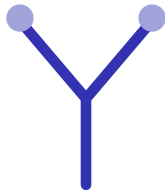


Immunity

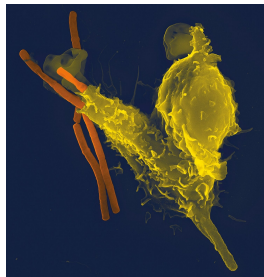
A-Level Biology ■ Topic 11

A-Level Biology



What we will cover

- 1 Phagocytosis
- 2 The primary response
- 3 Memory & immunity
- 4 Antibodies
- 5 Monoclonal antibodies
- 6 Vaccination



a phagocyte engulfing bacteria



Phagocytosis

- a **phagocyte** recognises a pathogen and engulfs it in a vesicle
- the vesicle fuses with a **lysosome** and the pathogen is digested
- antigens are displayed on the surface

Displaying the antigen links innate defence to the specific response.

The primary immune response

Clonal selection : the lymphocyte whose receptor matches the antigen is the one that divides. It produces **plasma cells** (make antibodies) and **memory cells** . The first response is slow – days to a peak.

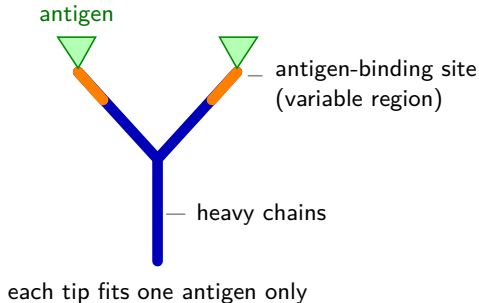
Memory and long-term immunity

On re-exposure, memory cells divide at once: a faster, larger **secondary response** .
That is why vaccination works – it creates memory without the disease.

Active immunity makes your own memory cells (infection or vaccine). Passive immunity is borrowed antibodies – immediate, not lasting.



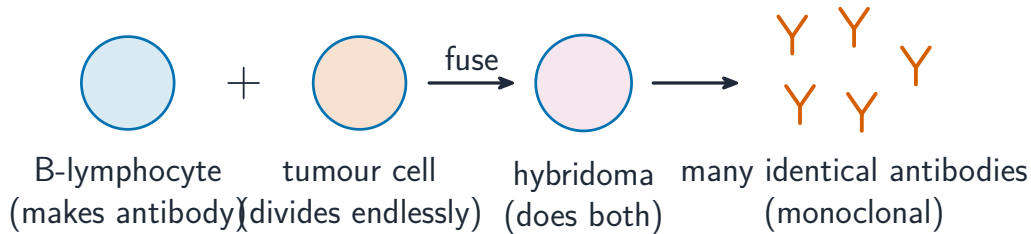
Antibodies



An **antibody** is a Y-shaped protein; its two tips (the **variable region**) bind one antigen only. They clump pathogens, mark them for phagocytes, and block toxins.

Monoclonal antibodies

A **monoclonal antibody** is one identical antibody, made by the **hybridoma** method (a B-lymphocyte fused with a tumour cell). Used in **diagnosis** (pregnancy tests) and treatment (drug targeting).





Types of immunity

- **active** – your body makes its own antibodies (slow, **lasting**)
- **passive** – ready-made antibodies (fast, **short**)

Each can be **natural** or **artificial**.

	natural	artificial
passive	after an infection (your body responds)	vaccination (safe dose of antigen)
	antibodies passed from mother to baby	injection of ready-made antibodies

Vaccination and herd immunity

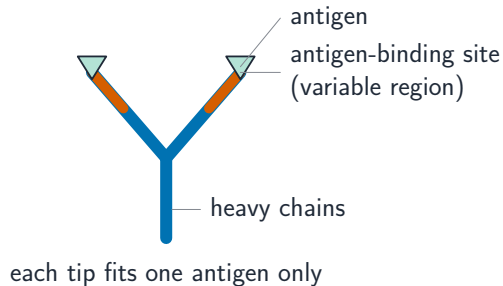
the disease cannot pass through vaccinated people



A **vaccine** gives antigens that trigger memory cells – immunity **without** illness.

If enough people are vaccinated, the pathogen cannot spread – **herd immunity** protects even the unvaccinated.

Antibodies, continued



An antibody is Y-shaped; the two tips are the variable regions that bind one specific antigen

What an antibody actually does

the shape

Y-shaped, with two **antigen-binding sites** whose shape is complementary to one antigen

neutralising

sticks to antigens, blocking the pathogen from binding to a host cell

agglutination

clumps pathogens together, so they are easier to engulf and cannot spread

opsonisation

marks pathogens so phagocytes recognise and engulf them

and toxins

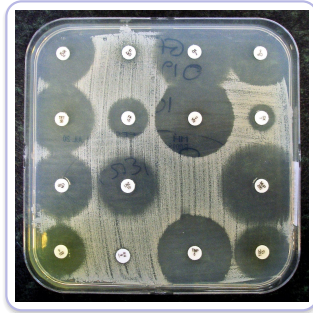
antibodies bind bacterial toxins, rendering them harmless

natural immunity and artificial immunity

acquired by infection or by vaccine; **active** means your own cells made the antibodies, **passive** means they were given to you

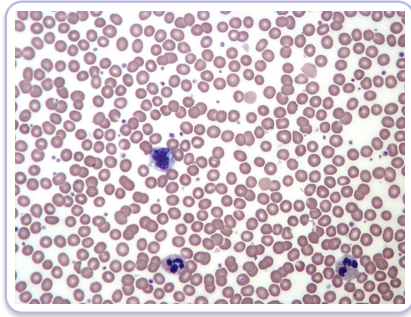
Breast milk is **natural passive**; a vaccine is **artificial active**; an antivenom is **artificial passive**.
Both axes are asked together.

Antigens: self and non-self



Clear zones on a culture plate: the immune system recognises non-self antigens and attacks foreign cells

Phagocytes – the first defence



A blood smear: the large stained cells are white blood cells, scattered among the many red cells

The cells of the immune response

neutrophils

the commonest phagocyte – a lobed nucleus, short-lived, first to arrive

macrophages

larger and longer-lived; they also **present antigen** to lymphocytes

B-lymphocytes B

divide into plasma cells, which secrete **antibodies**

T-helper cells T

recognise presented antigen and **activate** B cells and other T cells

T-killer cells

destroy the body's own infected cells

memory cells

remain after the infection, giving the fast, large **secondary** response

Phagocytosis is non-specific and immediate; the lymphocyte response is specific and slow the first time. The vaccine's whole purpose is to make the *second* response the first one you need.

The four kinds of immunity

natural active

you meet the pathogen, your own lymphocytes respond and leave memory cells

artificial active

a vaccine does the same without the disease

natural passive

antibodies received across the placenta or in breast milk

artificial passive

antibodies injected – an antivenom, or an antitoxin

active lasts

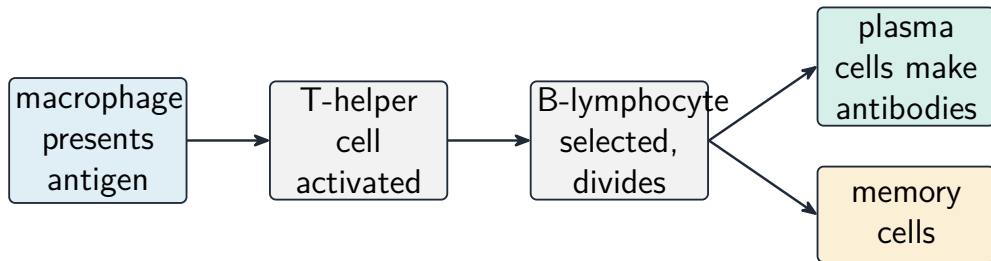
because memory cells remain

passive is immediate and brief

the antibodies were not made by you, so nothing remembers them

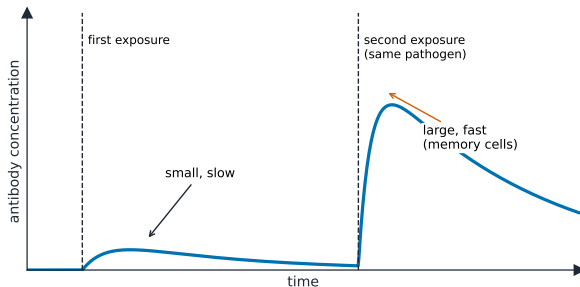
Two axes: **natural or artificial** is how you got it, **active or passive** is whether *your* cells made the antibodies. The exam asks for both words.

The primary immune response, continued



Only the B-lymphocyte whose shape matches the antigen is selected and cloned – into antibody-making plasma cells and long-lived memory cells

Memory cells and long-term immunity



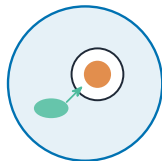
secondary response: faster and larger (memory cells)

The secondary response is faster and larger, because memory cells are ready

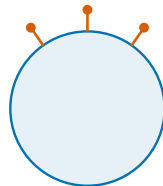
Phagocytes – the first defence, continued



1. engulfs the pathogen



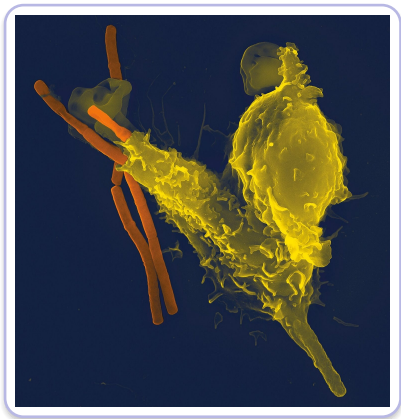
2. digests it with enzymes



3. displays the antigen

Phagocytosis: the phagocyte engulfs the pathogen, digests it, then displays its antigen

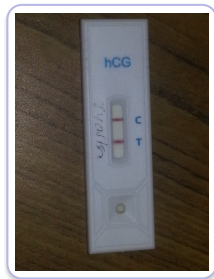
A phagocyte caught in the act



A false-coloured electron micrograph of the real thing: a **neutrophil** (yellow), one kind of phagocyte, stretching finger-like projections out to grab rod-shaped bacteria (orange).

It engulfs the pathogen, digests it inside a vesicle with enzymes, then **displays the antigen** on its own surface – which is what alerts the lymphocytes.

Monoclonal antibodies, continued



A pregnancy test is monoclonal antibodies at work. The antibodies are fixed at the T line and grab only one molecule – the pregnancy hormone hCG. The T line turns red only if hCG is in the urine; the C line always appears, to show the test ran properly

Monoclonal antibodies

Exam tips

- Distinguish **phagocytes** (engulf, non-specific) from lymphocytes: B cells → antibodies (humoral), T cells (helper/killer, cell-mediated).
- Label an **antibody** (variable region, antigen-binding site) and explain agglutination and neutralisation.
- Compare the **primary and secondary response** on a graph – memory cells make the secondary faster and larger.
- Distinguish **active vs passive** and **natural vs artificial** immunity with an example of each; explain vaccination and herd immunity.



Worked example – primary vs secondary response

Explain why the second exposure to a pathogen produces a much faster, larger antibody response.

- **Primary:** few B cells carry the right receptor, so clonal expansion takes days.
- They differentiate into **plasma cells** (antibody) and **memory cells**.
- **Secondary:** many memory cells are already circulating, specific to that antigen.
- They become plasma cells at once $\Rightarrow$ **faster, higher, longer** – often no symptoms.

Memory cells are the whole point of vaccination. The lag in the primary response is **clonal expansion** – finding and multiplying the right B cell.

Topic 11 – key takeaways

1

Phagocytosis

engulf, digest, display the antigen

2

Response

select & clone B-cells; plasma & memory cells

3

Memory

secondary response is faster & larger

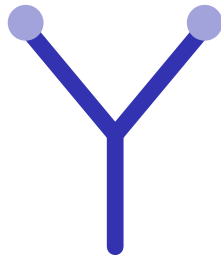
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Vaccination

builds memory; herd immunity protects all

Check yourself

- 1 What does a phagocyte display after digesting a pathogen?
- 2 Which cells give long-term immunity?
- 3 Which part of an antibody binds the antigen?
- 4 What protects the unvaccinated when most are immune?



Answers 1. the pathogen's antigen 2. memory cells 3. the variable region 4. herd immunity