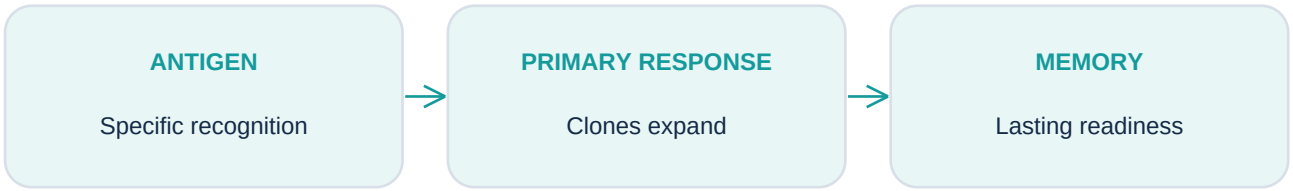
Prepare before exposure

Vaccination introduces a controlled antigenic stimulus. The aim is to build specific protection without the risks of the corresponding natural disease.

1. THE ANTIGEN IS THE TRIGGER

A vaccine supplies pathogen antigens, or genetic instructions that let cells make an antigen. Recognition stimulates the recipient's own adaptive immune response: this is artificially acquired active immunity.

2. THE CORE CAUSAL CHAIN



Later exposure to the matching antigen can trigger a more rapid, stronger secondary response. Vaccination prepares a response; it does not remove pathogens from the environment.

3. DIFFERENT WAYS TO PROVIDE ANTIGEN

Whole pathogen	A weakened live form, or an inactivated pathogen that cannot replicate.
Selected components	A subunit vaccine contains selected antigens; a toxoid is an inactivated bacterial toxin.
Genetic instructions	Some vaccines deliver instructions for antigen production rather than the antigen itself.

Do not confuse antigen with antibody. A vaccine stimulates antibody production; an antibody preparation transfers ready-made protection.

Antigen delivery and immune memory: WHO, How do vaccines work?
Whole-pathogen, subunit and toxoid vaccines: OpenStax, Microbiology 18.5.

Scope: Cambridge Biology 9700 syllabus, section 11.2, outcome 5, p. 31.

From recognition to memory

This simplified pathway follows a typical response to a protein antigen. B cells, helper T cells and antigen-presenting cells cooperate.

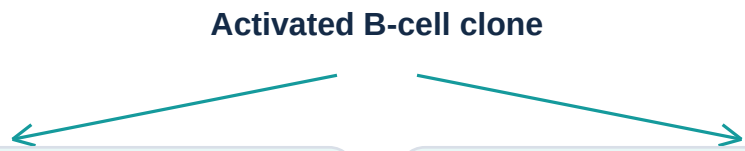
1. SELECT AND ACTIVATE

Antigen-presenting cells display antigen fragments to matching helper T cells. A B cell binds its matching antigen and can receive helper T-cell signals. Specific lymphocytes are activated; unrelated clones are not all activated equally.

2. EXPAND THE MATCHING CLONES

Activated lymphocytes divide by mitosis: clonal expansion. Daughter cells retain the relevant antigen specificity. Cells then differentiate into effector cells and memory cells.

3. FOLLOW THE B-CELL BRANCH



PLASMA CELLS

Secrete antigen-specific antibodies that help neutralise the target or promote its removal.

MEMORY B CELLS

Persist after the initial response and can rapidly expand and form plasma cells on re-exposure.

4. WHAT REMAINS?

Memory B and T cells can persist after antigen clearance. Long-lived plasma cells can also maintain antibody secretion. Memory B cells are not the cells that continuously secrete large amounts of antibody.

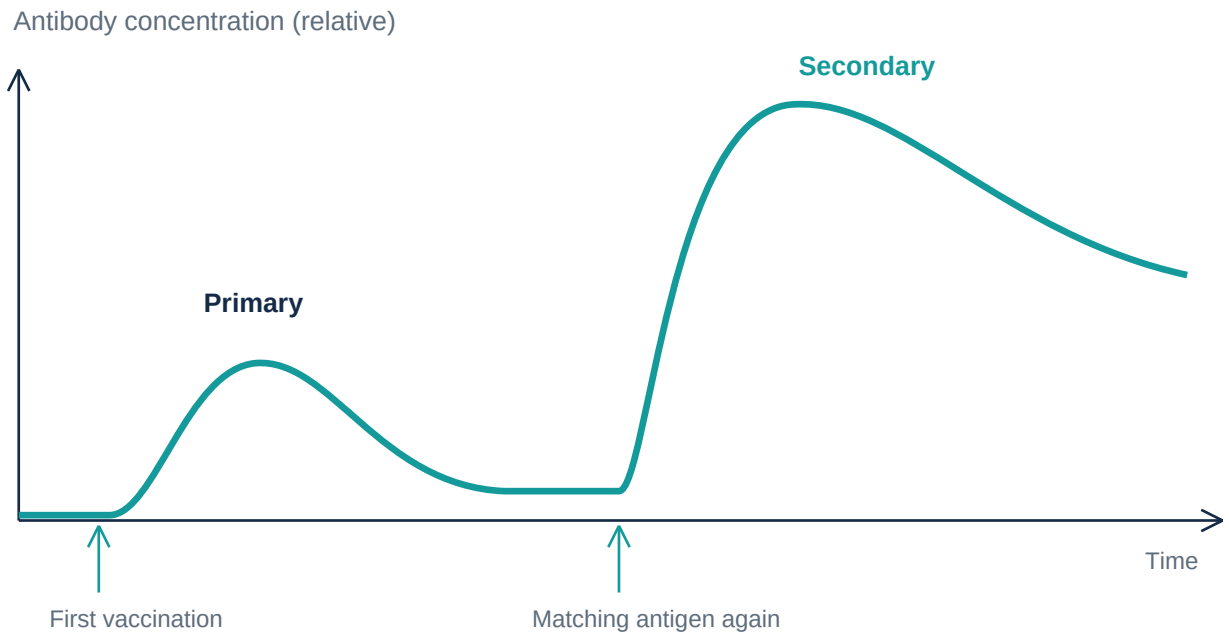
Clonal expansion, plasma cells and recall: OpenStax, Microbiology 18.4.
Active immunity and immunological memory: CDC, Principles of Vaccination.

Scope: Cambridge Biology 9700 syllabus, section 11.2, outcome 5, p. 31.

A head start next time

Recall is antigen-specific. A later encounter with the matching pathogen, or a booster containing the relevant antigen, can reactivate immune memory.

1. READ THE RESPONSE GRAPH



2. FASTER AND STRONGER

The primary response has a lag while specific cells are activated and expand. On re-exposure, memory cells support a shorter lag and greater antibody production. This can control the target before serious disease develops.

3. LONG-TERM DOES NOT MEAN GUARANTEED FOR LIFE

Protection varies with the vaccine and recipient. Additional doses can strengthen or restore protection. Vaccination does not guarantee that infection never occurs, but can reduce the risk of disease and its severity.

Graph is schematic: no fixed times, concentrations or protection threshold are implied.

Primary and secondary antibody responses: OpenStax, Microbiology 18.4.
Additional doses and limits of protection: WHO, How do vaccines work?

Scope: Cambridge Biology 9700 syllabus, section 11.2, outcome 5, p. 31.