

OCR (A) Biology A-level

Topic 4.1: Communicable diseases, disease prevention and the immune system

Notes



Pathogens

Bacteria and viruses are the main disease causing pathogens in humans. Even though they both cause disease, they vary in many ways. Their differences are as following:

Bacteria are prokaryotic cells meaning that they have no membrane bound organelles and, as such, do not have a nucleus – their genetic information is stored in the form of a **circular strand of DNA** whereas **viruses consist of just nucleic acid enclosed in a protein coat** and their genetic material can take the form of **DNA or RNA**

- **Bacteria do not require a host to survive** whereas **viruses are entirely dependent on their hosts** and cannot survive without them
- Viruses are **significantly smaller** than bacteria
- Bacteria have a cell membrane, cell wall and cytoplasm as well as other organelles such as ribosomes, plasmids, flagellum and pili whereas **viruses possess no such structures.**

An example of a bacterial disease is **tuberculosis** also known as **TB**. TB is caused by a bacterium called *Mycobacterium tuberculosis* which infects **phagocytes** in the lungs. The first infection is symptomless as the infected phagocytes are sealed in **tubercles** as a result of **inflammatory response** in the lungs. However, the bacteria lie **dormant** inside the tubercles as they are not destroyed by the immune system as tubercles are covered with a **thick waxy coat**. When the immune system becomes weakened, the bacteria become active again and slowly destroy the lung tissue thus leading to **breathing problems, coughing, weight loss as well as fever**. TB can potentially lead to death.

Meningitis can be caused by bacterial infection of the meninges (a set of protective membranes around the brain).

An example of a viral infection is **HIV i.e. Human Immunodeficiency Virus** which causes **AIDS**. The first symptoms of HIV include **fevers, tiredness and headaches**. After several weeks **HIV antibodies** appear in blood thus making a person HIV positive. After this period, the symptoms disappear until the **immune system becomes weakened** again thus leading to **AIDS**.

Another viral disease is **influenza** whereby the virus infects the ciliated epithelial cells of the gas exchange system. There are different strains of influenza

Examples of diseases caused by other organisms include **Athlete's foot** in humans which is caused by a **fungus** and is **spread by direct contact with the spores** on the skin surface or other surface and **Malaria** is an example of **indirect transmission** via **vector** in the form of a **female Anopheles mosquito**.



Plants are not immune to becoming infected. **Tobacco mosaic virus** infects tobacco plants, a major crop worldwide. **Potatoes** can be affected by **blight** which is caused by a **fungus** and **bananas** can also be affected by **fungus** causing **Black Sigatoka**

Plant defences against pathogens

Plants have evolved **defences against pathogens** which can either take the form of **physical** or **chemical defences**.

Physical barriers of pathogen entry include **cellulose cell walls**, a **lignin layer** which thickens the cell walls and **waxy cuticles**. **Old vascular tissue is also blocked** to prevent the spread of pathogens inside the plant.

In a case where a pathogen is detected, various mechanisms are activated to prevent the spread of infection through the plant. This includes **closing of the stomata** to prevent entry to leaves, additional **thickening of cell walls** with cellulose, **callose deposits between cell wall and cell membrane** near the site of infection to strengthen the cell wall.

Other mechanisms include **necrosis** which is when **cells near the site of infection are killed with the help of intracellular enzymes** which are activated by injury, that is in a case where cell damage occurs.

Another variation of necrosis is known as **canker** and this is the **necrosis of woody tissue in the main stem or branch**.

Chemical defences include **menthols** produced by mint which are an example of **terpenoids**- these are essential **oils with antibacterial properties**. Other examples include **phenols** such as tannin which interfere with digestion thus inhibiting insects from attacking the plant, **alkaloids** such as **caffeine** and **morphine** which have a bitter flavour- preventing herbivores from feeding on the plant. **Defensins** are cysteine-rich proteins involved in **inhibition of transport channels** whereas **hydrolytic enzymes** such as **chitinases** are released with the purpose of breaking down the cell wall of an invading organism.

Primary non-specific defences in animals

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 **compete with pathogens** for food and space

Non-specific responses of the body to infection include:

- **Inflammation** – histamines released by mast cells in injured tissue cause vasodilation which increases the flow of blood to the infected area and increases permeability of blood vessels. As a result of that antibodies, white blood cells and plasma leak out into the infected tissue and destroy the pathogen



- **Lysozyme action** – lysozyme is an enzyme found in secretions such as tears and mucus which kills bacterial cells by damaging their cell wall
- **Interferon** – interferons prevent viruses spreading to uninfected cells by stopping protein synthesis in viruses
- **Phagocytosis** is a process in which white blood cells engulf pathogens thus destroying them by fusing a pathogen such as bacteria enclosed in a phagocytic vacuole with a lysosome.
- **Blood clotting** which reduces the blood loss by temporarily sealing the opening thus preventing entry of pathogens

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** which activates other types of immune cells, immune response will be stimulated if the antigen is recognised as foreign.

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 **cell mediated response**

Specific immune response glossary:

- **Memory cells** are cells which replicate themselves when exposed to an invading pathogen and remain in the lymph nodes searching for the same antigen thus resulting in a much **faster immune response**
- **B effector/plasma** cells are **antibody producing** cells
- **T helper** cells **stimulate B cells and T killer cells to divide**
- **T killer** cells **destroy pathogen infected cells**



Humoral response

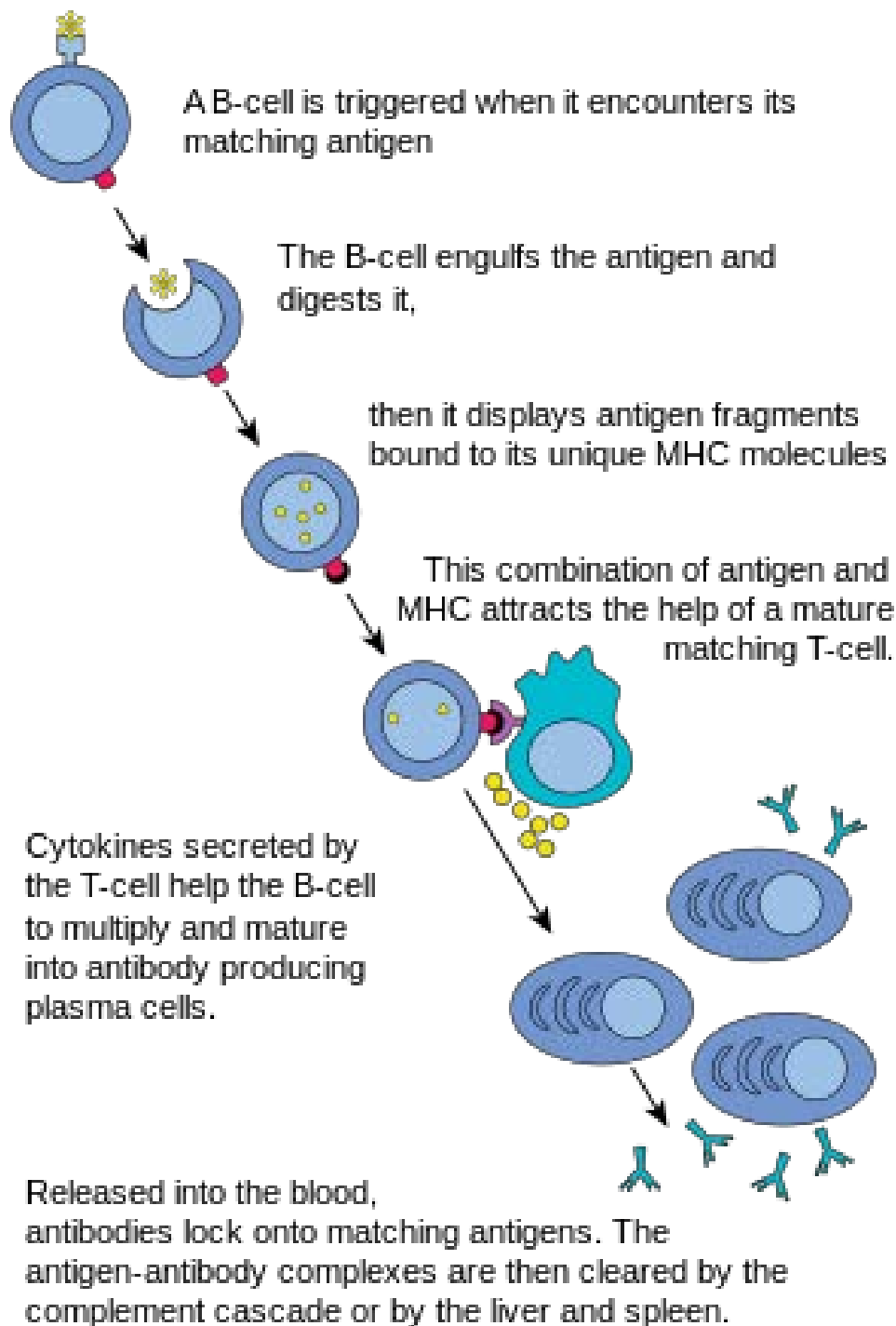


Figure 1 Wikipedia



Cell mediated response

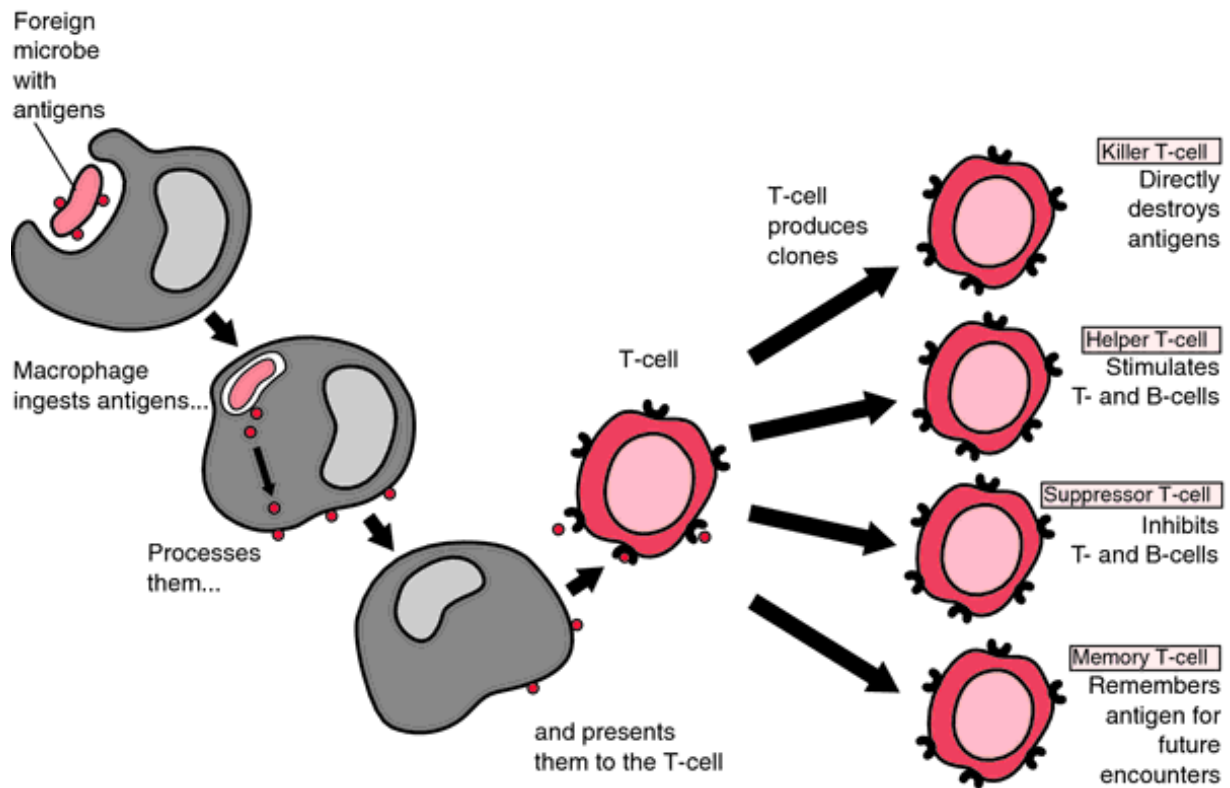


Figure 2 Socratic

Antibodies

Antibodies are **globular protein molecules** produced by **lymphocytes**. Antibodies are **complementary in shape to a specific antigen**, to which they attach and subsequently inhibit its action. This process is known as **neutralisation** and can occur in a number of ways, such as **facilitating binding** of phagocyte to pathogen, **agglutination** which is where several antibodies bind together as well as **neutralisation** of toxins released by the pathogen.

Antibodies are composed of **four polypeptide chains**, which are linked together by **disulphide bridges**. All antibodies possess a region known as the **constant region** which is involved in phagocyte interaction to stimulate phagocytosis. Antibodies also possess a **variable region** which differs for each type of antibody, of varying amino acid sequence which is responsible for the specificity of antibody for one particular antigen. All antibodies also contain **hinge regions responsible** for flexibility of the branches, which is important for binding to multiple pathogens.



Types of 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:

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

Antibiotics

Antibiotics can also be used to fight infection by killing the bacteria and stopping their growth. There are two types of antibiotics:

- **Bactericidal antibiotics** kill bacteria by destroying their cell wall thus causing them to burst
- **Bacteriostatic antibiotics** which inhibit the growth of bacteria by stopping protein synthesis and production of nucleic acids so the bacteria can't grow and divide

However, some bacteria become **resistant** to antibiotics as a result of **natural selection**. The bacteria which are not killed by the antibiotic possess a **selective advantage** – resistance which enables them to survive and reproduce. Therefore, the allele for **antibiotic resistance** is passed onto their offspring thus creating a **resistant strain**.

Resistance to antibiotics results in **antibiotic resistant bacterial infections in hospitals** such as **MRSA**. Hospitals have developed various ways of controlling the spread of antibiotic resistant infections, for example:

- New patients are **screened** at arrival, isolated and treated if they are infected to prevent the spread of bacteria between patients
- **Antibiotics are only used when needed and their course is completed to ensure that all the bacteria are destroyed** and to **minimise the selection pressure** on bacteria to prevent resistant strains from forming
- All staff must follow the code of practice which includes **strict hygiene regimes** such as **washing hands with alcohol based antibacterial gels** and wearing suitable clothing which **minimises the transmission of resistant bacteria**

