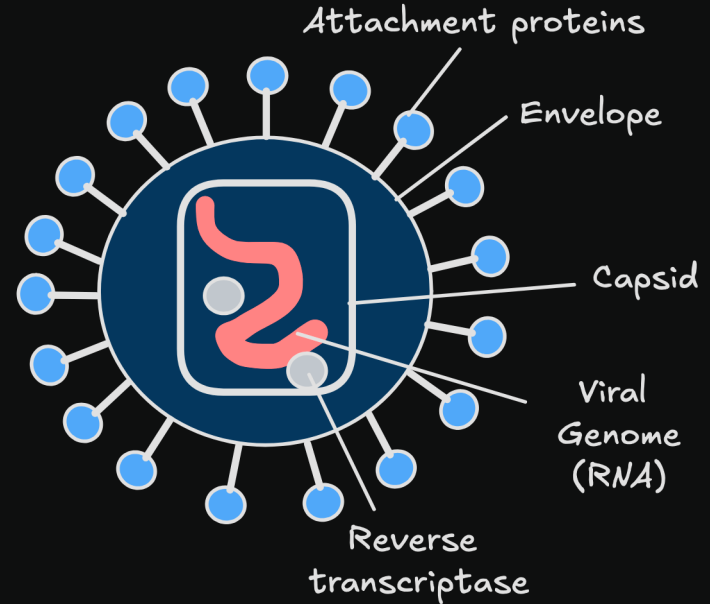


HIV & AIDS

AQA A-level Biology · Unit 2 · Topic 3.2

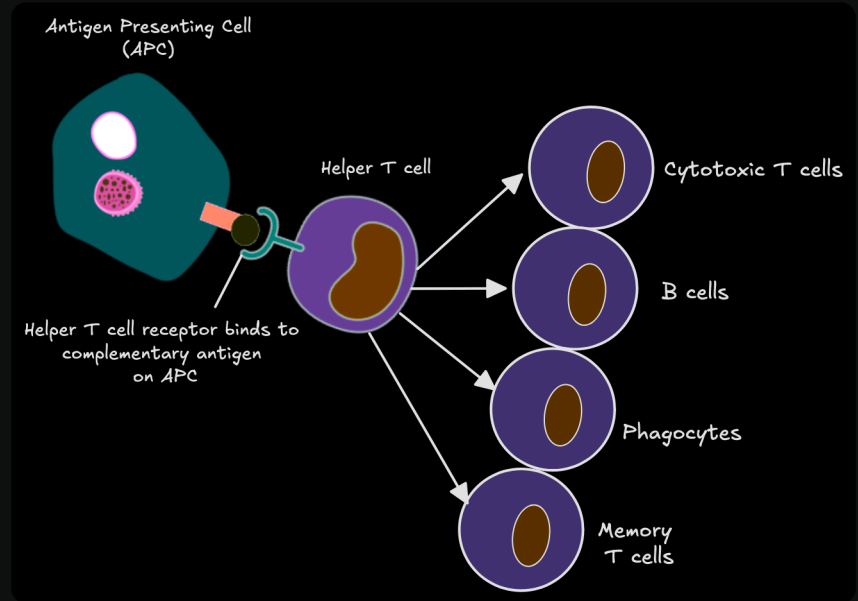
What this covers

- **Structure** of HIV – what's inside the virus
- **Replication** inside helper T cells
- How HIV causes the symptoms of **AIDS**
- Why **antibiotics don't work** against viruses

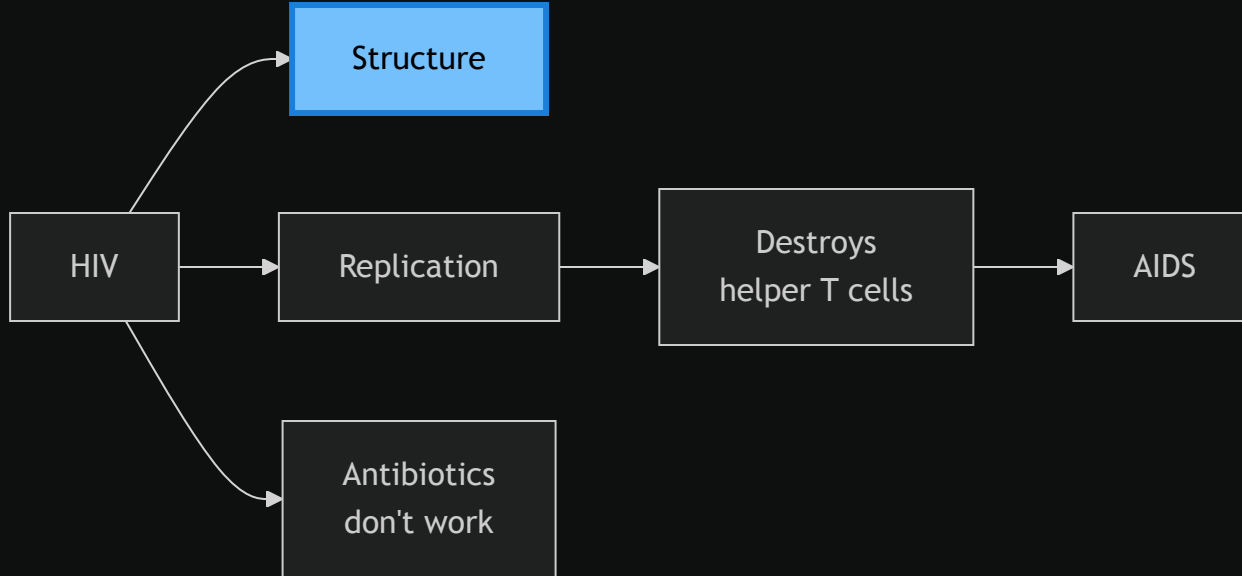


Quick recap — the role of helper T cells

- Helper T cells **activate**:
 - **Cytotoxic T cells** – destroy virus-infected & cancerous cells
 - **B cells** – produce antibodies
 - **Phagocytes** – engulf and digest pathogens
- Without helper T cells, **the immune system cannot mount a proper response**

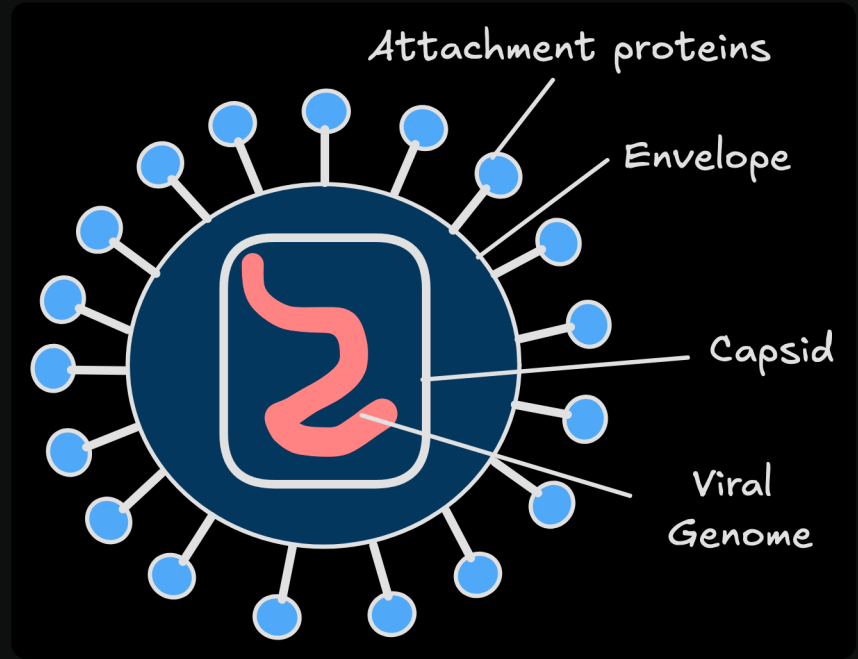


I. Virus & HIV structure



Recap — features common to all viruses

- **Genetic material** – DNA or RNA (not all viruses have the same one)
- **Capsid** – protein coat enclosing the genetic material
- **Attachment proteins** – bind to receptors on host cells
- Viruses are **acellular** (no organelles, no cytoplasm) and **non-living** (no metabolism, can't reproduce on their own)



Application — three features of all viruses

AQA Paper 1, 2023 · 2 marks

Give the three structural features found in all virus particles and describe the function of one of these features.

Hint: things found in ALL viruses – not just some. What contains the genetic material? What surrounds it? What helps it attach?

Mark scheme — three features of all viruses

1. **Genetic material, capsid** and **attachment protein** (*1 mark*)
2. Function of one:
 - Genetic material **codes for viral protein**
 - Capsid **protects the genetic material**
 - Attachment protein **binds to receptors on the host cell** (*1 mark*)

Accept "DNA or RNA" / "nucleic acid" / "genome" for genetic material. Accept "glycoprotein" for attachment protein. Don't include features only in SOME viruses (envelope, reverse transcriptase) or bacterial features (capsule, plasmids, flagella).

Application — why viruses are acellular and non-living

AQA Paper 1, 2023 · 2 marks

Explain why viruses are described as acellular and non-living.

Hint: **acellular** means "not made of cells". **Non-living** means they can't do the things living organisms do on their own. Two separate ideas – answer them separately.

Mark scheme — acellular and non-living

1. **(Acellular)** no cell-surface membrane

OR not made of cells

OR no organelles/cytoplasm (*1 mark*)

2. **(Non-living)** no metabolism/metabolic reactions

OR cannot independently move, respire, replicate or excrete (*1 mark*)

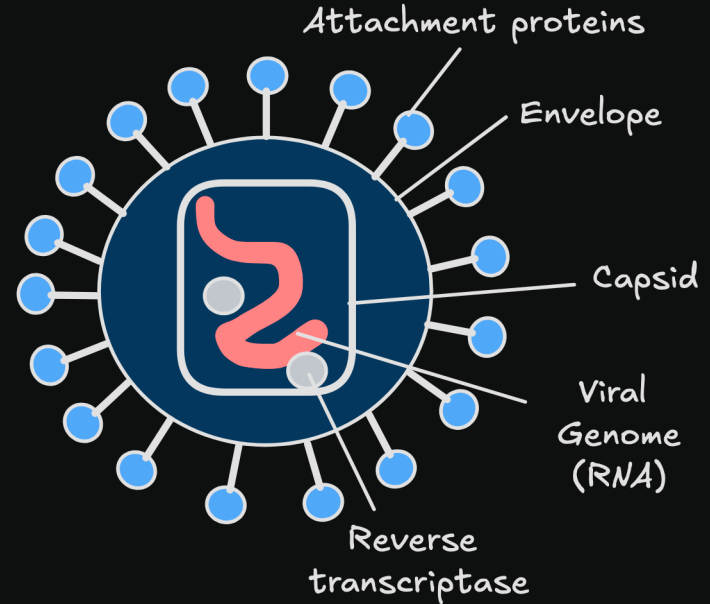
Accept any named metabolic reaction. Accept "reproduce" for "replicate". Ignore "do not contain membrane-bound organelles".

HIV is a retrovirus

- A **retrovirus** has **RNA** as its genetic material (not DNA)
- It uses an enzyme called **reverse transcriptase** to convert its RNA into DNA inside the host cell
- The name "retro" = doing the reverse of normal transcription (DNA → RNA)

Structure of HIV

- **RNA** – the viral genome
- **Reverse transcriptase** – enzyme inside the capsid
- **Capsid** – protein coat enclosing the RNA
- **Attachment proteins** – bind to **CD4 receptors** on helper T cells
- **Lipid envelope** – taken from the **host cell membrane** during budding



Application — describe the structure of HIV

AQA Paper 1, 2019 · 4 marks

Describe the structure of the human immunodeficiency virus (HIV).

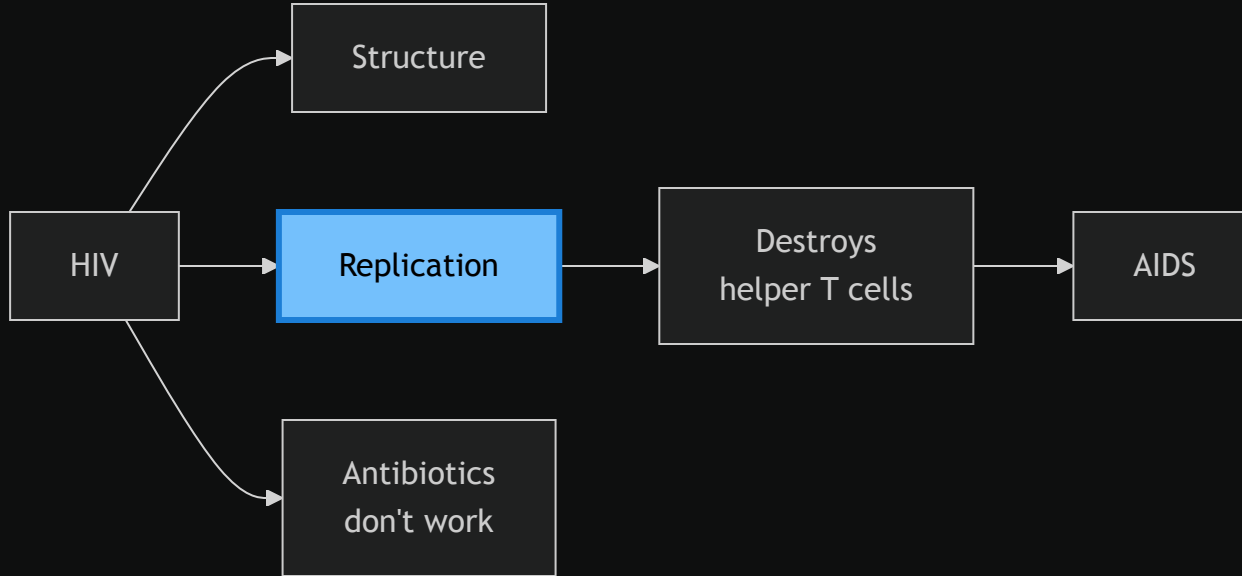
Hint: think of all the key components – genetic material, the unique HIV enzyme, the outside layer.

Mark scheme — structure of HIV

1. **RNA** (as genetic material) (1 mark)
2. **Reverse transcriptase** (1 mark)
3. (Protein) **capsomeres / capsid** (1 mark)
4. **(Phospho)lipid (viral) envelope** (1 mark)
5. **Attachment proteins** (1 mark)

Accept a labelled diagram. Reject "nucleus / DNA / plasmids", "capsule", "cell membrane", "cell wall". Attachment proteins: NOT antibodies.

II. Replication of HIV

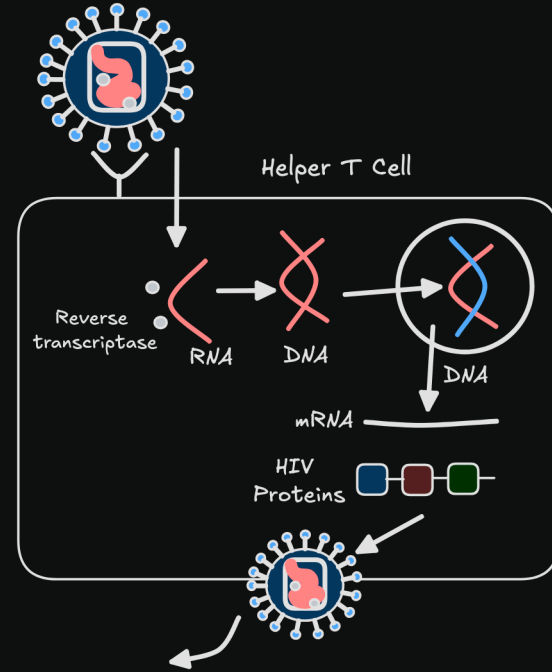


Why HIV needs a host cell

- HIV has **no ribosomes** and **no enzymes of its own** for protein synthesis
- It cannot make new viral proteins on its own
- It **hijacks the host cell's machinery** – ribosomes, amino acids, ATP – to make copies of itself

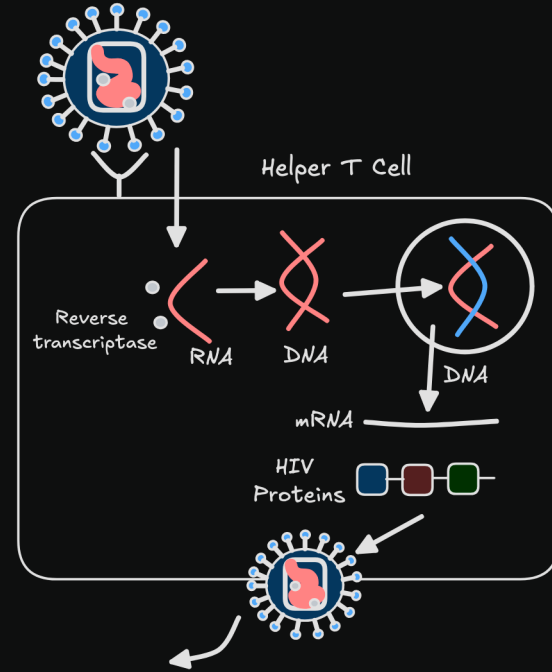
HIV replication — entry steps (1-2)

1. **Attachment protein** on HIV binds the **CD4 receptor** on the helper T cell
2. **Lipid envelope fuses** with the host cell membrane
– viral **RNA and reverse transcriptase** are released into the cytoplasm



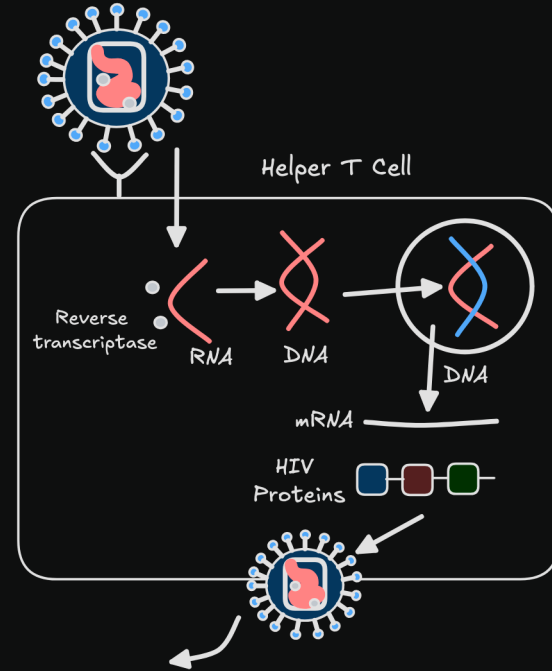
HIV replication — making new DNA (3-4)

3. **Reverse transcriptase** converts viral **RNA** → **DNA**
(the reverse of transcription)
4. Viral DNA is **inserted/incorporated into the host cell's DNA** (in the nucleus)



HIV replication — making new viruses (5–6)

5. Viral DNA is **transcribed into mRNA**, then **host ribosomes translate it into viral proteins**
6. New HIV particles are **assembled** and **bud off** the host cell, taking some membrane as their **new lipid envelope** – often killing the helper T cell



Application — describe HIV replication

AQA Paper 3, 2021 · 4 marks

Describe how the human immunodeficiency virus (HIV) is replicated once inside helper T cells (T_H cells).

Hint: start with reverse transcriptase. Where does the new DNA go, and what does the host cell do with it?

Mark scheme — HIV replication

1. **RNA converted into DNA** using **reverse transcriptase** (1 mark)
2. **DNA incorporated/inserted** into the helper T cell **DNA / chromosome / genome / nucleus** (1 mark)
3. **DNA transcribed into HIV mRNA** (1 mark)
4. **mRNA translated into viral proteins** (for assembly into new virus particles) (1 mark)

Reject "messenger" / "mRNA" for the first conversion (it's just RNA → DNA). Accept descriptions of transcription / translation. Reject "viral cells" – viruses aren't cells.

Compare — describe viral replication (any virus)

AQA · 3 marks

Describe viral replication.

Hint: this is the *general* viral replication pathway – not HIV-specific. What's the same? What's different?

Mark scheme — general viral replication

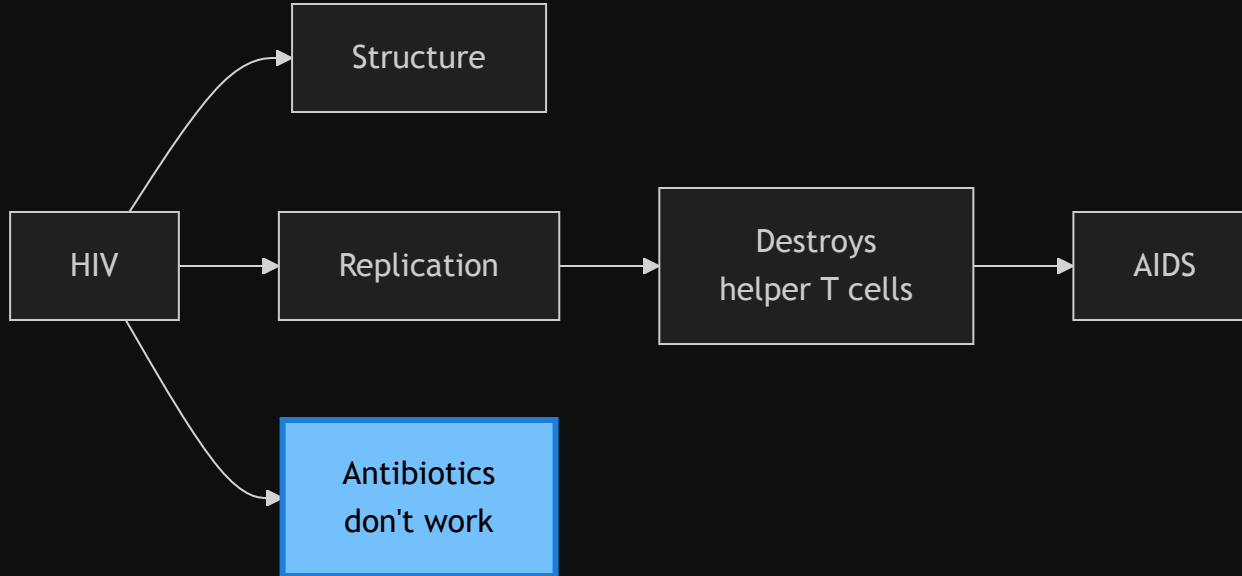
1. **Attachment proteins attach to receptors** (1 mark)
2. **(Viral) nucleic acid enters the cell** (1 mark)
3. **Nucleic acid replicated in the cell**
OR reverse transcriptase makes DNA from RNA (1 mark)
4. **Cell produces viral protein / capsid / enzymes** (1 mark)
5. **Virus assembled and released** from the cell (1 mark)

Accept "engulfment" or "injection" for entry (different for different viruses). Accept "lysis / burst / bud off / emerge" for released.

What's different about HIV?

- **Genetic material** – HIV has **RNA**; other viruses can have **DNA or RNA**
- **Reverse transcriptase** – HIV needs it to convert **RNA → DNA**; DNA viruses don't need this enzyme at all
- **Receptors** – HIV attaches to **CD4 receptors** on helper T cells; other viruses bind to different receptors on different cells

III. Antibiotics & viruses



Why do antibiotics work on bacteria?

- Antibiotics target structures **specific to bacteria**:
 - **Cell walls / murein** – humans don't have them
 - **70S ribosomes** – humans have **80S** ribosomes
- They target things humans either **don't have** or **have a different version of** – so bacteria are damaged, human cells are not

Why don't antibiotics work on viruses?

- Viruses have **no cell wall**
- Viruses have **no ribosomes of their own** – they use the host's
- Viruses live and replicate **inside host cells** – anything that destroys them would also destroy your own cells

HIV is treated instead with **antiviral drugs**, e.g. **reverse transcriptase inhibitors** – these target a process unique to HIV.

Application — why antibiotics aren't effective

AQA Paper 1, 2023 · Q1.3 · 1 mark

Give one reason why antibiotics are not effective against viruses.

Hint: what do antibiotics target? What do viruses NOT have?

Mark scheme — antibiotics & viruses

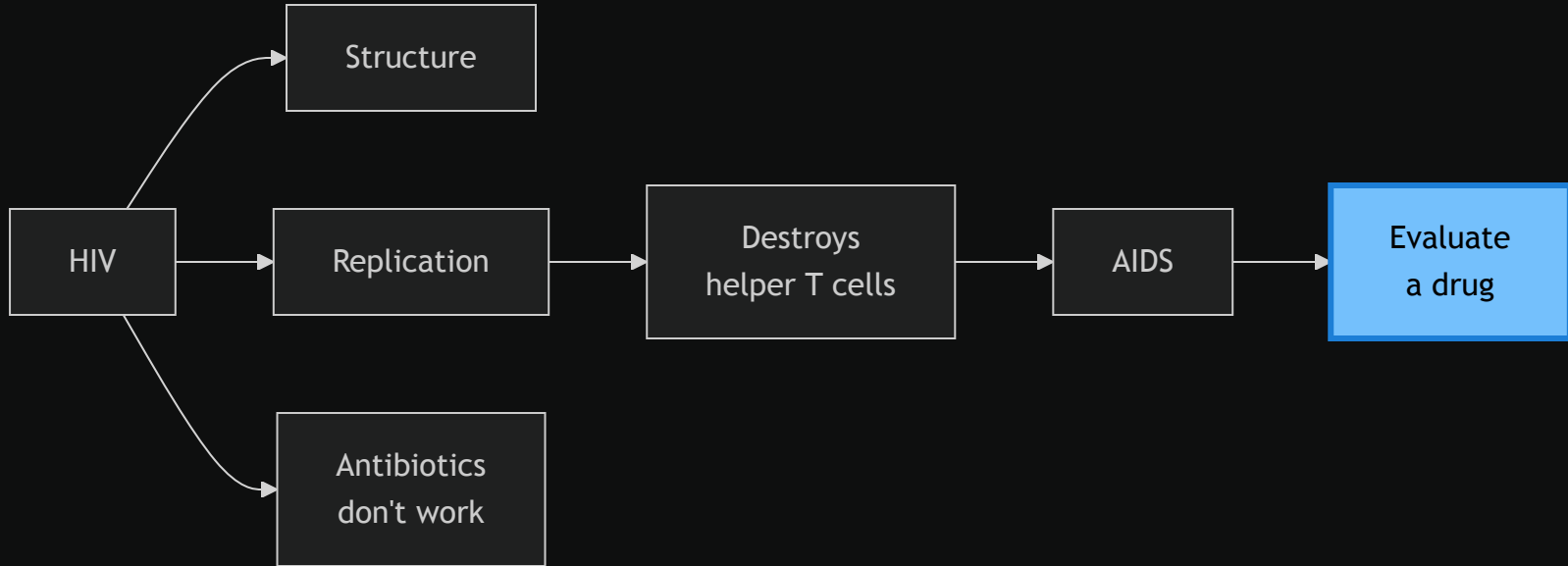
1. Viruses do **not have bacterial structures / enzymes**

OR do not have **metabolic processes**

OR do not have a **cell wall / murein** (*1 mark*)

Accept "do not have ribosomes". Ignore "70S" or "80S" specifics.

IV. Application — evaluating an HIV drug



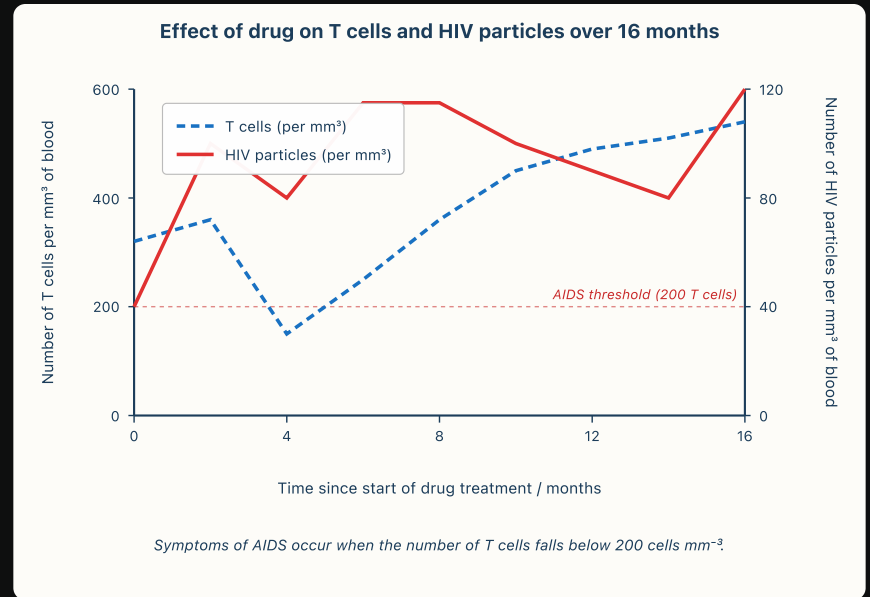
Application — evaluate the drug for treating AIDS

AQA · 5 marks

A scientist measured the effect of a drug on the **number of T cells** and the **number of HIV particles** in blood from a person **with AIDS**, over **16 months**.

Use all of the data to evaluate the effectiveness of the drug in treating AIDS.

Hint: comment on what the data shows AND on limitations of the study.



Mark scheme — drug effectiveness (5 max)

Not effective because:

1. T cells **< 200 at 4 months** (accept 3.5–5 months)
2. **Drug not effective**
OR AIDS symptoms occur
3. Does **not remove all HIV**
OR HIV constant/stable
OR slight increase over 16 months

OR Effective because:

9. T cells **> 200 after 5 months**
OR T cells increasing after 4 months
10. **Drug is effective**
OR AIDS symptoms relieved/removed

Limitations of the study:

4. **No statistical test**
5. **Only 16 months** of data
6. **Only one person** studied
7. **Unknown side effects** of drug
8. **No control group**

Recap — what you should know

The AQA spec points for this topic – by the end of this lesson you should be able to:

- **✓ Describe the structure of HIV** – what's inside the virus (RNA, reverse transcriptase, capsid, attachment proteins, lipid envelope)
- **✓ Describe how HIV replicates in helper T cells** – from attachment through reverse transcription, integration into the host DNA, and budding off
- **✓ Explain how HIV causes the symptoms of AIDS** – destruction of helper T cells, immune system collapse, opportunistic infections
- **✓ Explain why antibiotics are ineffective against viruses** – they target bacterial structures (cell wall, 70S ribosomes) that viruses don't have

Plus the supporting skills: list the **three features common to all viruses**, **compare** general viral replication with HIV's, and **evaluate** a drug treatment using data.

Common mark-scheme phrasing

- **HIV has RNA**, NOT DNA – never write "DNA" as the viral genome
- **Reverse transcriptase** – exact name, not "reverse enzyme"
- Attachment proteins are **NOT antibodies**
- **Host cell ribosomes** translate viral mRNA – be specific
- Viruses have **no cell wall** and **no cell membrane**
- **Viruses aren't cells** – reject "viral cells"