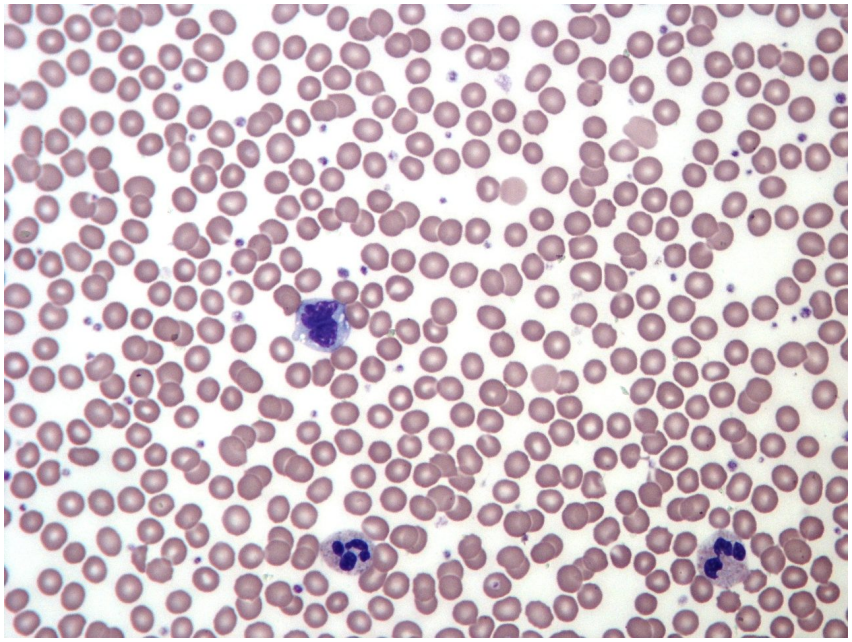
Immunity

A-Level Biology

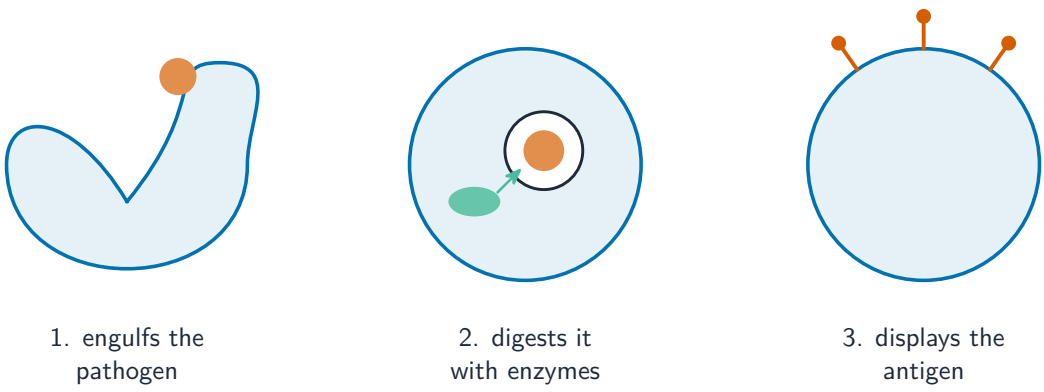
Phagocytes —the first defence

Your **immune system** 免疫系统 is the set of cells that defends the body against **pathogens** 病原体. The first cells to act are **phagocytes** 吞噬细胞, a group of white blood cells that includes **macrophages** 巨噬细胞 and **neutrophils** 中性粒细胞.



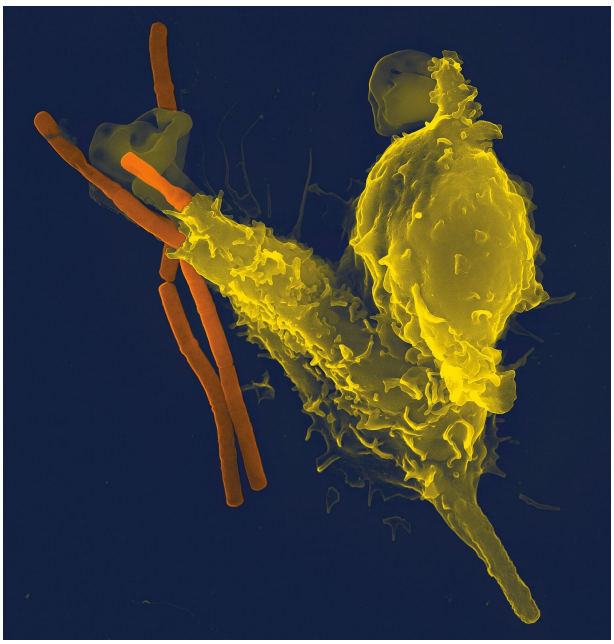
A blood smear: the large stained cells are white blood cells, scattered among the many red cells

A phagocyte destroys a pathogen by **phagocytosis** 吞噬作用: it surrounds the pathogen, takes it inside in a vesicle, and digests it with enzymes. After this, a macrophage displays parts of the pathogen on its own surface, ready to alert other immune cells.



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

This false-coloured electron micrograph captures the moment in real life: a phagocyte reaching out to grab and engulf rod-shaped bacteria.



*A real **neutrophil** (yellow), one kind of phagocyte, reaching out to engulf rod-shaped bacteria (orange) by phagocytosis*

Antigens: self and non-self

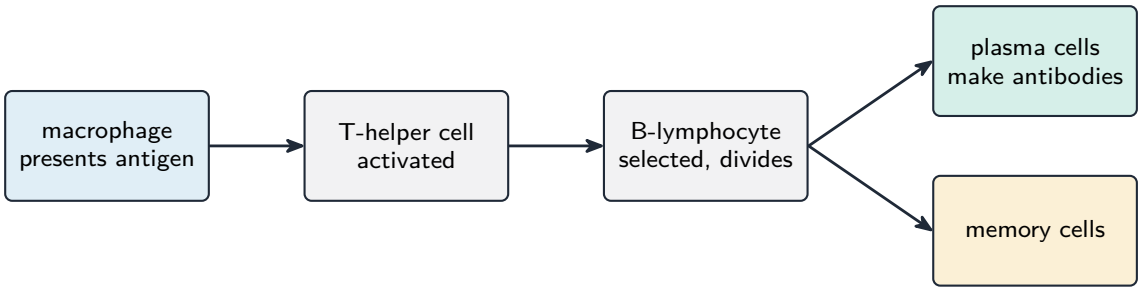
An **antigen** 抗原 is a molecule (usually a protein) on a cell surface that the immune system can recognise.

- **self antigens** 自身抗原 are the body's own markers. The immune system learns to ignore them.
- **non-self antigens** 非自身抗原 are foreign, for example the antigens on a pathogen. These trigger an immune response.

The primary immune response

The first time a new pathogen enters, the body makes a slow **immune response** 免疫反应. The main steps are:

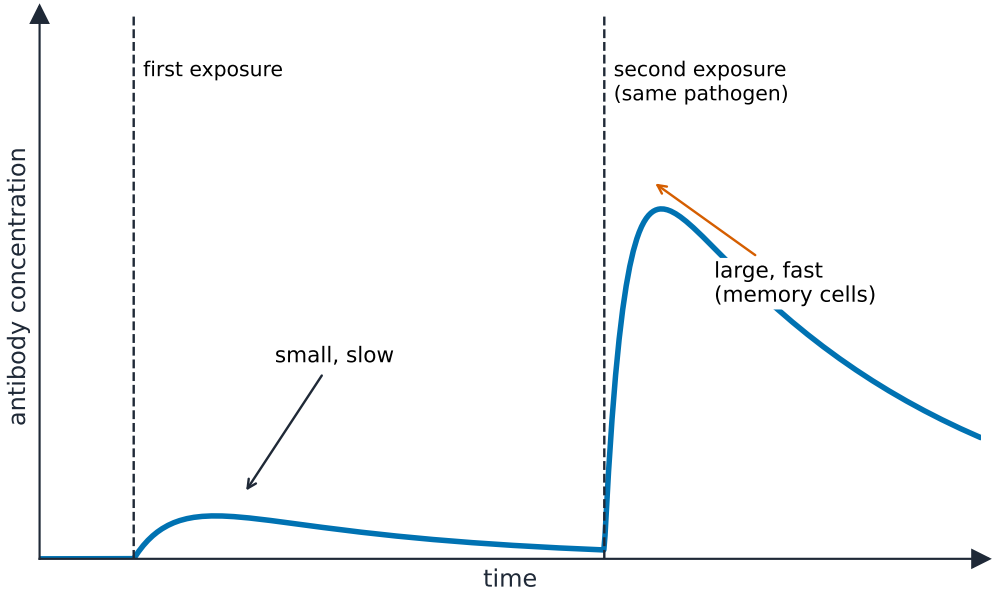
1. a macrophage engulfs the pathogen and displays its antigen.
2. **T-helper cells** 辅助性 T 细胞 recognise that antigen and become active. They release chemicals that switch on other cells.
3. **B-lymphocytes** 淋巴细胞 with a matching shape are selected. They divide to form **plasma cells** 浆细胞, which pour out **antibodies** 抗体, and **memory cells** 记忆细胞.
4. **T-killer cells** 杀伤性 T 细胞 destroy the body's own cells that have been infected.



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

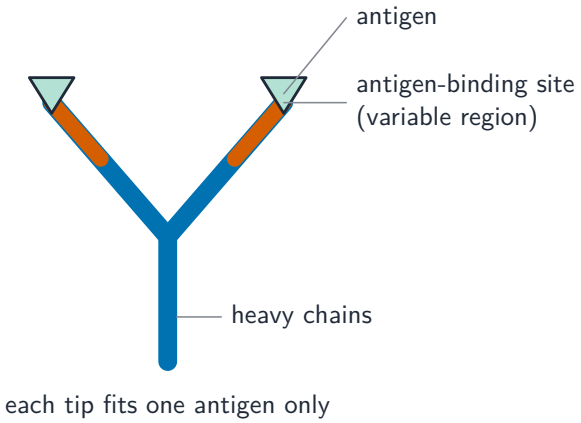
Memory cells stay in the body for years after the infection is over. If the **same** pathogen enters again, the memory cells start a **secondary** immune response that is much faster and larger than the first. The pathogen is destroyed before it can make you ill. This is what we mean by long-term immunity.



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

Antibodies

An antibody is a Y-shaped protein made by plasma cells. The two tips of the Y are **antigen-binding sites** 抗原结合位点. Each site has a special shape, called the **variable region** 可变区, that fits one antigen only, like a lock and key.



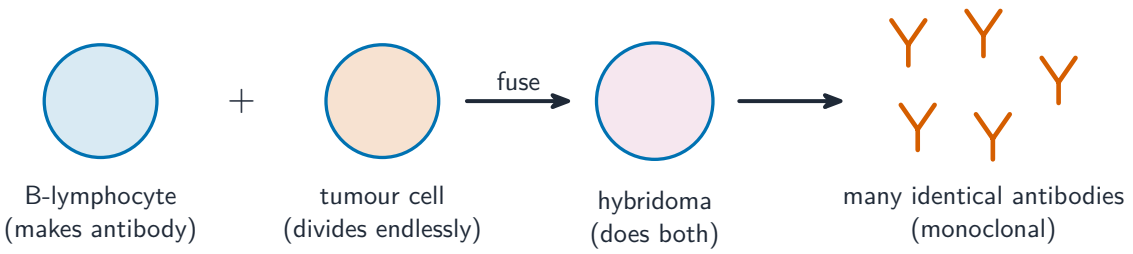
An antibody is Y-shaped; the two tips are the variable regions that bind one specific antigen

Antibodies help in several ways: they stick to antigens, clump pathogens together so they are easier to deal with, mark pathogens so phagocytes find them, and block harmful toxins.

Monoclonal antibodies

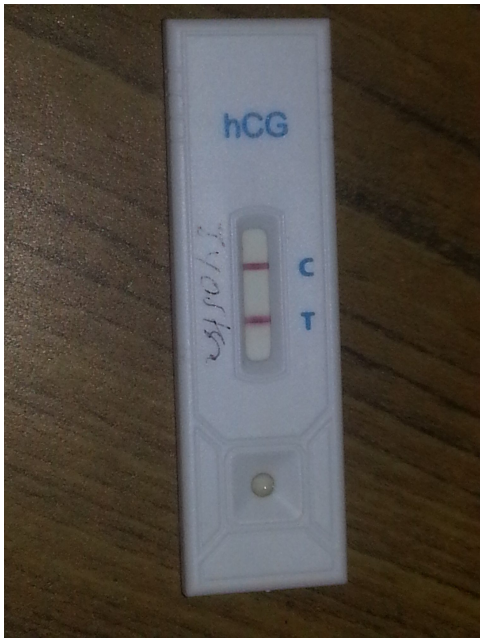
A **monoclonal antibody** 单克隆抗体 is a single type of antibody, all identical. They are made by the **hybridoma** 杂交瘤 method:

1. an animal is given an antigen, so it makes B-lymphocytes that produce the wanted antibody.
2. these B-lymphocytes are fused with tumour cells, which divide endlessly.
3. the fused cell (the hybridoma) both makes the antibody **and** divides without stopping, producing large amounts of one identical antibody.



Fusing a B-lymphocyte with a tumour cell makes a hybridoma that pours out one identical (monoclonal) antibody

Monoclonal antibodies are used in the **diagnosis** 诊断 of disease (to detect a specific molecule, as in a pregnancy test) and in treatment (to carry drugs to specific target cells, such as cancer cells).

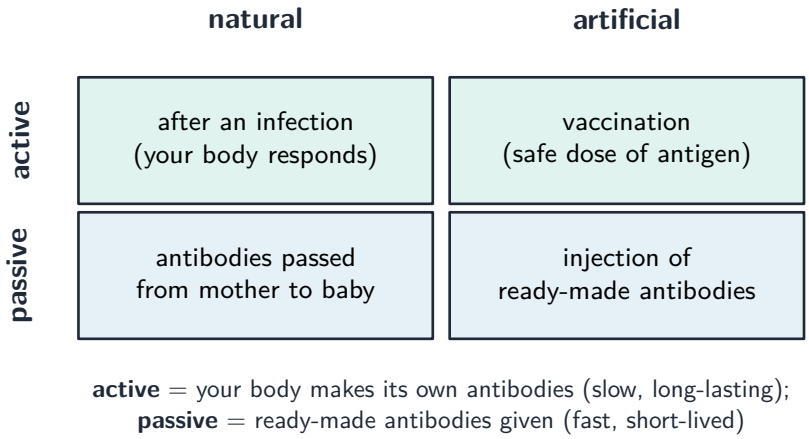


A pregnancy test is monoclonal antibodies at work. The antibodies are fixed at the T line and grab only one molecule —the pregnancy hormone hCG. The T line turns red only if hCG is in the urine; the C line always appears, to show the test ran properly

Types of immunity

Immunity can be active or passive, and natural or artificial.

- **active immunity** 主动免疫—your own body meets an antigen and makes its own antibodies and memory cells. It is slow to start but long-lasting.
- **passive immunity** 被动免疫—ready-made antibodies are given to you from outside. It works at once but does not last, because there are no memory cells.
- **natural immunity** 天然免疫—gained in a natural way (active: after an infection; passive: antibodies passed from mother to baby).
- **artificial immunity** 人工免疫—gained on purpose (active: your body is made to respond to a safe dose of antigen; passive: you are injected with ready-made antibodies).

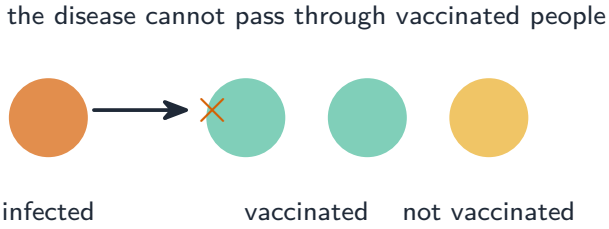


Active immunity (your body responds) lasts; passive immunity (ready-made antibodies) is fast but short

Vaccination

A **vaccine** 疫苗 contains antigens —often a dead or weakened pathogen, or part of one. The antigens trigger a primary immune response and make memory cells, so you gain long-term immunity **without** becoming ill.

Vaccination 疫苗接种 programmes can control the spread of a disease across a population. If enough people are vaccinated, the pathogen cannot pass easily from person to person. This protects even the people who are not vaccinated, an effect called **herd immunity** 群体免疫.



Herd immunity: when enough people are vaccinated, the pathogen cannot reach the few who are not

Worked example. Classify each as active or passive, natural or artificial: (a) a baby receives antibodies in breast milk; (b) a child is vaccinated against measles; (c) someone recovers from chickenpox; (d) a patient bitten by a snake is given antivenom. Ask two questions each time. **Did the person make the antibodies themselves?** If yes it is **active**; if they were handed ready-made ones, it is **passive**. **Did it happen by chance or deliberately?** Naturally, or artificially. So (a) is **natural passive** - ready-made antibodies by a natural route; (b) is **artificial active** - the vaccine's antigens make the child produce their own; (c) is **natural active** - the infection made them produce their

own; (d) is **artificial passive** - ready-made antibodies given deliberately. Only **active** immunity makes **memory cells**, which is exactly why passive immunity acts immediately but is **short-lived**.

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.