C.3.2 · Defence against disease · supported focus

International Baccalaureate · IB Diploma · Biology · HL

Scope and prerequisites

Supported HL focus. First assessment 2025; current subject brief acquired; full Biology guide not acquired. Remaining guide, assessment and practical requirements retain their recorded holds.

Prerequisites: cells and membranes from B.2 and enzymes from B.1. Each lesson develops its own method before independent transfer.

These are original or explicitly fictional teaching examples, not actual measurements or completed assessed learner investigations.

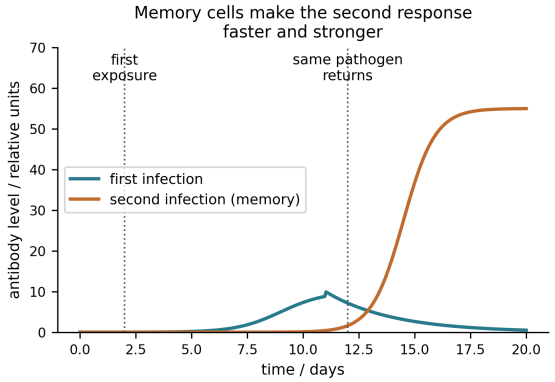
Defence against disease

What would explain this observation?

- Most people catch chickenpox once and never again, while a cold can return every year. What does the immune system remember, and why does it fail against the cold?
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

Build the model

- Pathogens carry **antigens** – marker molecules the body reads as foreign. Phagocytes engulf and digest pathogens, while lymphocytes make **antibodies**, proteins shaped to bind one specific antigen. The first response is slow because the matching lymphocytes must be selected and multiplied.
- After the first infection, **memory cells** remain. On re-exposure they produce a faster, stronger secondary response, often destroying the pathogen before symptoms appear. **Vaccination** creates memory cells without the disease. When enough of a population is immune, the pathogen cannot spread – **herd immunity**.
- antigen: A molecule recognised as foreign by the immune system; antibody: A protein that binds one specific antigen; memory cell: A long-lived lymphocyte that enables a fast secondary response; vaccination: Giving antigen material to build memory without disease; herd immunity: Population protection when too few susceptible hosts remain for spread.



Herd-immunity threshold for $R_0 = 4$

threshold = 1 − 1/R_0
= 1 − 1/4 = 0.75

at least 75% immune →
each case infects fewer than one person
→ the outbreak dies out

A vaccine protects neighbours who cannot be vaccinated

Choose evidence that can test it

- Track antibody concentration after a first and a second exposure to the same antigen: the model predicts a faster and larger second peak. A cold virus returns because its antigens CHANGE (new strains), so the memory cells no longer match – the exception that tests the rule.
- Compare outbreak sizes in populations with different vaccination coverage; above the threshold, outbreaks should fail to grow.

Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: a pathogen has a basic reproduction number $R_0 = 4$, so one case infects four others in a fully susceptible population. The herd-immunity threshold is $1 - 1/R_0 = 1 - 1/4 = 0.75$. At least 75% of the population must be immune for each case to infect fewer than one person, so the outbreak dies out.

Example:

A different pathogen has $R_0 = 2.5$. Find the herd-immunity threshold as a percentage using the same sequence: known quantities → model → relation → substitution → unit and interpretation. (Answer: $1 - 1/2.5 = 1 - 0.4 = 0.6 = 60\%$. A less contagious pathogen needs less coverage.)

Check the conclusion and its limits

- The threshold model assumes uniform mixing and equal susceptibility; real populations cluster, so actual protection can differ. Vaccine effectiveness is never 100%, so the needed coverage is higher than the arithmetic minimum.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

An antibody can bind equally well to any pathogen. This claim is false: each antibody is specific to the shape of ONE antigen – which is why a new cold strain escapes last year's antibodies, and why each vaccine targets chosen antigens.

Key:

Defence against disease: phagocytes engulf; lymphocytes make antigen-specific antibodies; memory cells give a faster, stronger second response. Vaccination builds memory safely, and herd immunity at $1 - 1/R_0$ protects the whole population.