IMMUNITY

PATHOGENS

If a pathogen gains entry to the body it could cause significant harm or even death. If they do enter, the subsequent defence mechanisms can be grouped into two types:

⇒ **Non-specific** - these defence mechanisms aren't specific to individual types of pathogens. Phagocytosis is an example of a non-specific defence mechanism

⇒ **Specific immune response** - this type of response distinguishes between pathogens and response is tailored to pathogen. SIRs involve lymphocytes, a specialised type of white blood cell.

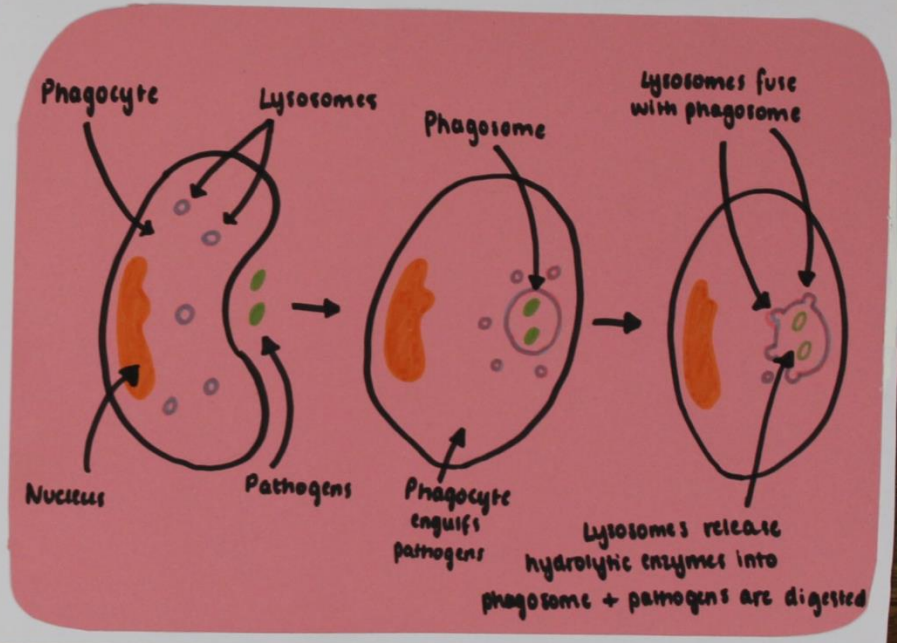
THE BODY'S BARRIERS

- **Skin** - provides a tough physical barrier that most pathogens cannot penetrate. Skin only ceases to be effective when punctured / not healthy.
- **Lysozyme** - An enzyme found in tears, saliva, sweat. It is anti-bacterial as it can hydrolyse bacteria cell walls. Tears also wash away debris + pathogens from the front of the eye.
- **Epithelial lining covered in mucus** (Eg in the respiratory tract) - Mucus traps pathogens + stops them penetrating the underlying membranes. Cilia (tiny hairs) line the respiratory tract + sweep the mucus up the trachea
- **Hydrochloric acid in the stomach** - Kills most pathogens in food we eat. Provides a low pH that denatures the enzymes of the pathogens.

Phagocytes including polymorphs (most common, 1st to arrive) + macrophages (develop from monocytes in the blood, they are larger + much longer lived than polymorphs) are able to squeeze through the capillary walls + engulf the pathogenic bacteria + surrounding cell debris at the site of the infection.

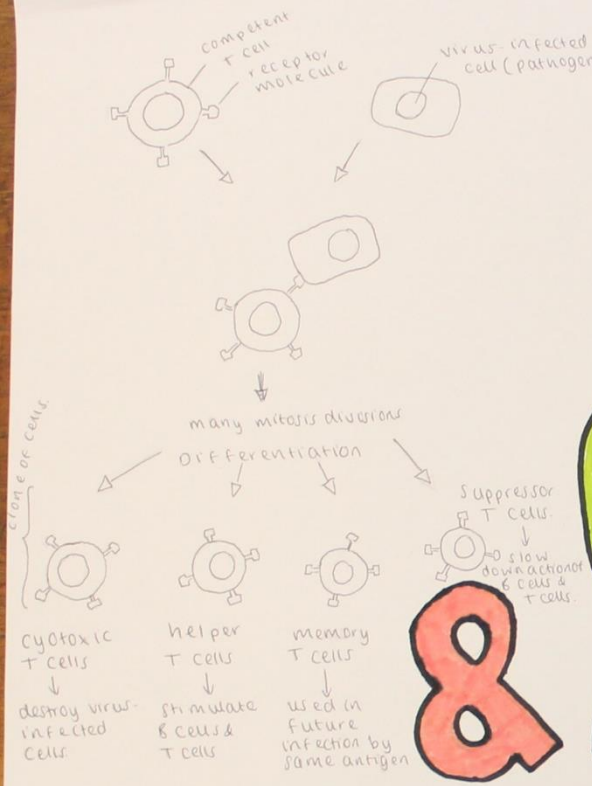
PHAGOCYTOSIS

⇒ The phagocyte moves towards the pathogen, attracted by the chemicals
⇒ Phagocyte membrane invaginates to enclose the pathogen
⇒ As pathogen is engulfed, invaginated phagocyte membrane forms a vesicle (phagosome) around the pathogen
⇒ Lysosomes move towards the phagosome and fuse with it
⇒ Hydrolytic enzymes within lysosome are released into the phagosome, onto the pathogen. These enzymes hydrolyse the pathogen
⇒ The soluble digested products are absorbed into the cytoplasm of the phagocyte



ANTIGENS & LYMPHOCYTES

by Sarah & Lucy & Zoe



Each antibody molecule has two identical antigen binding sites. These are different for each kind of antibody, which allows the antibody to recognise and attach specifically to a particular antigen. It is the sequence of amino acids at the antigen binding sites that makes the 3-D shape that fits with the specific antigen. It's like the lock and key mechanism in which an enzyme binds to its specific substrate.

In this case, an antibody-antigen complex is formed.

The antigen attachment site is known as the variable region and is specific to each antigen.

The rest of each polypeptide chain is termed the constant region, as it is common to other antibodies too.

Type of lymphocyte	Where formed?	Site of Development	Name of immune response	Nature of immune Response.
B-lymphocyte	Formed from stem cells in the bone marrow	Mature in bone marrow	Antibody-mediated immunity (humoral).	Produce antibodies which respond to antigens found in bodily fluids. Respond usually to bacterial or viral infection.
T-lymphocyte	Formed from stem cells in the bone marrow	Mature in Thymus gland (Lymph gland in the neck)	Cell-mediated immunity	respond to antigens attached to body cells. Respond usually to body cells affected by viral infection

How do lymphocytes know what is self and non-self?

There are many millions of different types of lymphocytes, each having receptors with a complementary shape to a potential antigen. In the foetus, these lymphocytes frequently make contact with other foetal (self) cells. Lymphocytes frequently are complementary in shape to foetal cells and are 'switched off' so by the time the baby is born, the functional lymphocytes that remain are those that are not complementary to self cells. However, because there are many million functional lymphocytes remaining there are only a few of each type. This is part of the reason why the specific immune response is relatively slow.

Self & Non-Self

Foreign cells are not recognised by the body, if detected they will produce an immune response.

It is specific molecules / clusters of molecules that form part of cell surface membrane that are recognised as foreign.

molecules are often protein, but can be: - polysaccharides, - glycoprotein, - glycolipid. → collectively referred to as ANTIGENS

Different pathogens have different antigens.

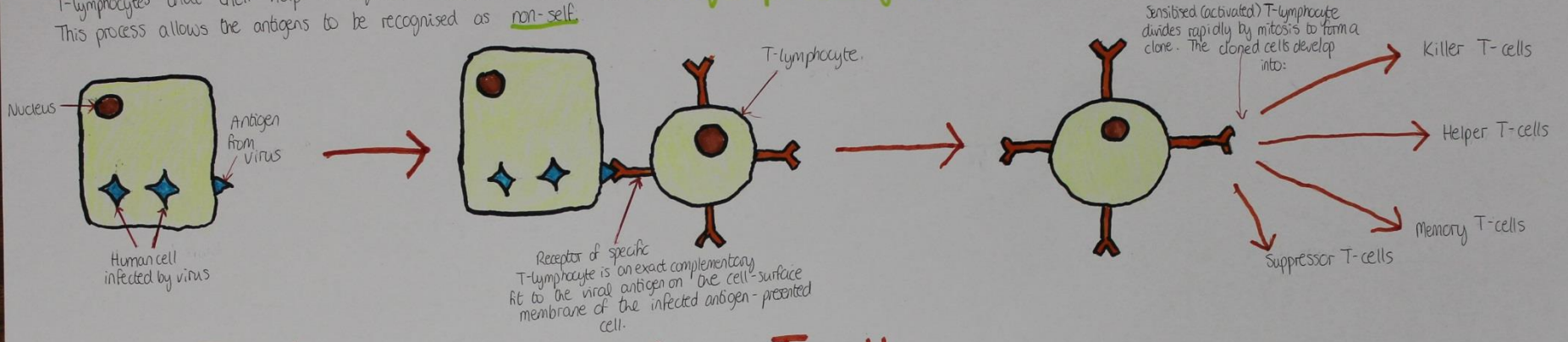
the immune response is specific to these antigens

The specific response is due to the lymphocyte having a receptor on its cell surface membrane that is complementary in shape to antigen

Antigen + lymphocyte fit together like lock + key.

Cell-mediated Immunity

- T-lymphocytes do not produce antibodies but are used directly against infected host cells, this can include working against cancerous tumour cells + transplanted tissue.
- Body cells that are infected with a bacterium/virus, place molecules from the pathogen in their cell surface membranes and this acts as a signal to T-lymphocytes that their help is required → these are known as **antigen presenting cells**; another example of this type of cell are macrophages (phagocytes). This process allows the antigens to be recognised as non-self.



Helper T-cells

- Helper T-cells **bind** with the antigen presenting cell and thereby stimulates other cells to be involved in the immune response.
- Promote the process of phagocytosis by stimulating macrophages (it would be slow without this).
- They attach **opsonins** to the pathogens that mark them out for attention of phagocytes.
- Secrete protein interferon that helps limit the ability of viruses to replicate.

NOTE: Helper T-cells co-ordinate the entire immune response, the HIV virus destroys these cells resulting in the complete breakdown of the immune system that leads to AIDs.

Killer T-cells

- Killer (cytotoxic) T-cells destroy infected cells by attaching to the antigens on the cell-surface membrane and producing chemicals that destroys the cell.

This includes:

- **protein perforin** (an enzyme) which punches holes in the cell-surface membrane.
- **nitric acid** that is directly toxic to cells.

- This destruction is less specific than the B response.

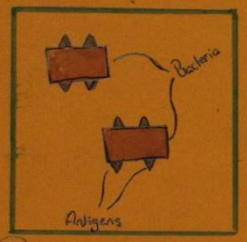
Memory T-cells

- these cells circulate in body fluids and can respond rapidly to future infection by the same pathogen (presenting the same antigen(s)).
- if a subsequent infection occurs, as the memory cells are already ~~in~~ sensitised they can very rapidly produce a large clone of T-lymphocytes.

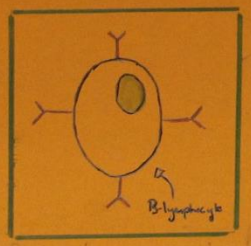
Suppressor T-cells

- Block immune responses so dampen the immune response to stop the reaction continuing after the threat has ended.

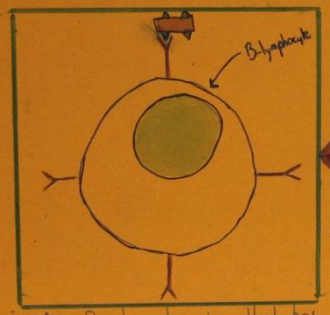
ANTIBODY MEDIATED IMMUNITY



Bacteria enter the blood stream or body fluid



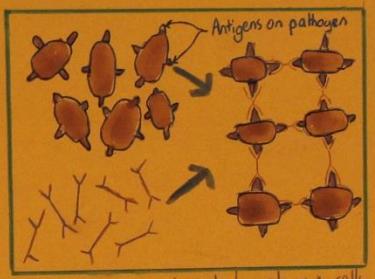
There are millions of different types with unique receptors



A B-lymphocyte that has a receptor with the **exact complementary** fit to the bacterial antigen is sensitised

Divides by **mitosis**

Plasma Cells



Antibody - antigen complex immobilises pathogens

Antibodies produced by plasma cells and complementary in shape to the pathogen antigens

Divides by **mitosis**

Memory Cells

* Can live for many years
* Inactive unless stimulated by presence of the same antigen
* Divide rapidly & produce vast numbers of plasma cells
* Provide a guarantee of long-term protection
* Involved in secondary immune response

TYPES of Immunity

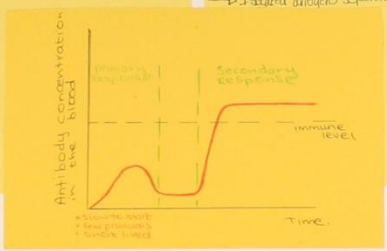
ACTIVE

Natural

- Develops through having had the disease
- primary response is slow as B-cells have to produce antibodies so individual feels ill.
- Secondary response is faster and produces more antibodies due to memory cells produced in first response.

AQUIRED (artificial)

- Vaccination contain killed or weakened pathogens which contain the antigens required to produce the immune response.
- They also contain modified toxins produced by the pathogen. The toxins must be modified to be harmless but unchanged so that they do not produce an immune response
- Isolated antigens separated from the pathogen itself



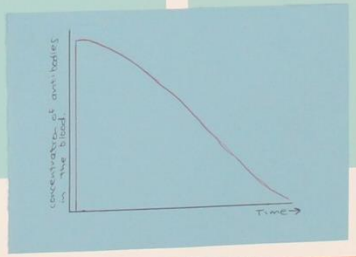
PASSIVE

Acquired (artificial)

- antibodies made in another individual, harvested and injected into another person.
- antibodies obtained from individuals recovering from illness
- these individuals will have high levels of the required antibody in their blood

Natural (innate)

- antibodies passing from mother to baby across the placenta and in the mother's milk (colostrum)
- this is crucial in the very early stages of life when the baby's immune system is still developing



TRANSPLANTS + BLOOD TRANSFUSION

The Rhesus System

Rhesus negative people don't have antigen D but can produce anti-D antibodies.
Rhesus positive people have antigen D and no anti-D antibodies, and will not produce them either.

Transplant Rejection.

- T lymphocytes are stimulated by non-self antigens present in the transplanted tissue.
- These T-cells are cloned by mitosis to produce killer T cells.
- The killer T cells destroy the transplanted cells

Agglutination

Antibodies complementary to the antigens on the surface of RBCs form complexes and then form clumping of Red Blood Cells.

BLOOD GROUP OF DONOR	BLOOD GROUPS OF RECIPIENTS.			
	A	B	AB	O
A	no reaction	agglutination	no reaction	agglutination
B	agglutination	no reaction	no reaction	agglutination
AB	agglutination	agglutination	no reaction	agglutination
O	no reaction	no reaction	no reaction	no reaction

During birth (or late pregnancy) some foetal red blood cells (rhesus positive) leak into the mothers circulation

↓

The mothers immune system will respond by producing the anti-D antibodies — by the time they are in significant numbers the baby will have been born

→ During subsequent pregnancies, the antibodies can cross the placenta and cause agglutination of foetal red blood cells, a condition known as haemolytic disease of the newborn

Blood Transfusion

Erythrocytes also have antigens on the cell surface membrane. The blood will not have antibodies that correspond to the antigens.

The type of antigens varies → In the ABO system there are 4 types: A, O, AB, O. This is an example of POLYMORPHISM.

The blood transfusion must be compatible eg... A can be donated to A as it contains anti B antibodies. A cannot be donated to B as it has compatible antigens → causing clumping

Reducing Transplant Rejection

- Tissue typing - Matching the donor and recipient antigens.
- Immunosuppression - Use of drugs to inhibit DNA replication / cloning of lymphocytes
- X-rays - irradiation of bone marrow or lymph tissue thus inhibits lymphocyte production

Group O doesn't have A or B antigens. So blood group O is referred to as the universal donor.

Blood group AB lacks both anti a and anti b antibodies. So blood group AB is referred to as the universal recipient.