TOPIC: ADAPTIVE IMMUNITY

Key Knowledge:

- The characteristics and roles of the components of the adaptive immune response against both extracellular and intracellular threats, including the actions of B lymphocytes and their antibodies, helper T and cytotoxic T cells

ADAPTIVE IMMUNE SYSTEM

The third line of defence against infectious disease is the adaptive immune system, which is **specific**:

- It recognises specific antigens in order to differentiate between different types of pathogens
- It produces a heightened response upon re-exposure to a pathogen (i.e. has immunological memory)

The principal components of the adaptive immune system are the lymphocytes residing in lymph nodes.

ANTIGEN PRESENTATION

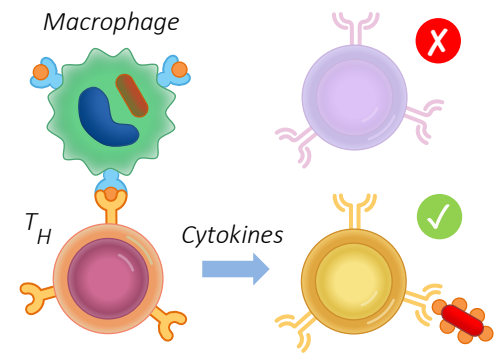
The adaptive immune system can recognise specific antigens when they are presented as a complex with molecular markers found on the surface of body cells. These markers are called major histocompatibility complex (MHC) molecules. All nucleated body cells possess **MHC class I** markers, which allow them to present internal antigens (e.g. virus particles or cancer proteins). Certain immune cells also possess **MHC class II** markers, which allow them to present external antigens acquired via phagocytosis. These antigen presenting cells include macrophages, dendritic cells and B cells. Antigens are presented to helper T cells in order to initiate an adaptive immune response (via either humoral or cell-mediated immunity).

MHC Class I
Found on all nucleated body cells *(not red blood cells)*
Presents endogenous antigens *(e.g. viral fragments or tumour proteins)*
Presents antigens to cytotoxic T cells *(initiates cell-mediated immunity)*

MHC Class II
Found on 'professional' antigen presenting cells *(macrophages, dendritic cells, B lymphocytes)*
Presents exogenous antigens *(digested fragments of foreign pathogens)*
Presents antigens to helper T cells *(initiates humoral immunity)*

CLONAL SELECTION

The body contains millions of different B and T lymphocytes that each recognise a single, specific antigen. Only the appropriate lymphocyte can be activated by a particular antigenic fragment to divide and form identical clones (clonal selection / expansion). As pathogens contain many distinct antigenic fragments on their surface, a single pathogen may stimulate several different B and T lymphocytes to form clones (this is called polyclonal activation). The proliferation of specific B and cytotoxic T cells first requires the release of **cytokines** from the appropriate helper T cell clone (helper T cells coordinate the entire adaptive immune response).

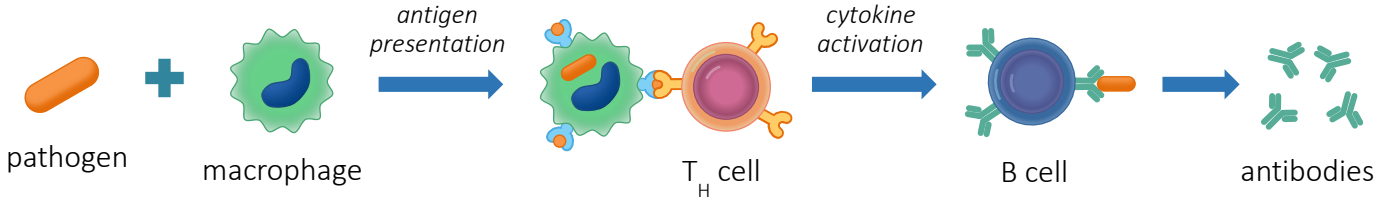


Antigen Presentation

Clonal Selection

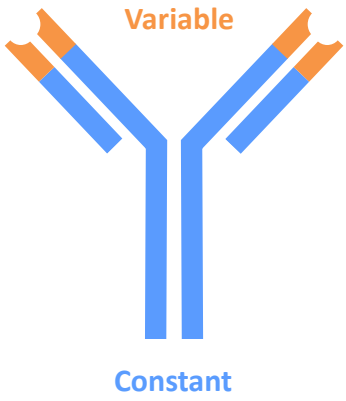
HUMORAL IMMUNITY

When the body is challenged by a foreign pathogen, phagocytic leukocytes will engulf them and present the antigenic fragments to specific helper T cells in the lymph nodes. These helper T cells will then release cytokines to activate specific naïve **B lymphocytes** that have also encounter the antigen. The B cells divide and differentiate to form a large quantity of short-lived **plasma cells** and a lesser quantity of memory cells. Plasma cells will produce antibodies that are specific to the antigen and facilitate pathogen elimination.



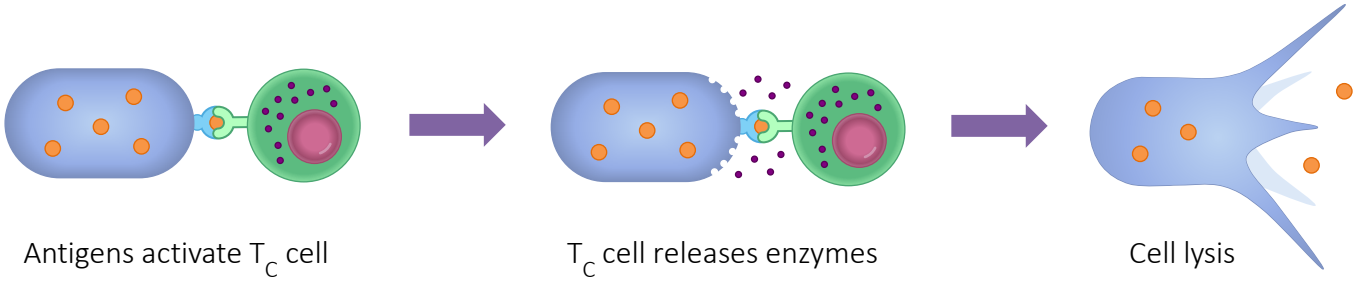
ANTIBODIES

Antibodies are proteins produced by B lymphocytes (and plasma cells) that are specific to a particular antigen. They are composed of four polypeptide chains that are connected by disulphide bonds to form Y-shaped molecules. Each antibody is composed of two heavy and two light chains, but differ in their **variable region** which is specific for a given antigen. The remainder of the antibody is constant and serves as a recognition site for immune cells. Antibodies facilitate pathogen destruction in a number of different ways, including via precipitation, agglutination and complement activation, but the primary way antibodies act to eliminate pathogens is via **opsonisation**.



CELL-MEDIATED IMMUNITY

Cell-mediated immunity occurs when body cells are infected or cancerous and need to be removed. These cells will present antigenic fragments on class I MHC markers to specific **cytotoxic T cells**. When activated by helper T cells, the cytotoxic T cell will bind to the presented antigen and destroy the compromised cell by either releasing perforating enzymes or triggering apoptosis (via the extrinsic pathway).



MEMORY CELLS

When B and T lymphocytes divide and differentiate, a small proportion of clones will differentiate into memory cells. Memory cells remain in the body for years (or even a lifetime). If a second infection with the same antigen occurs, memory cells will produce a secondary immune response that is **faster** and **more potent**, such that the symptoms of infection do not normally appear. Because the individual no longer presents with the symptoms of infection upon exposure, the person is said to have developed immunological memory and is now immune.