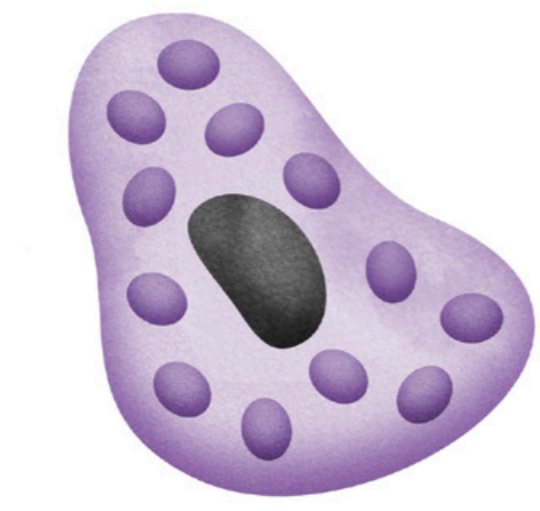


The immune response

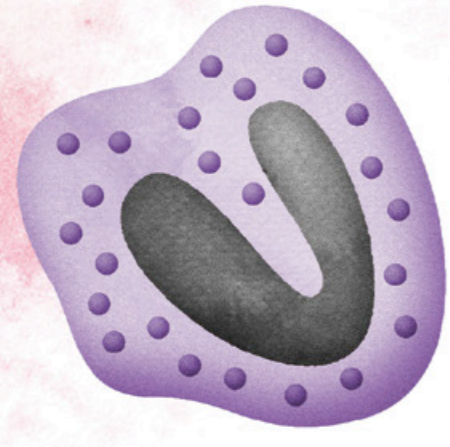
BigPicture

Non-specific (innate) immune system

Includes chemical and physical barriers (the first line of defence) and responses such as inflammation (the second line of defence). Its effects are rapid, short-lived and non-specific. Found in all multicellular organisms.



Mast cell
Cells involved in allergic responses, releasing histamine and other inflammatory molecules. Mast cells sit within skin and mucosal tissues.



Basophil
Cells involved in allergic and inflammatory responses. Basophils release histamine like mast cells, but unlike mast cells they circulate in the blood.

INFLAMMATION
Invading microbes trigger inflammation. This involves an increase in blood flow to the affected part of the body, which leads to swelling, pain and an increase in temperature. **Mast cells** and **basophils** are involved in inflammation.

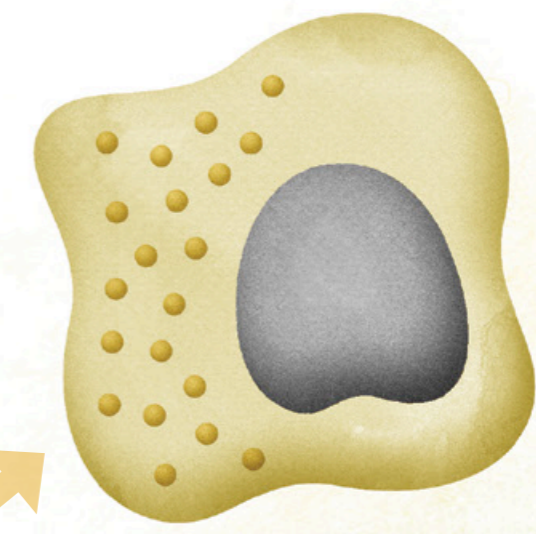
PHYSICAL AND CHEMICAL BARRIERS

- Physical barriers include the skin and the mucous membranes of the airways, guts, and urinary and reproductive systems.
- Chemical barriers include hydrochloric acid secreted by the stomach lining.

IF BREACHED

COMPLEMENT

A set of around 30 proteins in the blood plasma that can be activated by the presence of microbes or antibody-antigen complexes. **Complement** can destroy pathogens and activate phagocytic cells.



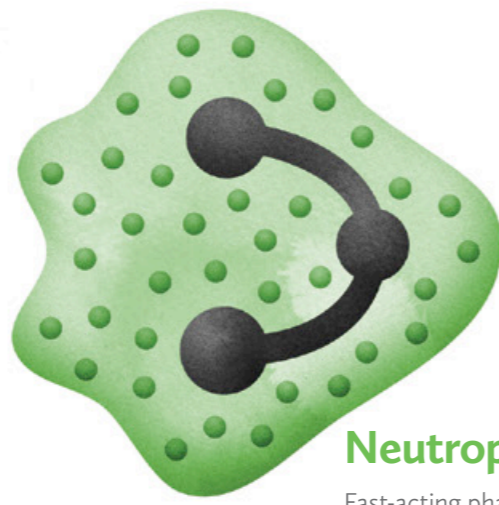
NATURAL KILLER (NK) CELLS

NK cells kill pathogen-infected cells and cancer cells. They also release chemicals called cytokines, which alert and attract other immune cells.

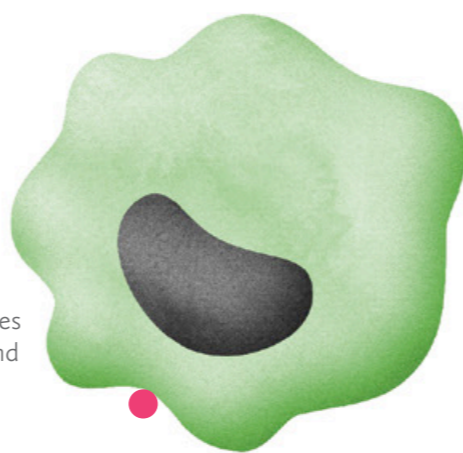


LEUKOCYTES

Made in the bone marrow, leukocytes, or white blood cells, are an important part of the immune system. There are two main types: granulocytes, which have granular cytoplasm and a lobed nucleus, and agranulocytes, which have smooth cytoplasm and a non-lobed nucleus. Leukocytes include **mast cells**, **basophils**, **macrophages**, **dendritic cells**, **neutrophils**, **eosinophils**, **B cells** and **T cells**.



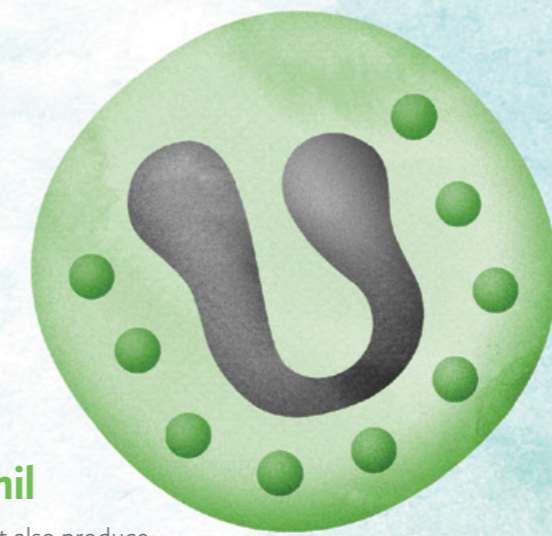
Neutrophil
Fast-acting phagocytes that flock to the site of inflammation.



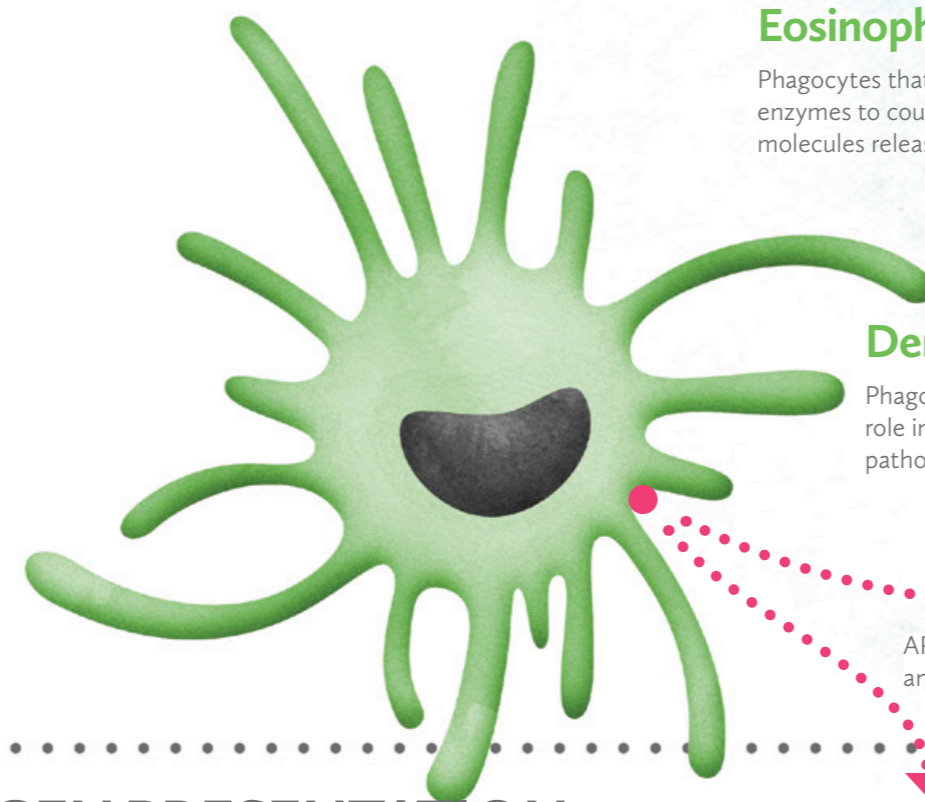
Macrophage
APCs that destroy foreign substances by phagocytosis (engulfing them) and activate other immune cells.

PHAGOCYTOSIS

White blood cells including **dendritic cells**, **macrophages** and granulocytes such as **eosinophils** and **neutrophils** engulf (or phagocytose) microbes or cells that are infected, damaged or dying. They enclose the particle or cell with a phagosome and then break down the contents with hydrolytic enzymes. Some cells then become antigen-presenting cells (APCs), which present the digested remains to other immune cells.



Eosinophil
Phagocytes that also produce enzymes to counteract the inflammatory molecules released by mast cells.



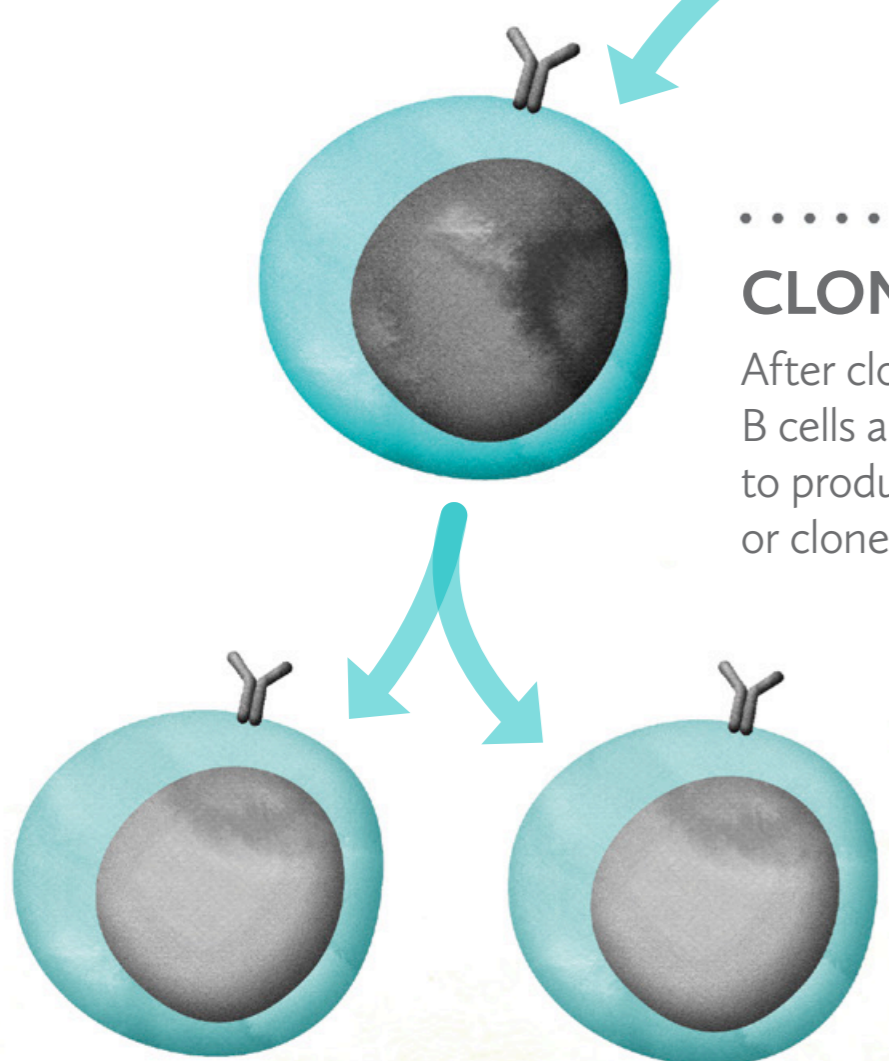
Dendritic cell
Phagocytic APCs with an important role in alerting T cells to new pathogens.

Specific (adaptive) immune system

The third line of defence against invading pathogens. In vertebrates, it provides long-lasting protection against specific pathogens or foreign substances.

LYMPHOCYTES

Agranulocyte white blood cells. Types include **B cells** and **T cells**.



Memory B cell
Long-lived B cells that remember past infections by recognising antigens to provide a secondary immune response.

Memory B cell

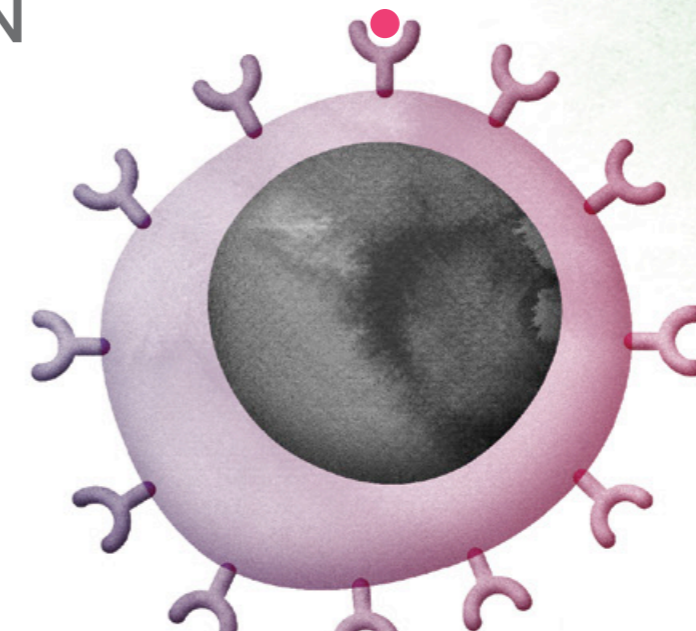
Plasma B cell

B cells that have been activated to produce antibodies. Each B cell makes only one type of antibody.

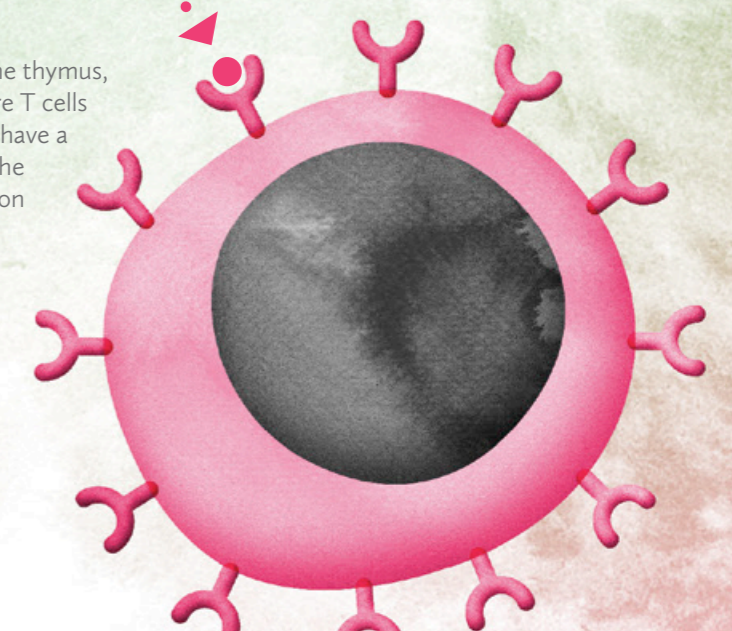
Plasma B cell

ANTIGEN PRESENTATION

Antigen-presenting cells (APCs) break up invading or non-self particles and cells and display parts of them – antigens – for other immune cells to inspect. They include macrophages and dendritic cells.



Helper T cell (CD4⁺)



Cytotoxic T cell (CD8⁺)

T cell
Named after the thymus, the organ where T cells mature. T cells have a protein called the T cell receptor on their surface.

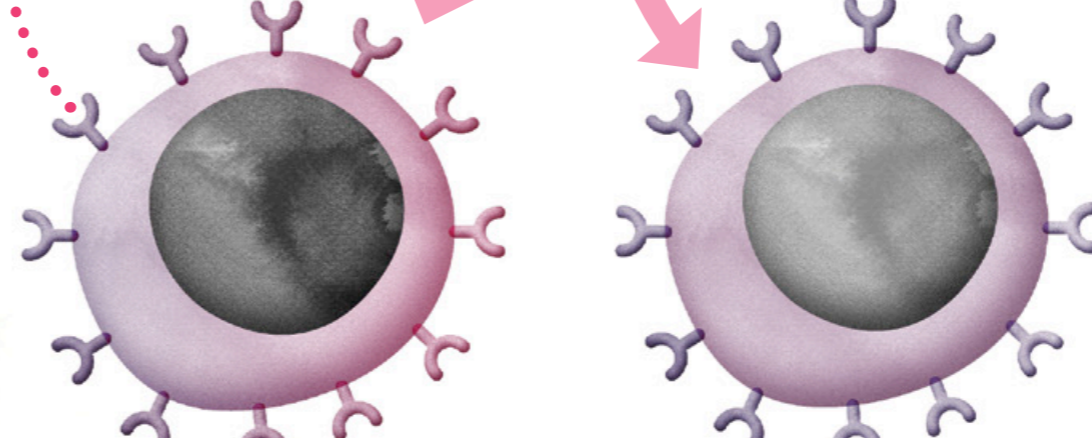
CLONAL SELECTION

The process by which a B cell and T cell specific to the antigen are selected for clonal expansion by an APC.

CLONAL EXPANSION

After clonal selection, the selected B cells and T cells divide by mitosis to produce many identical progeny, or clones.

Cytokines activate
Cytokines are proteins that act as messengers between cells. Released by immune cells, including helper T cells to signal danger or damage.



Helper T cell (CD4⁺)

Memory T cell

Memory T cell

Long-lived T cells that remember past infections to provide a secondary immune response.

Cytotoxic T cell (CD8⁺)

T cells that kill virus-infected cells and cancer cells by releasing toxic chemicals. Also known as CD8⁺ cells, because of a protein that they express on their cell surface, and as killer T cells.



Antibodies

Perforins

Proteins that cause cells to lyse (burst) by making pores form in the plasma membrane of the cell. Found in the granules of cytotoxic T cells.



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