

9.4 – The Search for Better Health:

1. What is a healthy organism?

- *Discuss the difficulties in defining the terms 'health' and 'disease':*
 - 'Health' is difficult to define as health has many components, such as physical, mental, and social, some of which are very subjective
 - 'Disease' is also difficult to define, as it also has many components. Because it is describing a state of impaired functioning, it depends on an organism's normal level of functioning, and what they expect their quality of life to be.
 - Definitions:
 - **Health:** A state of complete physical, mental and social health, and not merely the absence of disease or infirmity.
 - **Disease:** A state of impaired functioning of an organism, including impaired physical, social and mental functioning.
- *Outline how the function of genes, mitosis, cell differentiation and specialisation assist in the maintenance of health:*
 - **Genes:**
 - Genes control the production of proteins in the body (needed for proper functioning) and so healthy genes ensure the correct proteins are made.
 - Through production of proteins (especially enzymes), genes ensure the correct cell processes occur, maintaining metabolism and homeostasis.
 - **Mitosis:**
 - Mitosis is the process that enables genetic material to be copied exactly, ensuring the genes are correct and able to maintain health in their own way
 - Mitosis is also the process that organisms use to grow, and maintain and repair body cells, maintaining health
 - **Cell Differentiation and Specialisation:**
 - These 2 processes result in cells which are specialised for specific functions in the body, such as red blood cells, etc.
 - Together, all the specialised body cells work together in a coordinated way to maintain the health and proper functioning of the organism.

- *Use available evidence to analyse the links between gene expression and maintenance and repair of body tissues:*
 - A healthy organism is the result of:
 - The correct functioning of genes
 - The production of perfect copies of genetic material by mitosis
 - The expression of genes in cell specialisation and differentiation
 - The body's cells are always being replaced all the time, so the correct specialised cells must be produced to replace them.
 - This is done through mitosis, followed by gene expression.
 - Healthy cells have their cell cycle regulated by proteins that are produced by different types of genes
 - **DNA repair genes** ensure that the DNA is accurately copied
 - 2 genes that regulate the cell cycle are:
 - **Proto-oncogenes:** These produce proteins that stimulate division
 - **Tumour suppressor genes:** These produce proteins that stop division
 - In healthy cells, these two are balanced
 - In *unhealthy* cells:
 - Mutated proto-oncogenes are called **oncogenes** and cause uncontrolled cell division (cancers)
 - Mutated tumour suppressor genes lose their ability to control cell division. The rate of cell division increases and uncontrolled growth occurs – this also leads to cancers.

2. Over 3000 years ago the Chinese and Hebrews were advocating cleanliness in food, water and personal hygiene:

- *Distinguish between infectious and non-infectious disease:*
 - Infectious Disease:
 - Caused by an invasion of the body by PATHOGENS.
 - A **pathogen** is an infectious agent that causes disease
 - The disease can be transferred from one organism to another
 - Pathogens can be microscopic or macroscopic
 - E.g. viruses (influenza), bacteria (tonsillitis), protozoans (malaria), prions (CJD), fungi (tinea).
 - Non-infectious Disease:
 - Involves no pathogens
 - There is no transfer of the disease from one organism to another
 - Eg:
 - **Inherited** (genetic) disease: Down's Syndrome, haemophilia
 - **Nutritional** disease: scurvy, beriberi, kwashiorkor
 - **Environmental** disease: skin cancer, asbestosis
- *Explain why cleanliness in food, water and personal hygiene practices assist in control of disease:*
 - *Cleanliness in Food:*
 - Contaminated food is a source of pathogens (such as salmonella), and can very readily spread diseases
 - But microbes in food only become a health risk when they are allowed to multiply and reach large numbers
 - Modern methods to reduce the numbers of microbes in food include:
 - Heating: E.g. cooking food to kill microbes, pasteurisation
 - Cooling: Refrigeration of foods slows down the growth of microbes
 - Drying: Dehydrating foods, such as fruit or vegetables, and smoking meat, kills microbes, making them last longer

- All these methods are used to reduce the number of microbes and to control the spread of disease
- *Cleanliness in Water:*
 - Lack of clean water, such as in developing countries with no water purification or sewage systems, is a large factor in spreading disease.
 - The major cause of disease are the pathogens that originate from faeces
 - Water will always contain microbes, but reducing the numbers through treatment controls the spread of disease
 - Treatment of water, in processes such chlorination, reduces the risk of disease
- *Personal Hygiene:*
 - Personal hygiene is the process of keeping our bodies clean in order to maintain health.
 - Sanitation refers to the maintenance of conditions that promote health, including removal of wastes
 - Reducing pathogen numbers in modern times involves:
 - Sterilization: This is the complete removal of all traces of microbes. This is required in situations where pathogens are particularly dangerous, eg surgical rooms.
 - Disinfecting: This involves reducing microbes to a safe level, such as washing clothes or dishes with disinfectant.
- *Identify the conditions under which an organism is described as a pathogen:*
 - Organisms are called pathogens when they cause disease.
 - If an pathogen is to cause disease, it must:
 - Have *virulence*: that is, be present in sufficient numbers to cause the disease
 - Enter the host through a certain part of the body or survive on the body without being destroyed by the body's natural defences
 - Escape from one host to another
 - Survive transmission from one host to another
- *Describe ways in which drinking water can be treated and use available evidence to explain how these methods reduce the risk of infection from pathogens:*

- Waters from large undisturbed catchment areas need little treatment, as the process of sedimentation takes place naturally (like in a dam)
- However, water from rivers that lead from industrial sites, farms, or waste areas requires extensive treatment.
- The treatment of water usually has 3 stages.
- Primary Treatment:
 - **Screening** out large debris using bars and screens
 - **Degritting** – the removal of large grit particles
 - **Flocculation** – mixing of the water with chemicals to form suspended particles that contain many *microbes*
 - **Sedimentation** of suspended *microbe-full* particles to the bottom of tanks
 - **Sludge processing** – collection and processing of sediment from tanks
- Secondary Treatment:
 - **Filtration** – this removes nearly all the remaining microbes and other particles by passing the water through sand beds or charcoal.
- Tertiary Treatment:
 - **Chlorination** – adding chlorine to the water kills of the remaining harmful microbes
 - Other chemicals are added here, such as fluorides, depending on the location

3. During the second half of the nineteenth century, the work of Pasteur and Koch and other scientists stimulated the search for microbes as the cause of disease:

- *Describe the contribution of Pasteur and Koch to our understanding of infectious diseases:*
 - Until the mid 19th Century people thought that living things were produced by spontaneous generation: that they came into existence directly from non-living matter
 - For example, the Ancient Greeks thought that rats came from garbage
 - **Louis Pasteur (1825 – 1895):**
 - Pasteur discovered that infectious diseases are caused by micro-organisms
 - This is known as his ‘Germ Theory of Disease’
 - Pasteur’s Experiment:
 - He sought to disprove the theory of spontaneous generation
 - He hypothesised that microbes were in the air everywhere, and food spoils when these microbes land there and become active
 - Pasteur poured nutrient broth into 2 identical swan-necked flasks, and boiled both of them to kill off all microbes
 - Then he broke one of the ‘necks’ and left both flasks out in the open air
 - As he predicted, the flask with the broth open to the air developed cloudy bacterial growths, while the flask with the swan-neck stayed clear
 - This proved that the microbes that spoil food come from the air, and disproved spontaneous generation.
 - Pasteur’s Work with Anthrax and Vaccination:
 - Pasteur demonstrated that anthrax was caused by a rod-shaped bacterium
 - He developed a weakened strain of the bacterium, and using this, produced the first vaccine.
 - He took 50 sheep, and inoculated 25 of them with the weakened strain.
 - After they recovered, he injected all the sheep with the normal anthrax
 - The 25 that were inoculated survived, while the other 25 died

- Pasteur and Fermentation:
 - Pasteur examined samples of fermenting wines under the microscope
 - He observed YEASTS, which were converting the sugars to alcohol
 - He also observed BACTERIA, which were converting sugars to lactic acid.
 - The bacteria were also observed in sour milk and were the cause of food spoilage.
 - Pasteur showed that heating the wine or milk to 55°C for a few minutes kills the microbes that spoil them. This process is called pasteurisation
- **Robert Koch (1843 – 1910):**
 - Koch also studied the anthrax disease
 - Anthrax is a bacterial disease that affects both sheep and humans
 - The process of his investigation was:
 1. He obtained infected matter from a sheep suffering from anthrax
 2. He placed it on a slide, observed it under a microscope and saw active rod-shaped cells and inactive, dormant spores
 3. He established that the blood of animals with the disease always contained these micro-organisms, while the blood of healthy animals did not
 4. He found that if blood from an infected animal was injected into a healthy animal, it would cause disease.
 5. He grew cultures of the rod-shaped bacteria to infect mice – they developed the disease. This proved that it was the bacteria, and not any other blood component that caused disease.
 - Koch's Postulates (for establishing a certain microbe causes a disease):
 - The micro-organism must be present in every organism with the disease
 - The micro-organism must be isolated from the host and cultured
 - A potential host, when inoculated with the cultured micro-organism, must develop the same symptoms as the original host
 - The micro-organism must be able to be isolated from the second host and be identified as the same species as the original culture.

- *Distinguish between prions, viruses, bacteria, protozoans, fungi and macro-parasites and name one example of a disease caused by each type of pathogen:*
 - PRIONS:
 - They are non-cellular infectious agents that cause disease in *mammals*
 - Are abnormal proteins that are altered from normal shape (no DNA or RNA)
 - They can also convert normal proteins to abnormal proteins
 - Can be passed from one animal to another (usually by brain or spinal tissue)
 - EG: Bovine spongiform encephalopathy, Creutzfeldt Jacobs disease.
 - VIRUSES:
 - Non-cellular pathogens, simply a protein coat around genetic material
 - Are found in eukaryotic and procaryotic cells
 - Can only reproduce inside other cells (host cells), killing them.
 - No cure for viral diseases – vaccinations can reduce prevalence
 - EG: AIDS, smallpox, influenza
 - BACTERIA:
 - Unicellular, procaryotic cells. Cell wall surrounding cell.
 - No membrane bound organelles
 - Only some are pathogenic and cause disease; many are useful
 - Most live freely, but some are parasites
 - EG: Tetanus, pneumonia, anthrax
 - PROTOZOANS:
 - Unicellular eucaryotic, animal-like organisms; no cell wall
 - Free-living, or parasitic.
 - EG: Sleeping sickness, giardiasis, amoebic dysentery
 - FUNGI:
 - Eucaryotic organisms; have a cell wall made of chitin (not cellulose)
 - Some are unicellular (eg yeast), most are multicellular
 - They play an important role in decomposition of organic molecules, together with bacteria
 - EG: Ringworm, tinea

- MACROPARASITES:
 - Large disease causing organisms that can be seen with the naked eye
 - External parasites are called ectoparasites, internal are called endoparasites
 - EG: Ringworm, ticks, fleas, roundworms
- *Identify the role of antibiotics in the management of infectious diseases:*
 - Antibiotics are substances that are capable of destroying or inhibiting the growth of bacteria that cause disease.
 - They are chemicals that act selectively; they attack the bacteria but not the host
 - Antibiotics work at the cellular level; they destroy the cells of the bacteria
 - Howard Florey and Alexander Fleming discovered the first antibiotic: penicillin
 - Some antibiotics affect the structure of the bacteria – penicillin destroys cell walls and amphotericin destroys cell membranes
 - Broad-spectrum antibiotics affect a wide range of bacteria, narrow-spectrum act on only one or two.
- *Trace the historical development of our understanding of the cause and prevention of malaria:*
 - 4 BC: Greeks thought that the symptoms of malaria were caused by either breathing in marsh vapours or bites of insects that live in marshes
 - 1880: **Laveran** observed micro-organisms in fresh blood from malarial patients and suggested that malaria was caused by this micro-organisms
 - 1886: **Golgi** observed asexual reproduction of microbe in blood of patients
 - 1894: Patrick **Manson** proposed that malaria is transmitted by mosquitoes
 - 1898: **Grassi** discovered that malaria was transmitted by the *Anopheles* mosquito.
 - 1897-1899: **Ronald Ross** established that the protozoan Plasmodium was the cause of malaria, winning the Nobel Prize.
 - Early 20th: Treatments of malaria were developed, including anti-malarial drugs such as quinine. Efforts to stop the spread of malaria include using DDT to kill the disease vector – the mosquito.
 - Today: Resistance to quinine and other drugs by the Plasmodium, as well as DDT resistance by the mosquitoes has become a problem. Development of a malarial vaccine is the main direction research is going.

- *Describe one named infectious disease in terms of its: 1) Cause 2) Transmission 3) Host Response 4) Major Symptoms 5) Treatment 6) Prevention 7) Control:*
 - **Disease:** Malaria
 - **Cause:** 4 species of the protozoan, *Plasmodium*
 - **Transmission:** The *Anopheles* mosquitoes are the hosts that transmit the disease to humans during the blood-sucking process.
 - **Symptoms:** The different stages in the life cycle of the protozoan cause the different symptoms of the disease:
 - When the pathogen first enters the blood, it travels to the LIVER CELLS, where it hides from the immune system. There, it multiplies rapidly, producing dozens of cells called merozoites
 - The merozoites then travel back into the blood, where they infect RED BLOOD CELLS, again, multiplying asexually producing many cells.
 - The merozoites burst out of the red blood cells every 48-72 hours, and as they release toxins in this process, this causes the symptoms.
 - The toxins cause recurring attacks of shivering, fever, headaches, nausea, sweating and lethargy. The destruction of many red blood cells causes anaemia.
 - **Host Response:** At each stage of the parasite's life cycle, it produces a different set of antigens (they stimulate the immune response). The host produces antibodies to fight the pathogens, but the antigens continually change, so the immune response is not effective. The merozoites in the liver escape detection
 - **Treatment:** Natural resistance can develop, but only very slowly. Treatment of sufferers includes using anti-malarial drugs such as quinine (effective against parasites in red blood cells), and primaquine phosphate (works in both blood and liver cells). Some strains of plasmodium are resistant however.
 - **Prevention:** Protective clothing, insect repellent, mosquito nets.
 - **Control:** Aims to keep incidence of disease to a minimum in population. Drugs to destroy vector, and parasite. Destroying vector's habitat. Vaccines against plasmodium. Genetic engineering of mosquitoes to resist parasite.

- *Discuss problems relating to antibiotic resistance [Case Study]:*
 - 2 Strains of drug-resistant bacteria:
 - *Streptococcus Pneumonia* and *Staphylococcus Aureus*.
 - They cause meningitis and pneumonia
 - They cannot be treated with common antibiotics; they are resistant
 - One strain of *S. Aureus* has added a new gene, enabling it to spread through skin contact and even infect healthy people.
 - The ‘super-bugs’ are more common overseas than in Australia
 - They are blamed for thousands of meningitis and other infections every year.
 - Present trends suggest that by mid 2004, about 40% of *S. Pneumonia* bacterium will be resistant to the two most common antibiotics (penicillin and erythromycin).
 - To overcome these problems, steps must be taken to limit the use of antibiotics as the greater the use, the greater the risk of a mutation giving bacteria resistance.

4. Often we recognise an infection by the symptoms it causes. The immune response is not so obvious until we recover:

- *Identify defence barriers to prevent entry of pathogens in humans such as skin, mucous membranes, cilia, chemical barriers, and other bodily secretions:*

- **FIRST LINE OF DEFENCE**

- Present from birth.

- These physical barriers, e.g. skin, protect the body at possible entry points

- The protection provided is non-specific – it protects against all microbes

- **Skin:**

- Forms a tough outer barrier that surrounds the body

- Outer layers contain **KERATIN**, which microbes cannot penetrate, unless the skin is broken – e.g. a cut

- Skin has its own population of harmless bacteria. These keep the numbers of invading pathogens low – stops them multiplying (competition)

- Sebaceous glands (oil glands) secrete sebum (oil). The lipids in the sebum are broken down by the skin's bacteria into acids which inhibit bacterial and fungal growth

- If the skin is broken, a seal (clot) is quickly formed by the blood-clotting mechanism to prevent pathogen entry.

- **Mucous Membranes:**

- The digestive, respiratory, reproductive and urinary tracts are lined with thick mucus – it is sticky and traps dust particles and pathogens.

- Mucus also contains an antibody – IgA which reacts with potential pathogens

- Fluids such as saliva, tears and nasal secretions wash over mucus membranes and contain *lysozyme* – this breaks down bacteria cell walls.

- **Cilia:**

- Cilia are minute hairs that project from cells lining the nose, trachea and bronchial tubes

- Cilia beat and sweep mucus (containing dust and pathogens) towards the nose or throat opening where it is coughed out or swallowed
- **Chemical Barriers:**
 - These create conditions which makes the surfaces inhospitable for the potential pathogens.
 - E.G. In the digestive system:
 - The acidic environment in the stomach
 - The alkaline environment in the small intestine
- **Other Bodily Secretions:**
 - Populations of harmless bacteria in the vagina act on dead body cells to create acidic conditions – these prevent bacterial and fungal growth
 - Urine is sterile and acidic – it flushes out the ureters, bladder and urethra, preventing microbial growth.
- *Identify antigens as molecules that trigger the immune response:*
 - An antigen is a molecule that triggers the immune response
 - More specifically, antigens cause the formations of antibodies.
 - Antigen → ANTIbody-GENerating substance
 - It may be part of a pathogen or even a toxic molecule
 - **E.G.** – The glyco-protein spikes on the surface of the influenza virus act as antigens, triggering the immune response. The venom of poisonous snakes also contains antigens.
- *Explain why organ transplants trigger an immune response:*
 - All an individual's cells are recognised by the immune system as belonging to the body – the body recognises it as 'self'
 - Any other substances are recognised as 'non-self' – foreign.
 - A transplanted organ contains substances which the immune system recognises as being foreign. These substance acts as ANTIGENS.
 - This stimulates the body to make antibodies and other substances which attack and can possibly destroy the organ

- *Identify defence adaptations, including:*
 - ◆ *Inflammation response:*
 - ◆ *Phagocytosis:*
 - ◆ *Lymph system:*
 - ◆ *Cell death to seal off pathogen:*
- SECOND LINE OF DEFENCE
- This second line of the immune system is also non-specific (like the first line of defence). It is present from birth.
- This means that it will recognise any antigen and make no distinction between them. The immune response will be the same regardless of the nature of the antigen.
- **Inflammation Response:**
 - When body tissue is damaged, whether physically, or by microbes, the inflammation response begins
 - It is characterised by 4 symptoms – pain, redness, heat and swelling
 - The injured cells release chemokines which stimulate *basophils* and *mast cells* to release the chemicals HISTAMINE and PROSTOGLANDIN.
 - These two chemicals cause the blood vessels around the area to dilate and increase their permeability
 - It has 3 *stages*:
 1. Blood vessels around the damaged area **dilate** and increase their permeability (due to histamine and prostaglandin) – this increases blood flow to the area.
 2. The increased blood flow brings **heat** and **fluids**, which make the environment inhospitable to the microbes. Also, the increased blood flow brings PHAGOCYTES – these cells engulf foreign bodies.
 3. Tissues begin to repair after the threat is removed. New tissue is created, with the skin repairing first, to prevent more infectious agents entering.
 - The 3 beneficial functions of inflammation are:
 - It destroys the cause of infection and removes it from the body

- It limits the cause of infection to a small area
- Replaces or repairs tissue damaged by infection
- **Phagocytosis:**
 - Phagocytosis is the engulfing and destruction of foreign bodies by *phagocytes*
 - Phagocytes are white blood cells (leucocytes) that can engulf foreign bodies – there are two kinds: MACROPHAGES and NEUTROPHILS
 - Phagocytes can change shape and surround the foreign bodies. After it is engulfed, the foreign body is destroyed by combining it with enzymes.
- **Lymph System:**
 - The lymphatic system is a system of vessels that begins near the capillaries, run parallel to the veins and eventually empty into the veins before they reach the heart.
 - The lymph vessels contain a fluid called LYMPH, which is blood without red blood cells, platelets and large plasma proteins
 - The vessels collect into lymph nodes – these nodes are storage structures for lymphocytes and macrophages.
 - The lymph system contains organs which are very important in the immune system, such as the bone marrow (where white blood cells are formed, and where B cells mature) and the thymus gland (where T cells mature).
- **Cell Death to Seal Off Pathogen:**
 - When the body is unable to neutralise an antigen, it seals off the pathogens in a cyst or within a group of cells
 - These cells die so the pathogen can no longer survive
 - This cluster of cells, also called a granuloma, is made of a core of dead tissue, surrounded by layers of macrophages, then lymphocytes, then fibroblasts, which produce a tough outer wall.
 - These structures are produced in diseases such as tuberculosis and leprosy
- **Anti-Microbial Proteins [Extra]:**
 - INTERFERONS are a group of proteins produced by cells invaded by viruses
 - They cause surrounding cells to form their own anti-viral chemicals, preventing the spread of the virus [Acts ONLY on viruses].

- The COMPLEMENT SYSTEM is a group of 20 proteins that act in a ‘cascade’ of reactions to destroy pathogens.
 - This means that the first protein causes the production of the second, and the second the third, and so on.
 - The final protein embeds itself in the pathogen’s cell wall (or membrane) causing it to die by lysis (cell-bursting).
- *Show how a named disease results from an imbalance of microflora in humans:*
 - Microflora are micro-organisms that live on or in the body, and usually do not cause disease.
 - They are often part of the first line of defence – the harmless bacteria that secrete acids to destroy pathogens are an example.
 - **Candidiasis**, or ‘thrush’, is a disease caused by an imbalance in the numbers of the fungus, ‘Candida albicans’.
 - The disease can happen in the mouth, the respiratory tract, the gastrointestinal tract, and the female reproductive tract.
 - The fungus is usually kept in check from competition from other microbes such as bacteria living in the same area
 - The taking of certain medications, such as wide-spectrum antibiotics (which can kill beneficial bacteria) , or contraceptive pills, can upset the balance of microflora in the body, which can result in a increase in the numbers of the Candida fungus, leading to thrush.

5. MacFarlane Burnet's work in the middle of the twentieth century contributed to a better understanding of the immune response and the effectiveness of immunisation programs:

- *Identify the components of the immune response:*
 - ◆ *Antibodies:*
 - ◆ *B Cells:*
 - ◆ *T Cells:*
- THIRD LINE OF DEFENCE
- This is *acquired* immunity or *specific* immunity ('The specific immune response')
- This immunity is NOT present at birth – it is gained through exposure to infection
- The specific immune response acts only against **specific** microbes or substances
- That is, it only acts against certain antigens
- It has a MEMORY: this means that the cells can recognise antigens from previous infections, and so can act faster and more efficiently in the second exposure.
- Antibodies:
 - Are produced by the body in response to the presence of specific antigens
 - They are made by PLASMA B-CELLS
 - They are made of proteins called IMMUNOGLOBULIN in a Y shape.
 - Antibodies circulate in blood (in the plasma) and combine with antigens to destroy them.
 - All antibodies have 2 "binding sites" – these bind to the antigens.
 - Antibodies inactivate/destroy antigens in 4 ways:
 - Neutralisation: They can stick to the binding sites of viruses, or disable bacterial toxins by coating them. These are then engulfed by phagocytes.
 - Agglutination: Antibodies 'clump' together solid antigens such as bacteria, combining many bacteria into a solid mass. This mass is then engulfed.
 - Precipitation: Soluble antigens are stuck together by multiple antibodies, and are precipitated out of the solute (plasma). Phagocytosis follow.
 - Complement Activation: The antibodies can stick to the surfaces of bacterial cells, acting as tags for destruction by complement proteins.

- B-Cells:
 - Are a type of LYMPHOCYTE.
 - Lymphocytes are white-blood cells that act only against specific antigens
 - B-Cells are lymphocytes that matured in the bone marrow
 - **B**-Cell → **B**one marrow
 - These cells control the specific immune response only in the BLOOD
 - Thus, B-Cells give **humoral** (blood) or **antibody-mediated** immunity
 - B-Cells usually are found inactivated in the blood and lymph, but are activated by the presence of antigens
 - There is only ONE B-Cell for ONE antigen.
 - Once this ONE B-Cell is activated, it clones itself, and then differentiates into:
 - **Plasma B-Cells:** These cells create the antibodies. After the infection is gone, these cells eventually die off.
 - **Memory B-Cells:** These cells are formed in small numbers in the original infection, but do not die off. They stay behind to recognise the antigen if it appears again, hence having 'memory'.
 - B-Cells work mainly in the blood and interstitial fluids.
- T-Cells:
 - Are also lymphocytes (The T and B-Cells are the only lymphocytes)
 - T-Cells are lymphocytes that mature in the thymus gland
 - **T**-Cell → **T**hymus gland
 - These cells control the specific immune response in infected CELLS
 - Thus, T-Cells provide **cell-mediated** immunity.
 - After the T-Cells are activated by antigens, they differentiate into 4 types, which are explained in more detail later...
 - **Helper T-Cells:** These cells are for activating cytotoxic (killer) T-Cells and the B-Cells [This will be explained later...]
 - **Cytotoxic (Killer) T-Cells:** These cells attach to infected cells and produce chemicals which destroy pathogens
 - **Memory T-Cells:** Remain in the body and give long term immunity.
 - **Suppressor T-Cells:** They suppress the numbers of B and T-cells.

- *Describe and explain the immune response in the human body in terms of:*
 - ◆ *Interaction between B and T lymphocytes:*
 - ◆ *The mechanisms which allow interaction between B and T lymphocytes:*
 - ◆ *The range of T lymphocyte types and the difference in their roles:*
- Interactions Between B and T-Cells:
 - Firstly, the antigen travels in the blood until it is engulfed by a **macrophage**
 - The macrophage then becomes an **antigen-presenting cell** - it displays the antigen it has engulfed on its surface.
 - The macrophage then ‘alerts’ the immune system to the presence of large numbers of antigens in the body by *presenting* the antigen to a **Helper T-Cell**.
 - The Helper T-Cells then produce the chemical INTERLEUKIN, which stimulates T and B-Cells to differentiate into their different types
 - NOTE: The B and T-Cells can be activated either by Helper T-Cells, like above, or activated *directly* by antigens. Both processes have the same result:
 - The T-Cells are also activated by *infected cells* displaying the antigens
 - The B-Cells are also activated by *free antigens* in the blood.
 - The T-Cells differentiate into **Killer (cytotoxic) T-Cells**, **Memory T-Cells** and **Suppressor T-Cells**.
 - The B-Cells differentiate into **Plasma B-Cells** and **Memory B-Cells**
 - The Plasma B-Cells then destroy the antigen by secreting antibodies, and the Cytotoxic T-Cells also destroy the antigen in ways described later...
- The Mechanisms of Interaction:
 - **Clonal Selection:**
 - This is the work of MacFarlane Burnett
 - Before an antigen enters the body, there are already many types of lymphocytes in the body
 - The entry of an antigen causes the selection of only ONE of the types of lymphocyte – the one that has the binding site which matches the antigen

- This results in this lymphocyte **cloning** itself into large numbers of this same lymphocyte, so it produces the antibody that matches the antigen
- This selection means that all the lymphocytes that are produced in the response (all the T and B Cells) are all specific **ONLY** to that antigen
- This means that, for example, the Cytotoxic T-Cells for influenza bacteria cannot kill the pneumonia bacteria
- Macrophages engulf and kill all foreign cells – lymphocytes only act against the antigens that they specifically match.
- **Cytokines and Interleukins:**
 - Cytokines are a group of **SIGNALLING COMPOUNDS** made of proteins or polysaccharides that are used for communication between cells
 - They coordinate the functions of cells so that they can act together as a whole, such as in the immune response
 - Interleukins are a type of cytokine that are secreted by Helper T-Cells and the macrophages
 - When these cells secrete interleukins, they are signalling, or stimulating, the other cells to differentiate, in response to an antigen – such as a B-Cell changing into a Plasma B-Cell
 - This is the main mechanism that is used for intercellular interaction
- Types of T-Cells:
 - **Helper T-Cells:** These cells stimulate the B-Cells and T-Cells to differentiate into their different forms. They receive the antigen from macrophages and only stimulate the B and T-Cells with the same antigen-binding sites.
 - **Cytotoxic T-Cells:** A type of lymphocyte whose main function is to recognise and kill body cells that are infected by pathogens. They only work against infected cells, not directly against pathogens. How they work:
 - They are produced in response to Helper T-Cells, or free antigens
 - Infected body cells display the antigen of the pathogen within them using **MHC I** markers on their surface. These MHC I molecules hold the antigen and present it to the Cytotoxic T-Cells.
 - The Cytotoxic T-Cell has receptors which then bind to the antigen

- It then releases a chemical called PERFORIN – this perforates or makes holes in the cell membrane of the infected cell.
- The body cell **lyses** – water rapidly enters by osmosis and it bursts
- The infected body cell is killed, together with the microbe inside it.
- **Memory T-Cells:** These cells are produced during the time of infection, like all the other lymphocytes, but they remain dormant and survive for many years after the antigen is gone. Their function is to recognise the antigen rapidly if it reappears in a second exposure and to provide a quick and enhanced response – this is why in a second exposure, the symptoms disappear much faster, or aren't experienced at all.
- **Suppressor T-Cells:** These are produced only for a short while. These cells secrete chemicals to suppress the actions of B and T-Cells after the immune response has ended.
- *Outline the way in which vaccinations prevent infection:*
 - Vaccination (or immunisation) is the process of making people resistant to infection caused by a pathogen
 - It involves giving people an injection or oral dose of a vaccine
 - Vaccines can be:
 - Live viruses
 - Killed or weakened pathogens
 - Attenuated (harmless) strains of a pathogen
 - Inactivated toxins
 - Antibodies from blood of laboratory animals
 - These vaccines are injected into the body with the intention of providing immunity to the disease without giving the symptoms
 - Vaccines can give either ACTIVE or PASSIVE immunity:
 - **Active Immunity:** This is gained through injecting the antigen of the pathogen in the vaccine. This stimulates the whole immune response, including antibodies and T and B Memory Cells that are specific to that antigen, without the symptoms of the infection. The production of memory cells has 2 implications:

- If the pathogen does enter the vaccinated individual, the memory cells initiates a quick immune response, so the individual does not experience an 'infection'.
- It provides long-term protection, as memory cells last a long time.
- E.G. Measles vaccine
- **Passive Immunity:** This involves the injection of antibodies straight into the individual, in response to infection by a pathogen. The antibodies come from other organisms:
 - It by-passes the whole immune response – immediate protection
 - Gives protection from diseases the body has never been infected by
 - No memory cells produced. This means protection is only short-term
 - It may bring the risk of a reaction against foreign blood proteins
 - E.G. Tetanus serum
- *Outline the reasons for the suppression of the immune response in organ transplant patients:*
 - A transplanted organ is recognised as foreign tissue by the immune system
 - SUPPRESSION of the immune system is needed to prevent the body from **rejecting** the organ
 - Without suppression, the immune system would create antibodies and cytotoxic T-Cells to try and destroy the organ.
 - The chances of rejection is reduced by matching the transplant organ tissue with the tissue of the patient, and by providing immunosuppression drugs.
 - The danger of this therapy is the inability of the patient to fight off any infections, since the immune system is suppressed. The benefits of immunosuppression has to be balanced against the change of life threatening infection.
- *Evaluate the effectiveness of vaccination programs in preventing the spread and occurrence of once common diseases, including smallpox, diphtheria and polio:*
 - SMALLPOX:
 - **Cause and Symptoms:**

- Caused by the smallpox virus
- It enters through the throat and lungs, then undergoes a 12-day incubation
- Symptoms of the disease includes obvious vesicles on the skin, headaches, backaches and fever
- **History:**
 - First appeared in Asia or Africa around 10000 BC
 - Spread around the world by explorers, traders and crusades
 - Responsible for 1 in 10 of all deaths in Europe in the 19th Century
 - Reached Australia in 1789, with early European settlers, and had a devastating effect on Aboriginal communities
- **Vaccination Programs:**
 - Edward Jenner performed the first smallpox vaccination by inoculating people with cowpox
 - The vaccine was used by the WHO on a global scale in 1967
 - The WHO routinely immunised people with the vaccine, provided supplementary vaccinations and carefully supervised areas with the potential for infections
 - In 1980, the WHO announced the world free of smallpox
- **Evaluation of Effectiveness:**
 - Since the vaccination programs resulted in the complete eradication of the disease from the planet, it can be said that the programs were extremely effective.
- **DIPHTHERIA:**
 - **Causes and Symptoms:**
 - It is a bacterial infection that is spread through the air into respiratory surfaces, or by close physical contact
 - It gives throat infections, which results in breathing difficulties and death
 - **History:**
 - 100 years ago, 50% of all those infected with diphtheria would die
 - Large epidemics occurred in Europe after WWII
 - There have been recent outbreaks in Algeria and China

- **Vaccination Programs:**
 - In 1923, a vaccine was released
 - In 1974 the WHO began to expand its immunisation program globally
 - In 1990, the worldwide immunity rate was 80%
- **Evaluation of Effectiveness:**
 - The vaccination program reduced the spread of the disease from cyclic academics to occasional breakouts of low density
 - Even though the rate of immunity is high, the disease is still present in developing countries and has not yet been eradicated
- POLIO:
 - **Causes and Symptoms:**
 - Polio is the attack by polio viruses on the motor neurones of the spinal chord and the brain
 - Symptoms include high fever, back pains, muscle spasms and paralysis
 - **History:**
 - Disease existed in Ancient Egypt and killed hundreds and thousands of people in the 19th Century
 - The rate of polio began to fall in the 20th Century
 - **Vaccination Programs:**
 - The vaccination was first introduced in 1955
 - In the 1960's an oral form of the vaccine was introduced and the polio disease was brought under control
 - In 1988 the WHO began an immunisation campaign
 - The number of cases dropped by 80% in 1990
 - **Evaluation of Effectiveness:**
 - Despite widespread success in polio control, there are still small breakouts in around 70 countries.
 - Polio infection rates have been successfully controlled & reduced by 80%

6. Epidemiological studies involve the collection and careful statistical analysis of large quantities of data. Such studies assist the causal identification of non-infectious diseases:

- *Identify and describe the main features of epidemiology using lung cancer as an example:*
 - **Epidemiology** is the study of the factors that influence the incidence, distribution, and control of diseases within a population
 - Features of an epidemiological study that help prove the cause of disease:
 - Through analysis of statistics, it must demonstrate a significant link between the cause and the disease
 - There has to be a chronological order of events; that is, the cause must come before the disease
 - The study must be done on a large range of subjects, in terms of age, sex, race, occupation, socioeconomic status, and geographical position
 - The results should persist over time
 - The cause-and-effect relationship should be independent of other factors
 - The greater the exposure to the cause, the greater the incidence should be of specific disease
 - The study should be repeatable by other investigators at *different time*, and *different places*, using *different methods*.
 - There are three types of epidemiological studies:
 - Descriptive: These studies investigate:
 - The frequency of the disease
 - The part of the population affected – e.g. age, gender, occupation, etc
 - The location and time period of those affected
 - Analytical: These focus on finding a **cause and effect** relationship in the occurrence of the disease:
 - These studies look at factors that preceded the epidemics
 - They look at *control groups* – similar individuals without the disease
 - They examine factors that affect the risk of contracting the disease

- Experimental: These are used to test the effectiveness of a particular treatment, such as clinical trials of a new drug.
- The epidemiological studies concerning lung cancer are a good example – the studies range over many decades, starting from the 1950s, when levels of lung cancer first began to become noticeable.
- The people surveyed in the studies came from a wide range of ages, from WWI veterans who had started smoking because they were given free cigarettes to the wave of women who had begun to take up smoking in the 1970s.
- The studies have shown that there is a strong correlation between smoking and lung cancer.
- *Identify causes of non-infectious disease using an example from each of the following categories:*
 - ◆ *Inherited diseases*
 - ◆ *Nutritional diseases*
 - ◆ *Environmental diseases*
- Non-infectious diseases are not caused by pathogens
- They are not transmitted from one organism to another
- **Inherited Diseases:**
 - These diseases are caused by gene and chromosome abnormalities
 - They are transmitted by reproduction
 - They can be minor disorders, such as myopia or serious such as haemophilia
 - E.G. Down Syndrome is an inherited disease that is caused by the inheritance of once extra chromosome (trisomy 21). People with Down syndrome have a characteristic appearance and may have a shortened life span. Mothers who have children later in life are more prone to produce Down syndrome children.
- **Nutritional Diseases:**
 - These are caused by incorrect or insufficient diets
 - It can be over-eating (obesity) or under-nourishment (anorexia)
 - E.G. Scurvy – This disease is caused by the lack of vitamin C in the diet. It causes swelling of body parts and teeth start to fall out.

- **Environmental Disease:**
 - Many factors in the environment can cause disease
 - They include radiation, heavy metals, pollution, etc
 - E.G. Asthma – this disease is where the muscles in the airways contract and can cause severe breathing difficulties. Causes include pollution, pollen, dust storms, humidity, and many other environmental factors.
- *Identify the cause and effect relationship of smoking and lung cancer:*
 - A case study: LUNG CANCER:
 - **Definition:** Uncontrolled growth of tumours in the lungs
 - **Causes:** There is a obvious link between smoking and lung cancer. Tobacco smoke contains many carcinogens such as benzene.
 - **Effect:** As the tumour grows, the air sacs in the lungs are destroyed and breathing becomes difficult. The lungs collapse and abscess and the patient may begin coughing up blood. The cancer can metastasise (spread) to other vital organs and cause death.
 - **Statistical Information:**
 - Mass production of cigarettes began in 1880 – free cigarettes were given to WWI soldiers
 - In the 1930s there was a sudden lung cancer epidemic
 - The first epidemiological studies which showed a relationship between smoking and lung cancer were in the 1950s, but they did not have conclusive results – they just showed a reduced live expectancy
 - In 1964 the Surgeon’s General Advisory Committee concluded that cigarette smoking was a cause of lung cancer.
 - In the 1970s, as the numbers of female smokers began to increase, lung cancer became the number one cause of cancer death.
 - Studies have shown a correlation between the number of cigarettes smoked each day and the risk of contracting lung cancer at an earlier stage
 - Also, a gradual decrease in the numbers of people smoking in the past 20 years has been mirrored by a decrease in sufferers of lung cancer

- *Analyse and present information about the occurrence, symptoms, cause, treatment/management if a named non-infectious disease:*
 - **Disease:** Down syndrome
 - **Cause:** Trisomy - it is a genetic disease that is caused by the presence of an extra chromosome in the 21st position.
 - **Symptoms:** Lower than average mental ability, almond shaped eyes, shorter limbs, speech impairment, enlarged tongue and a high risk of heart failure
 - **Occurrence:** Approximately 1 per 733 live births
 - **Treatment/Management:**
 - Children with Down syndrome will need special care in many areas of life, including eating, washing and general hygiene
 - The reduced mental capacity, a symptom of the disease, may be a limiting factor on the development on the individual in respect to social development, schooling and the workforce
 - An important issue is the physical health of the patient with the disorder:
 - Physiotherapy may be needed, as children born with Down syndrome have weakened muscles, and shorter arms and legs
 - The increased risk of several diseases, most notably cardiovascular failure, is an important issue that must be managed with Down syndrome patients.

7. Increased understanding has lead to a wide range of strategies to prevent and control disease:

- *Discuss the role of quarantine in preventing the spread of disease and plants and animals into Australia or across regions of Australia:*
 - **Quarantine** is the controlling of the import or export of animals, plants, and other products for the purpose of controlling the spread of disease
 - The Role of Quarantine:
 - Protects the health of the human, animal and plant populations of Australia
 - Prevents the entry of **foreign pests** and **contagious diseases** into Australia
 - Quarantine laws prevent the entry of items considered a risk
 - Important animals face a time in isolation to ensure no disease is present.
 - Living plants are also quarantined to make sure they are not carrying pests or suffering from any infectious disease
 - Plant seeds are examined to check that no weed seeds are present
 - Used vehicles and agricultural machinery are inspected and cleaned to ensure no soil/plant matter enters the country
- *Evaluate the effectiveness of quarantine in preventing the spread of plant and animal diseases into Australia or across regions of Australia:*
 - Because of Australia's strict quarantine laws, Australian plants and animals **do not have** some of the serious disease found in other countries, such as foot and mouth disease, mad cow disease and rabies
 - E.G. Animal disease that has not entered Australia – **Foot and mouth disease:**
 - A highly contagious muscle-wasting disease of cloven-hoofed animals such as cows, sheep and goat
 - Symptoms include fever, dribbling, lethargy and blisters on mouth, tongue, lips, hooves and feet
 - It is caused by an airborne virus – it is spread not only by live animals but also by the carcass, and also in soil and equipment.
 - Quarantine regulations has prevented the entry of this disease – if an outbreak did occur, it would cost billions of dollars in loss.

- E.G. Plant disease that has not entered Australia – **Sorghum downy mildew**:
 - This disease has been prevented from entering into Australia
 - Caused by a fungus; if it was released into Australia, it would devastate wheat and other crops grown here
 - The fungus inhibits the plants ability to make chlorophyll, which results in the death of the plant
 - Quarantine measures include the banning of entry of any live plant material, and the strict examination of any seeds being brought in.
- E.G. Preventing spread of disease across regions of Australia – **Fruit flies**
 - Quarantine measures have been implemented that forbid the movement of fruit across state borders
 - These measures are in place to control the spread of fruit flies, which cause severe damage to fruit crops such as bananas
 - There is the Mediterranean fruit fly in Western Australia, and the Queensland fruit fly, in eastern Australia
 - The Northern Territory, South Australia and Tasmania do not have these pests, because of quarantine measures
- Overall, quarantine practices have been greatly effective.
- Due to the rigorous implementation of quarantine practices, most diseases and pests have not been brought to Australia.
- *Explain how one of the following strategies has controlled and/or prevented disease [Pesticides chosen]:*
 - Pesticides are used usually to kill the vectors that carry the disease
 - An example is using pesticides to control the malaria disease
 - DDT (dichloro-diphenyl-trichloroethane) is the pesticide that was used to kill populations of the Anopheles mosquito, the vector of malaria
 - It was very effective in the beginning, and numbers of malaria sufferers went down, but then pesticide-resistance reduced its efficacy
 - DDT was also used to kill lice on the bodies of soldiers during WWII
 - The lice carried diseases such as typhus fever
 - The pesticide prevented thousands of deaths

- *Discuss the changing methods of dealing with plant and animal diseases, including the shift in emphasis from treatment and control to management or prevention of disease:*
 - The incidence of disease has more commonly been met with an emphasis on treatment and control
 - More recently however the emphasis has shifted to the importance and effectiveness of preventing and managing diseases instead
 - These examples illustrate this:
 - Smallpox: A widespread disease that killed many in the 18th Century. Treatments were available, but were ineffective – many died. Prevention came in the form of vaccinations, and this has controlled the disease far more successfully than any treatments
 - Cancers: There are current treatments, such as chemotherapy, radiotherapy, and surgical removals. They are quite successful, especially if detected early. However, they are not 100% successful and can cause physical trauma to the body (scars). Prevention campaigns (public health campaigns) such as giving people advice on proper skin care (skin cancer) and quit-lines for smoking have reduced the numbers of cancers.
 - Plant Diseases: These include disease such as fungal root infections, pests such as aphids and disease causing organisms. The usual treatment is spraying with pesticides. However this has had a detrimental effect on the environment. Preventative measures are used, especially quarantine measures, biological control (introducing species to control pests) and genetic engineering
- *Evidence of pathogens and insect pests on plant leaves and shoots:*

| Pathogens | Insect Pests |
|---|---|
| <ul style="list-style-type: none"> - Bacteria cause spots on the surface of the leaves ('rust' on the Banksia leaves) - Fungal infections are shown by dark growths on the stems ('black stem rot') or on the undersides of leaves. | <ul style="list-style-type: none"> - Insects ('azalea lace-bugs') feed on the plant itself, creating holes and damage. - Other insects, such as psyllids, reproduce on the plants, and leave behind egg shells and holes. |