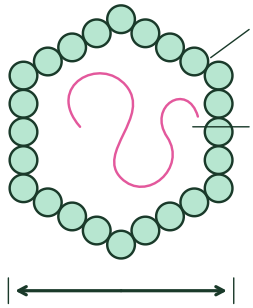
How a virus *borrows* a cell

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

A virus is a few genes in a protein coat with no metabolism, so only a host cell can make more of it.



Draw it like this. A capsid of protein units round DNA or RNA, and nothing else.

A2.3.1 COMMON TO ALL VIRUSES

A virus is genes in a *protein box*

- Viruses are so varied that only **a few features** are shared by every one of them.
- A virus has **no cytoplasm**, no ribosomes and few or no enzymes, so it cannot release energy, make proteins or copy its own genes.
- It is an **obligate parasite**: only the host cell it infects can reproduce it. It is grown in living cells, never in a nutrient broth.

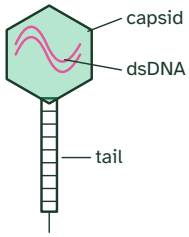
SHARED BY EVERY VIRUS

S Small a fixed size	**G** Genes DNA or RNA	**C** Capsid a protein coat	**N** No cytoplasm or ribosomes	**E** Enzymes few or none

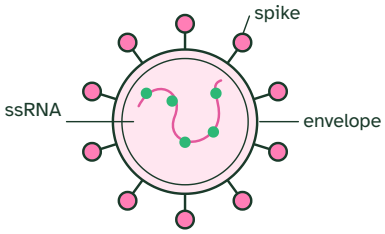
A2.3.2 DIVERSITY OF STRUCTURE

No two *alike*

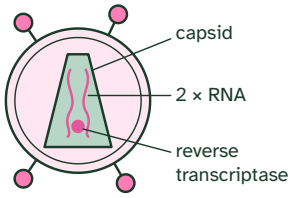
- Genes may be **DNA or RNA**, and either may be **single- or double-stranded**.
- Some have only a capsid. Others are **enveloped** in membrane taken from the host cell.
- Shapes range from many-sided capsids to helical rods and heads with tails.



Phage lambda



Coronavirus



HIV

	PHAGE LAMBDA	CORONAVIRUS	HIV
G **Genes** the nucleic acid	**dsDNA**	**ssRNA**	**ssRNA, two copies**
C **Capsid** the protein coat	Many-sided head on a long tail	Helical: the RNA is wound with protein	Cone-shaped, holding **reverse transcriptase**
E **Envelope** host membrane	**None**	**Yes**, studded with **spike proteins**	**Yes**, with a few protein knobs
H **Host** the cell it infects	The bacterium *E. coli*: its tail binds receptors on the wall	Human and other animal cells: spikes bind their receptors. One causes COVID-19.	Helper T cells: reverse transcriptase copies its RNA into DNA

A2.3.3 TAKE OVER, BURST OUT

The *lytic* cycle of phage lambda

- A virus relies on its host for **energy, nutrition and protein synthesis**: the cell supplies ATP, nucleotides, amino acids, enzymes and ribosomes.

STEP 1
Attach
The tail binds to **receptor proteins** on *E. coli*.

STEP 2
Inject
The DNA goes in; the empty capsid stays out. The DNA forms a circle.

STEP 3
Copy
Host enzymes copy the phage DNA many times.

STEP 4
Make proteins
Host ribosomes make capsids, tails and phage enzymes.

STEP 5
Assemble
Parts join into new phages, each head packed with DNA.

STEP 6
Lyse
A phage enzyme breaks the wall; the cell bursts and about 100 phages leave.

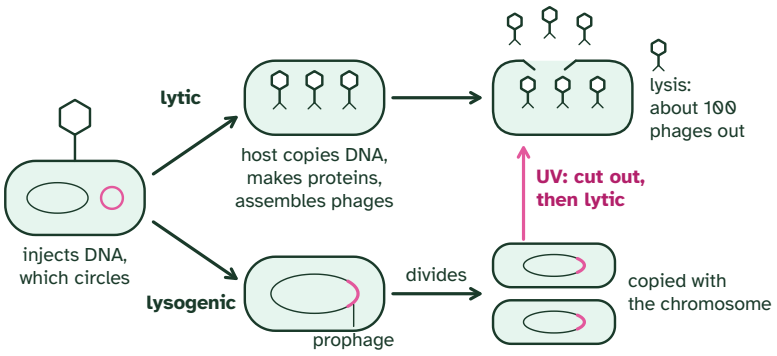
- One cycle takes **under an hour**, and **the host cell is destroyed**.

Lying low, many origins and *fast* evolution

A2.3.4 PHAGE LAMBDA AGAIN

Lying low: the *lysogenic* cycle

- Once its DNA has circled, lambda may take the **lysogenic cycle** instead.
- A phage enzyme **inserts the DNA into the host chromosome** at one site: it is now a **prophage**.
- A **repressor protein** keeps the phage genes off, so the cell lives. The prophage is **copied with the chromosome** at each division.
- **Induction:** stress such as UV destroys the repressor; the prophage is cut out and the lytic cycle runs.



A2.3.5 ORIGINS OF VIRUSES

Many *beginnings*

- Viruses vary so much that they probably **arose several times**, not from one ancestor. Three hypotheses, not exclusive:

IDEA 1
Escaped genes
Genes that moved about in a cell escaped and gained a coat.

IDEA 2
Reduced cells
Parasitic cells lost parts until only genes and a coat were left.

IDEA 3
Virus first
Replicators existed before cells, then lived on as their parasites.

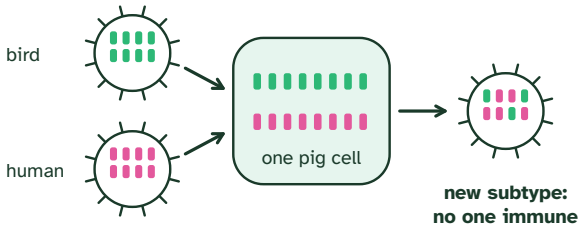
- Shared features may be **convergent evolution**: the same **obligate parasitism** shaped unrelated starts alike.
- Viruses **share the genetic code** with cells, so they likely arose from cells that used it.

A2.3.6 RAPID EVOLUTION: A MOVING TARGET

Why some viruses evolve *so fast*

M Mutation RNA copied without proofreading	**G** Generations a new one in hours	**N** Numbers huge, in each host	**S** Selection by immunity and drugs

- **Influenza, drift:** mutations in the genes for its surface proteins build up, so old antibodies fit less well. **A new vaccine every year.**
- **Influenza, shift:** two strains in one cell swap some of their **eight RNA segments**: a new subtype and a pandemic risk.
- **HIV:** many variants arise in one patient and one drug soon selects resistance, so it is given **three or more drugs at once**. No vaccine works.



WATCH OUT

Five mistakes that *cost marks*

- ✕ **Antibiotics do not work on viruses.** They act on cell walls and bacterial ribosomes, which viruses lack.
- ✕ **An envelope is host membrane.** The virus takes it as it leaves.
- ✕ **The phage makes nothing itself.** After injection, host enzymes and ribosomes do every step, following the phage's genes.
- ✕ **A prophage is not a virus waiting outside.** Its DNA is part of the chromosome in every daughter cell.
- ✕ **Viruses do not change to escape a drug.** Mutations are random; the drug selects the resistant variants.

COVER THE SHEET

Can you *answer these?*

1. State five structural features that all viruses share.
2. Compare the structure of phage lambda and HIV.
3. Outline the phases of the lytic cycle of phage lambda.
4. Distinguish between the lytic and lysogenic cycles.
5. Outline the evidence that viruses have several origins.
6. Explain why the influenza vaccine is changed every year.
7. Explain why HIV is treated with three drugs at once.

IN THE EXAM

Name the host's part in each lytic step ("host ribosomes make the capsid proteins"). For lysogeny write **inserted into the host chromosome as a prophage**, not "hides".

GO FURTHER

An animated phage film, interactive figures and quick checks are in the full guide online.