CAIE Biology A-level

Topic 11: Immunity

Notes

Immune response

Physical barriers to infection include:

- **Skin** is a **tough physical barrier** consisting of **keratin.**
- **Stomach Acid** (hydrochloric acid) which **kills bacteria.**
- **Gut and skin flora –** natural bacterial flora **competes with pathogens** for food and space.

Non-specific responses of the body to infection include:

- **Phagocytosis** is a process in which **specialised white blood cells** engulf pathogens, thus destroying them by fusing the phagocytic vacuole containing the pathogen with a lysosome. The phagosome and lysosome combine, and enzymes from the lysosome destroy the pathogen. The main phagocytes are macrophages and neutrophils.

After the pathogen is engulfed and destroyed, its chemical markers called **antigens** are then **presented on the surface of the phagocyte**. The phagocyte then becomes an **antigen presenting cell** (APC), which activates other components of the immune system. An immune response will be stimulated if the antigen is recognised as foreign. Antigens can be **self** or **non-self**. Self antigens are antigens that are part of the body's own cells and are not normally recognised as foreign. Non-self antigens are foreign antigens (not the body's own) which can **initiate an immune response**.

The specific immune response is antigen specific and produces responses specific to one type of pathogen only. This type of immune response relies on **lymphocytes produced in the bone marrow**:

- **B cells** mature in the bone marrow and are involved in the **humoral response.**
- **T cells** move from the bone marrow to the thymus gland, where they mature. They are involved in the **cell-mediated response.**

Primary immune response

When the body encounters a pathogen for the first time, the immune system initiates antibody production, which helps to destroy the pathogen.
T and B memory cell production is also initiated so that if the body were to encounter the same antigen again it would immediately destroy it (secondary immune response).

Secondary immune response

The secondary immune response occurs when the body encounters a pathogen after initially destroying it in the primary response. This may be the second encounter or third, fourth, fifth, etc. Immunological memory gives a rapid production of a large number of antibodies due to memory cells.

Memory cells are cells which rapidly divide when re-exposed to the same antigen. They remain in the lymph nodes searching for the same antigen, thus resulting in a much **faster immune response.** This allows long-term immunity.

Specific immune response glossary

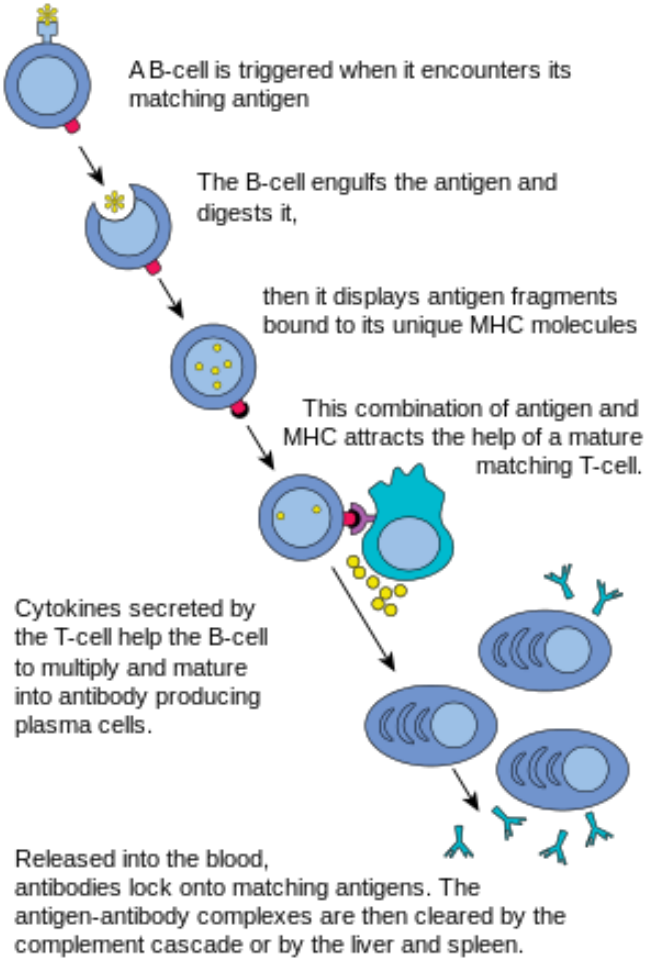
T lymphocytes

- **T helper** cells **stimulate B cells and T killer cells to divide.**
- **T killer** cells **destroy pathogen-infected cells.**

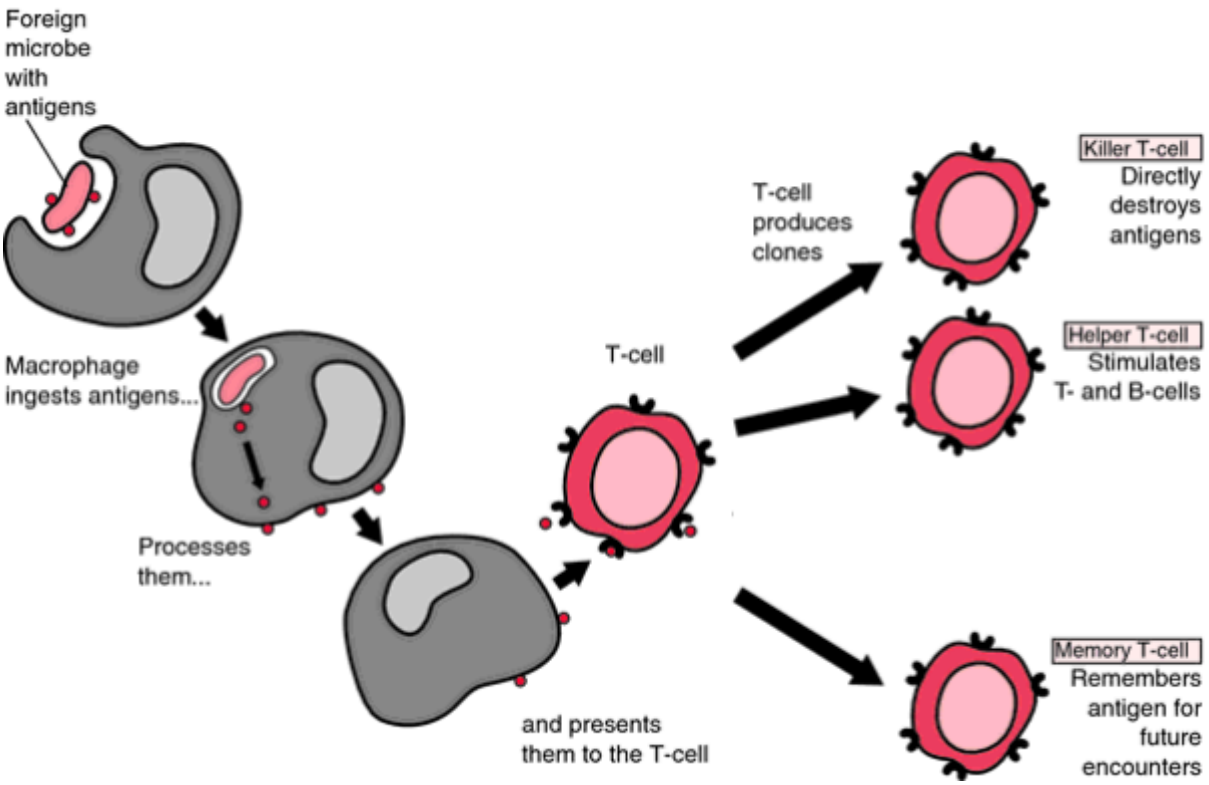
B lymphocytes

- **B effector** cells: form **clones** of plasma cells.
- **Plasma cells**: produce a **large amount of antibodies** specific to a foreign antigen.

Humoral response



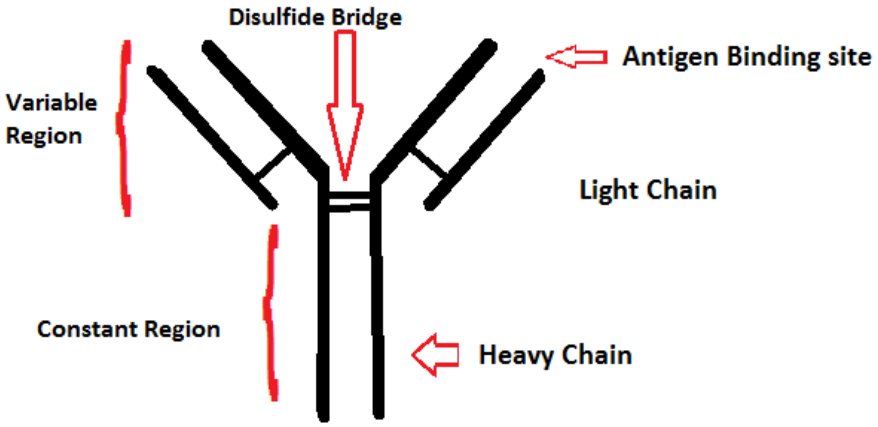
Cell-mediated response



Antibodies

Structure

- **Y-shaped glycoproteins.**
- Bind to specific antigens to trigger an immune response.
- **Two long identical polypeptide chains** and **two shorter identical chains.**
- The chains are held in place by **disulfide bridges** which also help them maintain their shape.
- Antibodies bind to the antigen via a 'lock and key' mechanism similar to enzymes.
- The variable regions of the antibodies are complementary to specific antigens.
- **Two antigen binding sites** allowing an antibody to bind to **two** antigens.



Monoclonal antibody production via the hybridoma method:

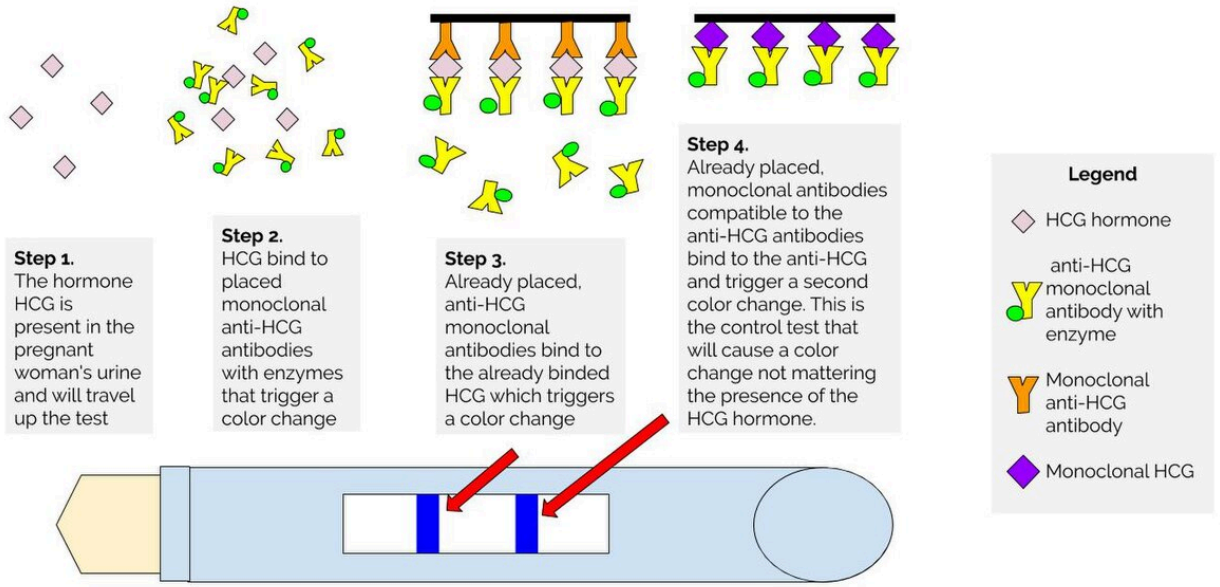
- Inject mouse with antigen. This initiates the immune response and the mouse produces antibodies specific to the antigen.
- The spleen cells that produce antibody-secreting lymphocytes are removed.
- Spleen cells bind with myeloma cells to produce hybridoma cells.
- The hybridoma cells can divide continuously to produce many antibodies. These are all specific to the original antigen.

Monoclonal antibodies can be **used in the treatment of diseases such as cancer.** Cancer cells have specific antigens on their surface, which monoclonal antibodies can bind together to form a mass. This allows cancerous cells to be easily identified and treated. Monoclonal antibodies can carry the drug to cancerous tumours or they can trigger immune responses to destroy the tumour.

Application of monoclonal antibodies in pregnancy test:

The test utilises the principle that antibodies have a **variable region** with a specific shape that is **complementary** to a specific antigen.

- **Reaction Zone:** The test stick contains free-moving monoclonal antibodies specific to hormone hCG found in the urine of pregnant women. These antibodies are typically tagged with a colored dye or enzyme.
- **Antigen Binding:** If hCG is present in the urine, it binds to these mobile monoclonal antibodies, forming antigen-antibody complexes.
- **Test Zone**: As the urine moves up the stick by capillary action, it reaches a zone where stationary antibodies are fixed in place. These also bind to the hCG complexes, trapping them in a single line. The concentrated dye creates a visible colored line, indicating a positive result.
- **Control Zone:** A second line of stationary antibodies binds to the excess mobile antibodies (regardless of hCG presence) to confirm the test is working correctly.

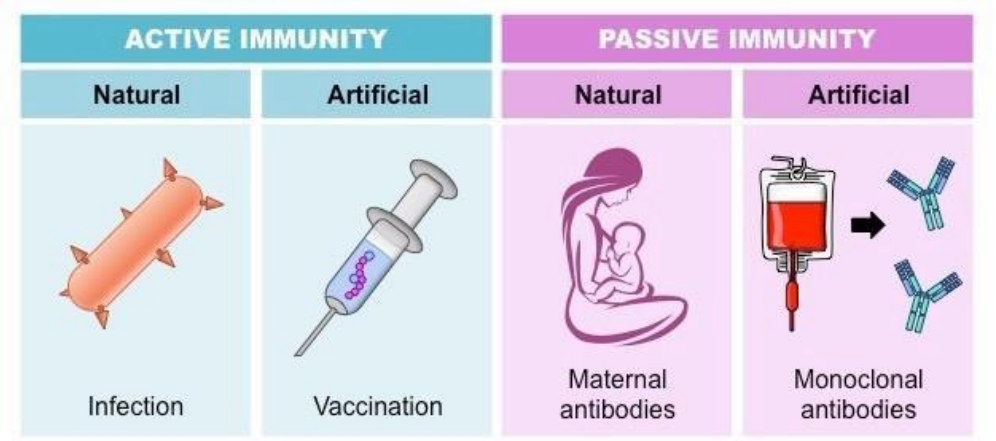


Results for a POSITIVE pregnancy test
(a negative result would show only the color change that occurs in step 4)

The same principle applies in diagnosing other diseases using monoclonal antibodies.

Immunity

Immunity can either be **active or passive**; active **immunity results from the production of antibodies by the immune system** in response to the presence of an antigen whereas passive immunity results from the **introduction of antibodies from another person or animal.** There are also two subtypes of immunity; natural or artificial.



Type of immunity	Passive immunity	Active immunity
Antibodies	Both types involve antibodies (from natural or artificial sources)	
Memory cells	No memory cells and antibodies not replaced when broken down - short-term	Memory cells produced - long-term
Effectiveness	Immediate	Time lag
Source of antibodies	External source	Lymphocytes
Direct contact	No direct contact with antigen necessary	Needs direct contact with antigen

- **Natural active immunity** arises from being exposed to an antigen/getting the disease.
- **Natural passive immunity** is the result of crossing of mother's antibodies through the placenta and their presence in breast milk.
- **Artificial active immunity** is acquired through vaccinations which stimulate the immune system and lead to production of antibodies.
- **Artificial passive immunity** is where antibodies are injected into the body.

Vaccinations

Vaccinations help provide **long-term immunity** and also help prevent **epidemics** by preventing the spread of the disease to the greater population. When a significant amount of the population is vaccinated, it also provides immunity to the individuals within the population who have not been vaccinated (**herd immunity**). Herd immunity reduces disease spread within a population.