** (inhaled droplets),
- the **digestive system** (food and water),
- the **skin** (cuts, bites, injections, needles),
- the **urinogenital** tract, and the **placenta**.

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Barriers to infection

Barrier	How it protects
Skin	A tough physical barrier of keratin; **sebum** is slightly acidic
Stomach acid (pH 1–2)	**Kills** most bacteria swallowed
Mucus and cilia	Mucus traps microbes in the airways and cilia sweep them up and away
Gut and skin flora	Harmless bacteria that **compete** with pathogens for food and space, and produce substances that stop their growth
Lysozyme in tears and saliva	An enzyme that **hydrolyses** bacterial cell walls

Non-specific responses

These act against **any** pathogen, are fast and provide no memory.

- **Inflammation**: damaged cells and **mast cells** release **histamine**, which makes capillaries **leakier** and wider, so more plasma and **phagocytes** reach the infected area (the area becomes red, swollen and warm).
- **Phagocytosis**: **neutrophils** and **macrophages** engulf the pathogen, which is held in a **phagosome**, and **lysosomes** fuse with it and release **enzymes** to digest it.
- **Lysozyme**: breaks down bacterial walls.
- **Interferon**: a protein released by virus-infected cells that stimulates neighbouring cells to produce substances that **inhibit viral replication**.
- **Fever**: a raised body temperature slows pathogen growth.

Phagocytosis steps: the phagocyte is attracted to the pathogen (chemotaxis), the pathogen is engulfed into a phagosome, lysosomes fuse to form a phagolysosome, enzymes digest the pathogen, and antigens may be displayed on the phagocyte surface.

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