Section 6.1 – Defence mechanisms

Defence mechanisms

Non-specific – mechanisms that do not distinguish between one type of pathogen and another, but respond to all of them in the same way. These mechanisms act immediately and take two forms:

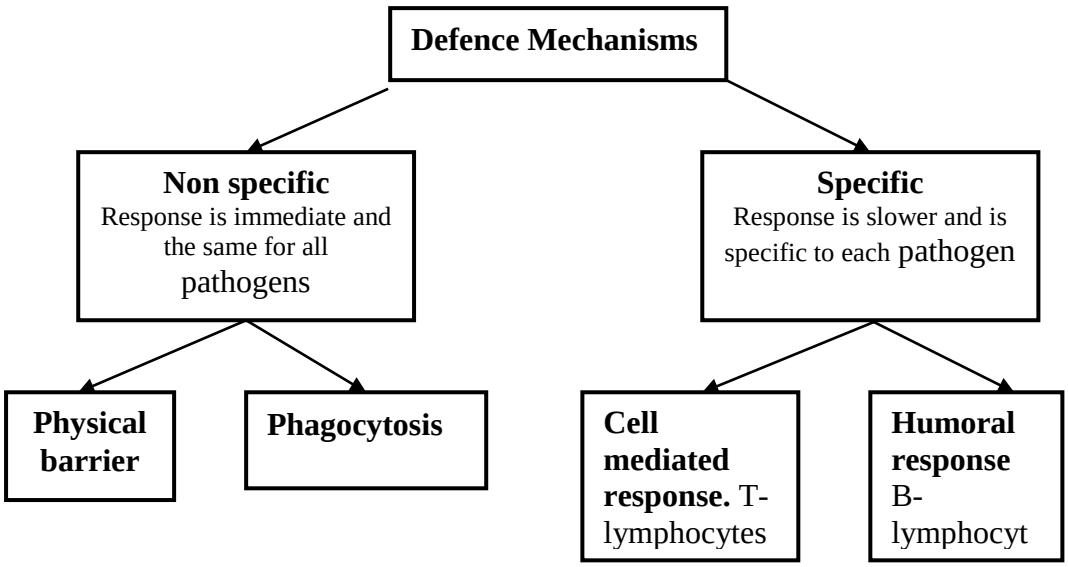
A) barrier of entry
B) phagocytosis

Specific – Mechanisms that do distinguish between different pathogens. The response is less rapid but provides long lasting immunity. The response involves a type of white blood cell called a lymphocyte and can take two forms:

A) cell mediated response (T-lymphocytes)
B) Humoral responses (B-Lymphocytes)

Recognising your own cells

Lymphocytes must be able to distinguish between pathogens and the bodies own cells. If they did not, they would destroy the body's tissue.



- T-lymphocytes already exist within the body.
- There is over 10 million different types of T-lymphocytes.
- Given that there are so many different types of lymphocyte in the body. There is a high probability that when a pathogen enters the body the antigen on its surface will be complementary to a specific lymphocyte.
- There are very few of each lymphocyte so response to an infection is slow.

Section 6.2 – Phagocytosis

There are two different types of white blood cells. There are phagocytes and lymphocytes.

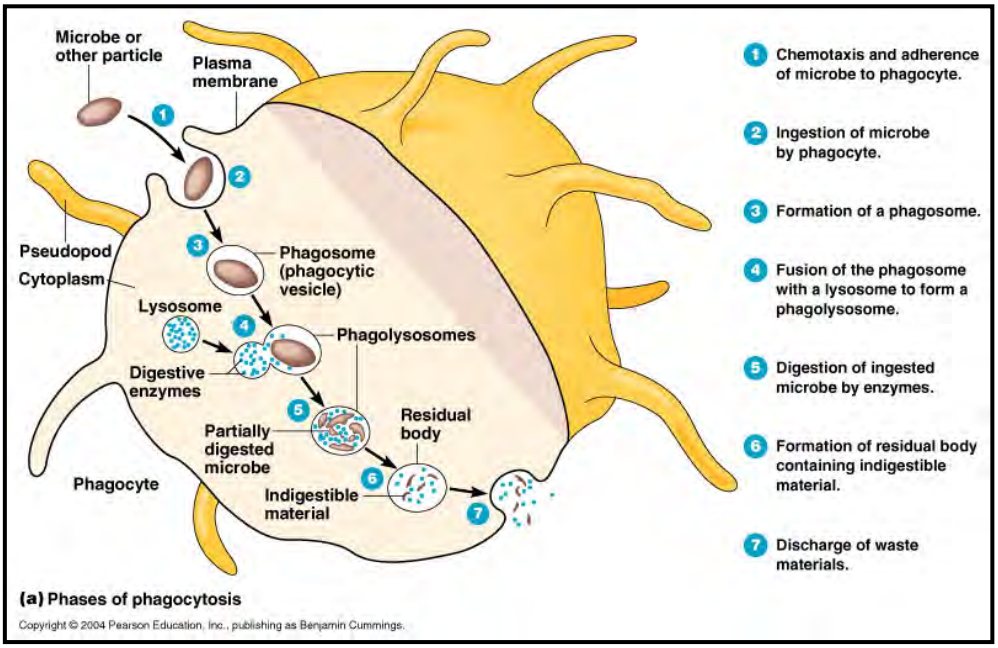
Phagocytes ingest and destroy pathogens by a process called phagocytosis.

Barriers of entry

- **A protective covering –** The skin covers the body's surface, creating a barrier that is hard for pathogens to penetrate.
- **Epithelia covered in the mucus** – Many epithelia produce mucus. In the lungs pathogens are often caught in the mucus and moved by the cilia.
- **Hydrochloric acid in the stomach** – Provides a low pH that denatures the pathogens enzymes.

Phagocytosis

- Pathogens are engulfed by phagocytes in the form of vesicles which are formed on the cell-surface membrane.
- Chemical products of the pathogen act as attractants which draw the phagocyte towards it.
- Phagocytes attach themselves to the surface of the pathogen.
- They engulf the pathogen to form a vesicle known as a "**phagosome**".
- Enzymes within the Lysosomes join with the phagosome and release their contents. The enzymes within the Lysosomes digest the pathogen.
- The soluble products of the pathogen are absorbed into the cytoplasm of the phagocyte



Section 6.3 – T cells and cell-mediated immunity

Antigens

An antigen is any part of an organism or substance that is recognised as foreign and stimulates a response from the immune system.

Antigens are normally proteins that are part of the organism's cell-surface membrane.

Lymphocytes

B –Lymphocytes are associated with humoral immunity i.e. immunity involving antibodies that are present in the body's fluids, or "humour".

T – Lymphocytes are associated with cell-mediated immunity i.e. immunity involving body cells.

Both types of lymphocytes are formed from stem cells in the bone marrow.

Cell-mediated immunity

T – Lymphocytes can distinguish foreign material from the bodies own tissue because:

Phagocytes have engulfed and broken down a pathogen and have presented some of its antigens on its own cell-surface membrane.

Body cells that have been invaded by a virus also manage to present some of the virus' antigens on its surface as a sign of distress.

Cancer cells also present antigens on its cell-surface membrane.

T-Lymphocytes only respond to antigens that are attached to a body cell. This type of response is called "cell-mediated immunity".

A) Pathogens invade body cells or are taken in by phagocytes.

B) The phagocyte places the antigen on its own cell-surface membrane.

C) Receptors on certain T helper cells fit exactly onto these antigens.

D) This stimulates other T cells to divide rapidly by osmosis to form a clone.

E) The cones T cells:

a) Develop into memory cells that provided rapid response in the future.
b) Stimulate phagocytes to engulf the bacteria by phagocytosis.
c) Stimulate b cells to divide
d) Kill infected cells

T cells do not kill cells by phagocytosis. Instead, they produce a protein that makes a hole in the pathogen or infected cells. The hole then makes the cell freely permeable to all substances and quickly dies as a result.

Section 6.4 – B cells and humoral immunity

Humoral immunity is so called because it involves antibodies which are soluble in the blood and tissue fluid, also called "humour".

A typical pathogen may have more than one type of antigen on its surface.

Toxin molecules will also act as an antigen.

Each B cell develops into two different types of cell:

Plasma cells secrete antibodies directly. They only live for a few days but produce more than 2000 antibodies every second. This is known as the **primary immune response**

Memory cells live for decades in some cases. When they encounter the same antigen they divide rapidly into plasma cells and more memory cells. The memory cells provide long term immunity. This is known as the **secondary immune response.**

1. The surface antigens of the invading pathogen are taken up by the B cells.

2. The B cells process the antigens and present them on their surface.

3. T helper cells attach to the processed antigens and B cells thereby activating them.

4. The B cells are now activated to divide by mitosis to give a clone of the plasma cells.

5. The cloned plasma cells produce antibodies that exactly fit the antigens on the pathogens surface.

6. The antibodies attach to antigens on the pathogens and destroy them. This is the primary immune response.

7. Some B cells develop into memory cells. These can respond to future infections by the same pathogen by dividing rapidly and developing into plasma cells that produce antibodies. This is the secondary immune response.

Antigenic Variability

The antigens that pathogens are made of, and the ones they produce are constantly changing, this is known as antigenic variability. This explains why it is possible to get the same diseases more than once. Influenza for example has many different strains and so when a new strain enters the body, its antigens are not complimentary to the antigens or the memory cells produced from the last infection. Due to this the most use its primary immune response.

Section 6.5 – Antibodies

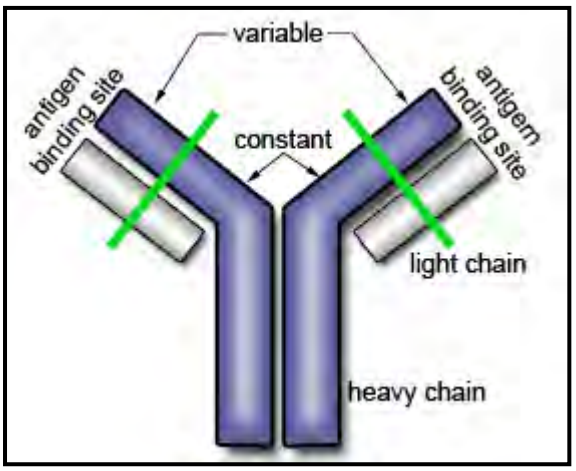
Antibodies are proteins synthesised by B cells.

Antibodies react with antigens by binding with them.

Structure

Antibodies are made up of four different polypeptide chains.

The chains of one pair are long and are called heavy chains, while the other pair have shorter chains and are called light chains.



Antibodies have a binding site that is very specific to the antigen once together they form and antigen-antibody complex

The binding site is different for all antibodies and is known as the variable region.

The rest of the antibody is the same and is called the constant region.

Monoclonal antibodies

A pathogen entering the body is likely to have hundreds of different antigens on its surface. Each antigen will induce a different B cells to divide and clone its self. Each clone will produce a different antibody known as a polyclonal antibody.

Antibodies that can be isolated and cloned are called monoclonal antibodies.

Monoclonal antibodies have a number of uses such as:

The separation of a chemical from a mixture

Immunoassay- this is the method of calculating the amount of substance in a mixture. It is used in pregnancy testing kits, testing for drugs in the urine, and detecting the immunodeficiency virus (aids test)

Cancer treatment – it is possible to manufacture monoclonal antibodies that will attach themselves to cancer cells. They will then activate a cytotoxic drug that will kill cells. This drug will only be activated by cells to which the antibody is attached.

Transplant surgery – Even with close matching the transplanted tissue will experience some rejection from the T – cells. Monoclonal antibodies can be used to knock out these T – Cells.

Section 6.6 – Vaccination

Passive immunity is produced by the introduction of antibodies into individuals from an outside source. As the antibodies are not being produced by the individuals themselves, they are not being replaced when they are broken down in the body and so the immunity is generally short-lived.

Active immunity is produced by stimulating the production of antibodies by the individuals own immune system. In is generally long-lasting.

Vaccination is the injection of a substance into the body with the intention of stimulating active immunity.

Features of a successful vaccination program

- The success of a vaccination program depends on a number of factors:
- A suitable vaccine must be economically available in sufficient quantities
- There must be very few if any unpleasant side effects from the vaccine.
- Means of producing, storing and transporting the vaccine must be available.
- There must be the means of administrating the vaccine at the right time.
- It must be possible to vaccinate the vast majority of the vulnerable population.

Why vaccination does not eliminate a disease

- Vaccination fails induce immunity amongst some individuals.

- Individuals may develop the disease immediately after vaccination but before their immunity levels are high enough to prevent it.

- Pathogens may mature rapidly so that their antigens change suddenly rather than gradually. This is due to the antigenic variability.

- There may be many varieties of a particular pathogen.

- Certain pathogens can hide from the body's immune system by hiding themselves with cells or by living in places that are out of reach.

The problems of controlling cholera and tuberculosis by vaccination

- Cholera is an intestinal disease and is not easily reached by the immune system.

- The antigens on the cholera surface change rapidly.

- The increasing amounts of people with HIV has led to more people having impaired immune systems and so are more likely to contract TB.

- The proportion of elderly people in the population is increasing. These people have less effective immune systems and so vaccination is less effective at stimulating immunity.