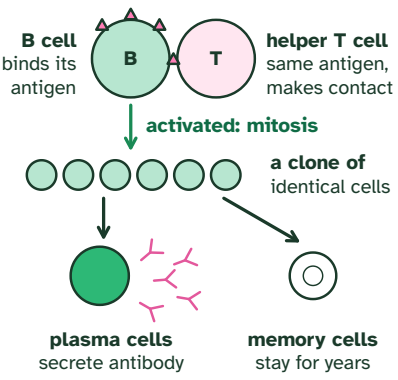
How the body *fights* infection

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

THE ONE IDEA

Barriers keep pathogens out; phagocytes eat what gets in; lymphocytes make specific antibodies and keep memory cells. That memory is immunity.



Draw it like this. Two signals, then mitosis: one clone, two fates.

C3.2.6 to 9 START HERE

One B cell fits: *clonal selection*

- An **antigen** is a recognition molecule, usually a **protein or glycoprotein** on the outside of a pathogen. Lymphocytes recognise it; they circulate in the blood and gather in **lymph nodes**.
- You carry a huge number of B cells, each making **one specific antibody**. Only a few fit any one antigen; the antigen selects them.
- **Activation needs two things:** the B cell binds its antigen, and an **activated helper T cell** for the same antigen makes contact and sends chemical signals.
- The activated B cell divides by **mitosis** into a clone. Most become **plasma cells** secreting that antibody in quantity; some become memory cells.

Red blood cells carry antigens too: transfused blood of another group can trigger antibodies.

CLONAL SELECTION IN FIVE STEPS — *Rude Aliens Might Steal Rockets*

R	**Recognise** receptor fits antigen	**A**	**Activate** helper T contact	**M**	**Multiply** mitosis, a clone	**S**	**Secrete** plasma cells	**R**	**Remember** memory cells

C3.2.1

Pathogens

- A **pathogen** is an organism that causes disease; passed from person to person, it gives an **infectious disease**.
- Usually **viruses, bacteria, fungi and protists**. **Archaea** are not known to cause human disease.
- **Careful observation:** Snow mapped cholera deaths round one London pump (1854); Semmelweis cut childbed fever in Vienna by hand washing.

C3.2.2

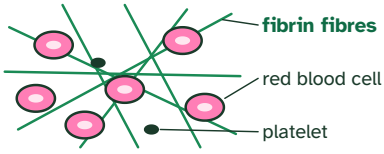
Skin and *mucous membranes*

- **Physical barrier:** tough outer layer of **dead, keratin-filled cells**, with no gaps.
- **Chemical barrier:** sweat and oils make it **acidic**; sweat and tears carry **lysozyme**, which splits bacterial walls.
- **Openings** are lined by **mucous membranes**: sticky mucus traps microbes, and cilia sweep it to the throat.

C3.2.3

Sealing a cut: *clotting*

- **Platelets** stick at the cut and **release clotting factors**, which start a cascade.
- At its end **thrombin** converts soluble **fibrinogen** into insoluble **fibrin** fibres.
- The fibrin mesh **traps red blood cells**: a clot, which dries into a scab.



In order: *Penguins Frequently Catch Minnows* (platelets, factors, cascade, mesh)

C3.2.4

Innate against *adaptive*

Innate born with it

Broad categories of pathogen, the same way every time; **does not change** during life. Its cells: the **phagocytes**.

Adaptive learns

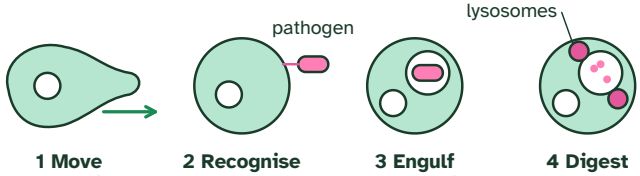
A **specific** response to one pathogen. Builds a **memory**, so each response is more effective. Its cells: the **lymphocytes**.

- **Example:** after chickenpox, a second meeting with the virus years later causes no illness. That is the adaptive system.

C3.2.5

Phagocytes eat what gets in

- Phagocytes leave the blood at an infection and move to it by **amoeboid movement**.
- Receptors **recognise** the pathogen; it is **engulfed by endocytosis** into a vesicle, and lysosomes fuse with it: their **enzymes digest** it.



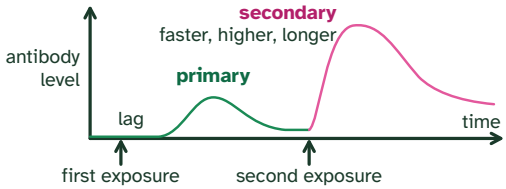
Remember the four: *My Rhino Eats Dinner*

Immunity, *drugs* and disease in populations

C3.2.10, C3.2.16

Memory cells and vaccines

- **Immunity** is the ability to eliminate an infectious disease. It comes from **memory cells**: long-lived lymphocytes that can make the specific antibody.
- Meet it again: memory cells respond at once, with more antibody, faster.
- A **vaccine** contains **antigens**, or **DNA or RNA coding for an antigen**, so it gives immunity **without causing the disease**.
- **Example:** mRNA COVID-19 vaccines code for the spike protein.



C3.2.11, C3.2.12

HIV and AIDS

- HIV passes in **body fluids**: blood (shared needles), unprotected sex, mother to baby (birth, breast milk); never by touch.
- It infects and kills **helper T cells**, so **B cells cannot be activated** and fewer antibodies are made.
- Then **AIDS**: death from **opportunistic infections**, not HIV itself.

C3.2.17

Herd immunity

- Enough people immune: **transmission is greatly impeded**.
- It shields those who **cannot be vaccinated**: we **depend on each other**.
- About $1 - 1/R_0$ must be immune: **95%** for measles, R_0 12 to 18.
- **Nature of science:** side effects are minimal, not nil; media report work still under evaluation.

C3.2.18 SKILLS

Reading *COVID-19* data

PERCENTAGE	WORK IT OUT
change	(new – old) ÷ old × 100 40 → 160: **+300%**
difference	difference ÷ mean × 100 18 and 2: **160%**

- **Correlation is not causation**. Check what is counted, how many, over what time.

C3.2.13, C3.2.14

Antibiotics and resistance

	BACTERIUM	HUMAN CELL
Wall	Penicillin blocks its building	None
Ribosome	70S: tetracyclines block it	80S, not hit

No wall or ribosomes of its own: antibiotics **fail against viruses**.

- A chance mutation lets one bacterium survive: the drug is the **selection pressure**. Plasmids spread genes for several drugs: **multiresistant** MRSA.
- **Careful use** slows it. **Screening chemical libraries** finds new ones, such as halicin.

C3.2.15 MOST NEW HUMAN DISEASES BEGAN IN ANIMALS

Zoonoses: from animals to us

DISEASE	HOST AND ROUTE
Tuberculosis	Cattle (*Mycobacterium bovis*): unpasteurised milk, close contact.
Rabies	Dogs and bats: a bite, virus in saliva.
Japanese encephalitis	Pigs and wading birds: *Culex* mosquito bites.
COVID-19	Bat viruses, probably via another animal; then **person to person**.

WATCH OUT

Six mistakes that *cost marks*

- ✕ **Antibodies are not made in advance.** The matching B cell is selected.
- ✕ **An antigen alone does not activate a B cell.** A helper T cell must activate it too.
- ✕ **Memory cells give immunity, not plasma cells.** Plasma cells soon die.
- ✕ **Antibiotics do not kill viruses.** A virus has no wall or ribosomes.
- ✕ **Bacteria become resistant, not people.** The drug selects them.
- ✕ **HIV kills helper T cells, not B cells.** So no B cells are activated.

COVER THE SHEET

Can you *answer these?*

1. State four kinds of pathogen.
2. Outline how skin and clotting keep pathogens out.
3. Outline the four stages of phagocytosis.
4. Distinguish innate from adaptive immunity.
5. Explain how a B cell is activated and cloned.
6. Explain how HIV leads to AIDS.
7. Explain why antibiotics fail against viruses.
8. Describe the routes of two zoonoses.
9. Explain how vaccines protect a whole population.
10. Calculate the percentage change from 50 to 20.

IN THE EXAM

Antibody production, in order: antigen binds the B cell, an **activated helper T cell** makes contact, **mitosis** gives a clone, **plasma cells** secrete, **memory cells** remain.

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.