9.4 Search for Better Health

1. What is a healthy organism?

Discuss the difficulties in defining the terms 'health' and disease'

- Health: A state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity.
- Disease: Any condition that adversely affects the normal functioning of any part of a living thing. A state of impaired functioning of an organism impaired physical, social or mental functioning. When a part of the body does not function in the normal way.

Health

- *Physical Health* - Refers to the physical state of the body, such as fitness, body weight and functioning of the systems in the body
- *Mental Health* – Ability to function and cope with changing situations in our life.
- *Social Health* – Ability to interact, communicate and socialise effectively.
- Health is very difficult to define as it has many components, physical, social and mental functioning, all of which are subjective (own opinion/different individuals have different ideas on what is considered healthy).
    - Example: A person who is physically fit and has no sickness can be considered healthy; however they may have mental problems such as depression. Whereas a person with a disability could still be classed as healthy as they have adapted to living with their disability.

Disease

- Disease is also difficult to define as it has many components to it. It is describing a state of impaired function; it depends on an organism's normal level of functioning and what they expect their quality of life to be. The normal is different for every individual, what's seen as a disease in one person may be normal in another.
    - Example: Normal absent-mindless present in elderly people is a normal aging process, however in teens it is considered a problem as it isn't considered normal in teenage society.

Outline how the function of genes, mitosis, cell differentiation and specialization assist in the maintenance of health

Process/Structure	Definition	Outline of how this process assists in the maintenance of health
Cell Differentiation/ Cell Specialisation	During the development of a cell, the cell differentiates and becomes a specialised cell for a specific function.	• Many types of cells have specialised roles in maintaining the health of an organism. E.g. there are specialised blood cells that produce antibodies to attack a disease-causing micro-organism. • These two processes together enable cells to work together in a healthy body to carry out complex functions in order to maintain and repair tissue. • If these processes did not occur the cells would not be able to function efficiently and processes in the body would not occur.
Genes	Genes are heredity units that control the production of polypeptides which make up proteins needed in the body for growth, repair & normal cell functioning.	• A malfunction in a particular gene may result in the inability of cells to functioning properly leading to disease, e.g. cystic fibrosis is a genetic disease that is caused by the mutation of the CFTR gene. • Genes also controls how and when an organism's tissues are maintained and repaired, any malfunction in these genes will be detrimental to healthy cells. • Genes provide the code for proteins that are needed for growth and repair, enzymes which control all body processes are proteins (meaning they have been produced from genes). • Control the process of protein synthesis.
Mitosis	Process of cell division by which identical body cells are produced in order for growth, repair and genetic stability.	• Allows the organism to grow, the more cells the larger the organism. • Maintains and repairs body cells, thus maintaining health.

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

Distinguish between infectious and non-infectious disease

- A disease is an abnormal medical condition of an organism that impairs body functions; it is associated with specific signs and symptoms.
- Infectious Disease:
- Disease caused by a pathogen (organisms or infecting agent)
- The disease can be transferred from one organism to another
    - Measles, Chickenpox, Aids, Hepatitis, Typhoid, Influenza
- Non-Infectious Disease:
- It is a disease that is not caused by a pathogen.
- Cannot be transferred from person to person (with the exception of inherited diseases)
- Non-infectious diseases have a number of causes: inherited, nutritional or environmental
    - Inherited (genetic) disease: Down's Syndrome, Haemophilia
    - Nutritional disease: Scurvy, Beriberi
    - Environmental disease: Skin cancer, Asbestosis

Explain why cleanliness in food, water and hygiene practices assist in control of disease

- Micro-organisms are everywhere around us and can easily enter our bodies through any openings (cuts, wounds etc). Not all micro-organisms cause disease, but in order to prevent the growth of pathogenic micro-organisms and hence control the spread of disease it is important that hygienic practices are followed.
- Cleanliness in food:
- Contaminated food is a source of pathogens; Salmonellosis caused by bacteria called *Salmonella* is transmitted in uncooked food.
- Microbes in food become a health risk when they are allowed to multiply and reach large numbers which can happen quickly if conditions are right.
- Cleanliness in Water:
- Important that water quality is maintained in order to minimise the risk of pathogens multiplying and the risk of the transmission of these pathogens in contaminated water.
- Lack of clean water, such as in developing countries with no ways to purify the water, is a large factor for the spread of disease.
- The main causes of disease are the pathogens originating from faeces seeping into the water through sewage systems.
- Personal Hygiene:
- Personal hygiene involves keeping our bodies and any openings on them clean to reduce the risk of pathogens entering our body.
- If our body is kept unclean, the buildup of microbe's increases, thus increasing the chances of them entering our body causing disease.
- How personal hygiene is maintained:
    - Washing hands and covering mouth when sneezing: reduces spread of pathogens from person to person.
    - Sterilization of surfaces: Complete removal of all traces of microbes, this is required in situations where pathogens may become dangerous e.g. surgical room.
    - Coughing and sneezing into a tissue: Prevents the spread of airborne droplets.

Cleanliness and Hygiene Practices	What you might do. Example	How does this help control the spread of disease?
Cleanliness With Food	• Washing hands regularly before handling food. • Proper precautions taken such as not leaving food on the bench to be infected by micro-organisms. • Freezing food/Boiling food.	• Washed hands prevent infecting the food with micro-organisms. • Food left on the bench can acquire large numbers of bacteria. • 3. Boiling food kills bacteria (salmonella killed at 71^{o}c), Refrigeration slows microbe growth.
Cleanliness With Water	• Boiling water • Water treatment on drinking water	• Kills pathogens within the water • Kills any bacteria before people drink it, making it safe
Personal Hygiene	• Regular bathing to maintain hygiene • Brushing Teeth • Washing hands • Covering Sneezes/Coughs	• 1/2/3. Cleans off any germs or bacteria that have accumulated in or on our body. • Prevents the spread of airborne diseases.

Identify the conditions under which an organism is described as a pathogen

- Pathogens are defined as any infective agent that causes diseases.
- They can either live in or on another living organism and cause a disease.
- Pathogens include: prions, viruses, bacteria, protozoans, fungi and macro-parasites.
- Pathogens can be transmitted directly (person to person), indirectly (air, food and water) and by another organism transmitting it from person to person (vector) e.g. with malaria where the mosquito is the vector.

- Conditions in which an organism is a pathogen:
  - Must be *virulent*, meaning it's able to cause an infection/disease.
  - Must be able to survive transmission from one host to another.
  - E.g. Cholera bacteria must first survive on food then be ingested.
  - Must enter the body through a certain part without being destroyed and then also reproduce.
  - E.g. smallpox enters the digestive system, where it's too virulent for the bodies defence system, thus enable to destroy it.

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

- **Describe the contributions 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, this included infectious disease causing microbes.
- **Louis Pasteur:**
  - Pasteur discovered that infectious diseases are caused by micro-organisms, this is known as his ***'Germ theory of disease'***, this theory states that germs (microbes) cause disease and that all micro-organisms come from pre-existing micro-organisms.
  - He also disproved the spontaneous generation theory stating that life such as maggots present in rotting flesh arose spontaneously from nothing.

  Swan Flask Experiment:

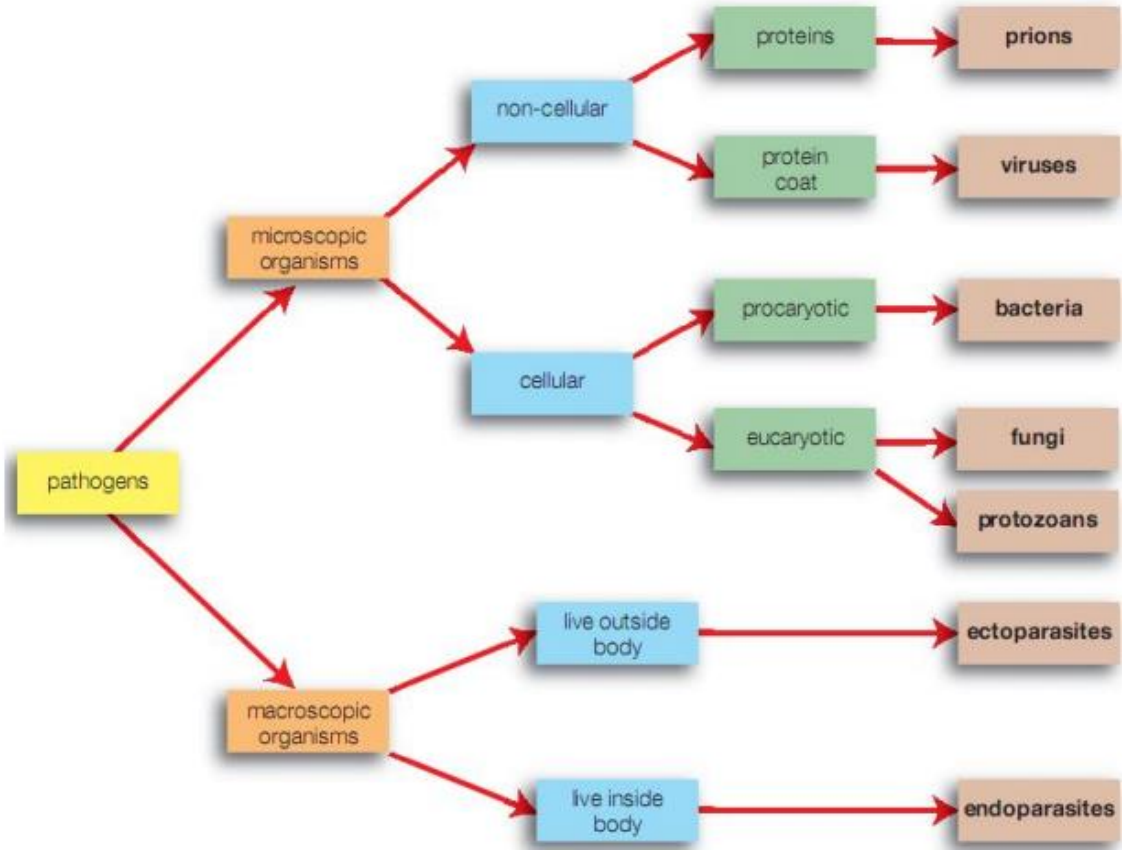
  - He hypothesized that microbes were in the air everywhere, and food spoils when these microbes land there and become active.
  - He poured nutrient broth into two identical swan-necked flasks, and boiled the broth to kill off any microbes.
  - He broken one of the necks of the flasks and left both of them out in the open air, the flask with the broth exposed to air developed bacterial growth, whilst the swan neck flask stayed clear of bacterial growth.
  - This supported his theory that microbes do not spontaneously generate, that they must be present in the air. The broth within the swan-necked flash had no microbes in it as it was not exposed to the air whereas the other flask was. This proved that the **organisms** that contaminated the broth and caused it to decay must be **carried in the air** and **not be spontaneously generated.**
  - Also further evidence for this was that in the curve of the swan-necked flask microbes were trapped.
  - Work with Anthrax and Vaccination:
    - He developed a weakened strain of this bacterium and used it to produce the first vaccine.
    - He took 50 sheep, gave 25 of them the weakened strain. After that he injected all 50 sheep with the normal strain of Anthrax.
    - The 25 with the weakened strain (vaccine) survived, while the other 25 died.
    - The reason the 25 sheep that had the introduced strain survived is because the body had been already exposed to the disease and it could be ready to recognize the real infection and repel it. This was known as a **vaccine**, and he further put forward the theory of '**principle immunity**' used today through vaccines.
  - Pasteur and Fermentation:
    - Pasteur found that micro-organisms (bacteria) were the cause of wine, beer and vinegar spoilage. He discovered the solution was to hear these long enough to kill the contaminating bacteria that were present after fermentation.
    - This was called **pasteurisation**; it is still used today to keep products such as milk free of disease causing organisms and is suitable to drink.
- **Robert Koch:**
  - He developed the **Agar plate technique** for growing micro-organisms, and used it to culture (study) the isolated bacteria *Anthrax Bacillus.*
  - He examined the blood of sheep that had died from Anthrax and identified it was caused by a rod-shaped bacteria that he isolated and grew.
  - He established that the blood of animals with the disease always contained these rod-shaped organisms, while the blood of healthy animals did not.
  - He then found if blood from an infected animal was injected into a healthy animal it would cause disease.
  - He grew cultures of the rod-shaped bacteria to infect mice; each one he injected developed the disease. Proving that the disease was caused by the bacteria and not the blood of the animal.
- Koch determined that each disease is **caused by a specific micro-organism.**

- The principles he used to identify the specific micro-organisms that were responsible for a disease came to be known as **Koch's postulates**.
  - Koch's Postulates:
    - The steps that must be followed to determine if a particular micro-organism is responsible for causing a disease is known as *Koch's Postulates.*
      1. The same micro-organism must be present in every diseased host.
      2. The micro-organism must be isolated and cultured in the laboratory and accurately described and recorded.
      3. When a sample of the pure culture is inoculated into a healthy host, this host must develop the same symptoms as the original host.
      4. The micro-organism must be able to be isolated from the second host and cultured and identified as the original species.

- **Distinguish between:**
  - **Prions** **- Fungi**
  - **Viruses** **- Macro-parasites**
  - **Bacteria**
  - **Protozoans**

And name one example of a disease caused by each type of pathogen.

- Non-Cellular life: Is life that exists without a cell structure.
- Cellular life: Life that exists with cell structure.
- Eukaryotic: A cell which contains a nucleus and membrane bound organelles.
- Prokaryotic: A cell that does not contain a nucleus.

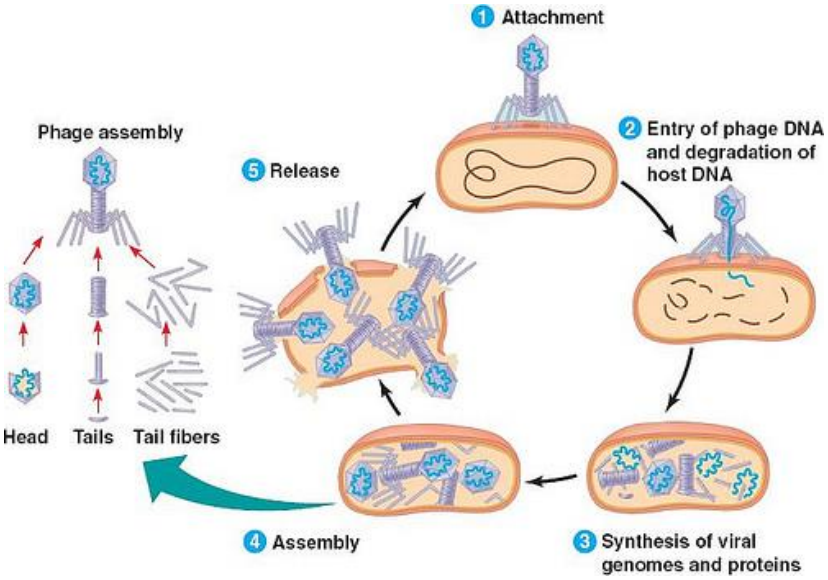


➔ **Prions: Creutzfeldt-Jakob (CJD) disease**

- Non-cellular, Protein causes disease in mammals.
- Are altered protein shapes, contain no DNA or RNA
- Can alter other proteins to develop more prions causing a chain reaction.
- Can be passed from one organism to the other.

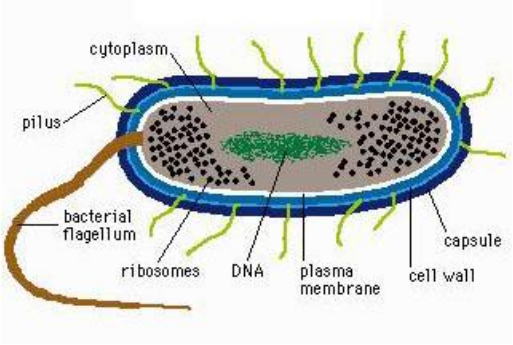
➔ **Viruses: Influenza, Measles, AIDS, common cold**

- Non-cellular, Protein coat around genetic material (DNA or RNA)
- Consist of DNA or RNA enclosed in a protein coat.
- Viruses are larger than prions and many times smaller than bacteria (30 – 300 nm)
- Unable to reproduce on their own. Can only reproduce inside other cells (host cells), killing them in the process.



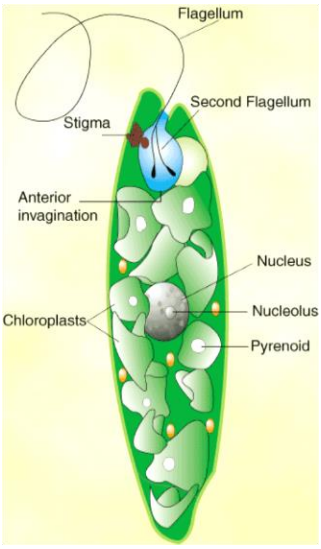
➔ **Bacteria: Cholera, Boils, Pneumonia**

- Unicellular (single celled), Procaryotic organisms, Cell wall.
- No membrane bound nucleus or organelles. But have a plasma membrane.
- Some are pathogenic and cause disease, but most are useful.
- They are larger than viruses but smaller than protozoans (0.5 – 100 um).
- They are classified on the basis of their shape – Spherical (Coccus), Rod shaped (Bacillus) and Spiral shaped (Spirillum).
- Produce asexually using the process of binary fission (dividing in two).



➔ **Protozoans: Malaria**

- Unicellular, Eucaryotic (Have cell membrane bound nucleus and organelles), NO Cell Wall.
- Many are free-living and do not cause disease, but some are pathogenic.
- Range in size from 1 – 300 um
- Reproduce asexually through the process of binary fission.



➔ **Fungi: Athletes foot (Tinea), Candidiasis (Thrush)**
- Unicellular OR Multicellular, eucaryotic, Cell wall.
- Some are unicellular (yeast) but most are multicellular (mushrooms), they reproduce asexually or sexually.
- Similar to protozoans, but they contain a cell wall.

➔ **Macro-parasites:**
➔ Ectoparasites – **Fleas, Ticks, Leeches**
➔ Endoparasites – **Tapeworms cause taeniasis.**
- Multicellular, eeucaryotic
- Large disease causing organisms that can be seen with the naked eye.
- External parasites are called ***ectoparasites.***
- Internal parasites are called ***endoparasites.***

- **Identify the role of antibiotics in the management of infectious disease.**
  - **Antibiotics:** Are substances capable of destroying or inhibiting the growth of bacteria that cause disease, without destroying the host.
  - Alexander Fleming discovered the first antibiotic: penicillin in 1928, this was a breakthrough as many infectious and diseases that were fatal at the time were able to be treated.
  - Some antibiotics affect the structure of the bacteria: **Penicillin** destroys cell walls by accumulating in the bacteria, and **Amphotericin** destroys cell membranes, **Erythromycin**

4. Often we recognize 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:**
  - **Skin - Mucous membranes - Cilia - Chemical Barriers**
  - **Other Bodily secretions.**

- The first line of defence is not specific, and involved both physical and chemical barriers to prevent the entry of pathogens into the blood and tissues.

➔ **Skin (Physical barrier):**
- The skin is the largest organ of the human body, forms a tough outer barrier surrounding the body, preventing the entry of pathogens.

- It is dry, to prevent the growth of pathogens.
- If the skin is cut (or broken), the blood clots immediately to produce a temporary patch to maintain the barrier until the skin reforms.
- Oil glands secrete oil (sebum's), which are broken down by the skin's bacteria into acids which inhibit bacterial growth.

➔ **Mucous membranes:**

- The respiratory, digestive, reproductive and urinary tracts are covered with membranes that produce a thick layer of mucus that traps the entering pathogens. Mucus holds the pathogen, until it is removed by processes such as coughing
- The mucus also provides a nutritious layer in which the harmless microbes live and produce substances that prohibit the growth and entry of pathogens.

➔ **Cilia (physical barrier):**

- Cilia are tiny hairs that line the respiratory surfaces of the trachea and bronchial tubes.
- They beat upwards to move mucus containing trapped pathogens towards the throat where they are removed by coughing or sneezing.

➔ **Chemical Barriers:**

- Different chemicals secreted in different parts of the body act as a barrier to the invading pathogens.
- E.g. Acidic conditions in stomach, hydrochloric acid and alkaline conditions in small intestine

➔ **Other bodily secretions (physical & chemical barriers):**

- Urine is sterile and highly acidic, flushes and cleans the ureter, bladder and urethra. Preventing growth of microbes.
- Tears contain lysozymes that destroy the cell wall of some bacteria. As the tears are produces and they eyelid blinks, the eye is cleaned and pathogens washed away.
- Saliva also contains lysozymes and washes microbes from the teeth and lining of the mouth.

- **Identify antigens as molecules that trigger the immune response.**
  - An **antigen** is any molecule the body recognizes as foreign and that triggers an immune response.
  - On the surface of cells in the body there are 'marker' molecules that identify the cell as belonging to the body ('self'). This protects the body's cells from attack by its own immune system.
  - When pathogens enter the body they have chemical markers, called antigens on their surface. This is recognized as not belonging to the body ('not self') and an immune response is triggered to destroy the foreign organisms.
  - It is not only pathogens that have antigens on their surface. Any foreign cell, cell fragment, protein debris can also contain antigens. The venom of a poisonous snake also contains antigens. In these cases the immune response will be activated because the body recognizes all these as foreign molecules ('not self')
  - **Antibodies** are what the immune system produces to destroy **antigens.**
- **Explain why organ transplants should trigger an immune response.**
  - When a person has an organ transplant, they are receiving an organ from somebody else. On the surface of the cells the 'marker' molecules (antigens) are different to the marker molecules on their own cells.
  - The transplanted organ is therefore identified as foreign ('not self') and the immune response is activated to attack the organ in order to defend the body.
  - This is because the transplanted organ contains substances which the immune system recognizes as being foreign. These substances act as **Antigens.**
  - Patients can be treated with immunosuppressant drugs, which will also lessen the immune response so that the transplanted organ is not attacked. However this has the disadvantage of making the patient more susceptible to infection pathogens and must take further precautions.
- **Identify defence adaptations, including:**
  - **Inflammation response - Phagocytosis**
  - **Lymph system - Cell death to seal off pathogen**
- When pathogens successfully penetrate the first line of defence and enter into the organism, non specific (same as the first line) responses that are the 'second line of defence' are quickly activated to destroy the invading pathogens.

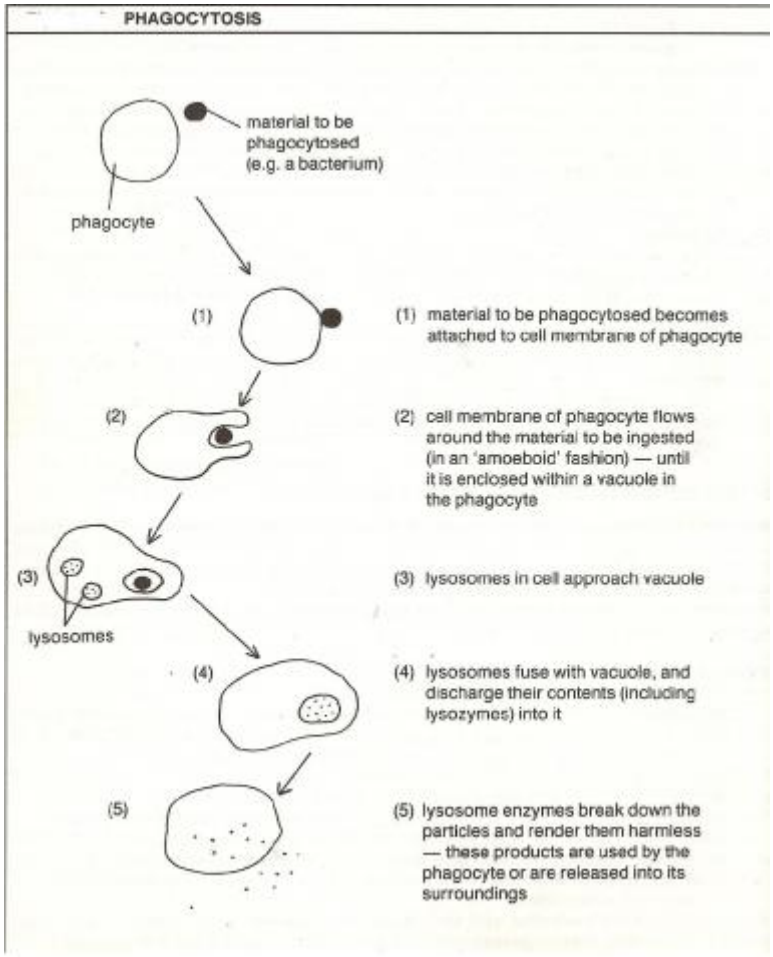
➔ **Inflammation response:**

- Non-specific defence mechanism that occurs at the site of infection. When body tissue is damaged or infected they release chemical alarm signals such as ***histamines*** and ***prostaglandins***.
- These cause the blood vessels to dilate, increasing blood flow to the site of infection or injury; this causes the area to become red, hot, swollen and also the increased blood flow brings phagocytes (type of WBC)
- These chemicals also increase the permeability of blood vessels; this allows the movement of phagocytes from the blood into the tissues so they can attack invading pathogens.
- The increased blood flow brings heat and fluids, which makes the environment further inhospitable to the invading pathogens, as it can inactivate some enzyme sand toxins made by the pathogens.
- Once the pathogens are destroyed, they are removed along with any toxins and the tissues are repaired.
- Pain, Redness, Heat and Swelling are characteristics of inflammation.

➔ **Phagocytosis:**

- Phagocytes are specials white blood cells that can engulf foreign cells, there are two main types:

- **Neutrophils**: First to be called upon the site of an infection, they are however short-acting and then self-destruct after a few days. They are used to fight short, severe infection.
- **Macrophages:** Long-lasting phagocytes that can stay in tissue or travel from blood vessels into infected tissues. They are used by the body to fight chronic (long-lasting) infections. After the macrophage has destroyed the foreign particle, parts of the antigen are displayed on the surface of the macrophage (For T-Helper cells)



- **Phagocytosis** is the process by which phagocytes change their shape so they can surround a foreign particle such as bacterium.
- Once it is inside the cell, enzymes are released to destroy the foreign material.

➔ **Lymph System:**

- Lymph is intercellular (between cells) tissue fluid that has white blood cells.

- 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. At special places there are vessels that collect into lymph nodes.
- If there is an infection in the tissues the foreign particles along with dead cells and other debris move with the fluid into the lymph vessels. Once reaching a lymph node the waste particles are filtered off and any particles are destroyed by macrophages.
- This is why swollen lymph nodes (glands) are a good indicator of infection.

➔ **Cell death to seal off pathogens:**

- When the body is unable to get rid of a pathogen, body cells die to seal off an area of tissue that is infected and is not being successfully defended by the body.
- Infected cells are surrounded by a wall of dead cells to prevent the infection from spreading to other areas, what is formed is called a cyst (***garnuloma***)
- The cells inside will then die, causing destruction of the pathogens that are infecting them.

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 immunization programs.

- **Identify the components of the immune response:**
  - **Antibodies - T cells - B cells**
  - The third line of defence is called the immune response and is a **specific response,** it becomes activated if foreign particles are successful in penetrating the barriers of the first line, and survive the second line.
  - It involves the production of two different types of lymphocytes, B cells and T cells, which are specific to the invading pathogen.
  - It is characterised into two parts:

  ➔ **Anti-body mediated immunity (humoral immunity):** Immunity that is mediated by the secretion of antibodies by lymphocytes. These antibodies are produced by B-Cells; there are thousands of antibodies, each specific for an antigen.

  ➔ **Cell-mediated immunity (cellular immunity):** Response that does not involve anti bodies but rather the activation of certain cells to destroy pathogens directly. These are T-Cells.

  - In this process of destroying the foreign material the cells remember the specific antigens so that next time these antigens enter the body they are destroyed as soon as they are recognised.
- **B-Cells:**
  - B-Cells are lymphocytes that are produced and matured in the bone marrow. B – Cell -> Bone marrow.
  - Upon maturing they are released into the blood and lymph nodes. B-cells are usually inactivated but are activated by the presence of antigens.
  - Once B cells become activated they mass clone and then differentiate into:

  ♦ **Plasma B-Cells:** These cells create antibodies; the antibodies then move to the site of the infection and combine with the antigen to form the **antigen-antibody complex** which deactivated the antigen. 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 recognize the antigen, if it appears again, hence having memory.

  ♦ **Antibodies:**

  - Antibodies are proteins, called immunoglobins which are produced in response to the presence of an antigen in the body. When the appropriate B cells are activated they form plasma cells that produce antibodies.
  - These antibodies then seek out the antigen and bind to a part of it, forming the **antigen-antibody complex**, which causes the deactivation of the antigen.
  - There are a number of ways in which the antigen can be destroyed, either immobilising it, blocking and neutralising the active binding site of the antigen or causing the **antigen-antibody complex** to clump together making them easier to eliminate by phagocytosis.

- **T-Cells:**
  - T-Cells are lymphocytes that are produced in the bone marrow and mature in the thymus gland. T – Cell -> Thymus Gland.
  - After they mature, T cells are released into the blood and lymph nodes.
  - Each T cell has a particular surface receptor protein that can recognise a specific antigen.
  - After T cells are activated by antigens, they differentiate into 4 types:
  - **Helper T-Cells:** These cells are for activating cytotoxic (killer) T-Cells and the B-Cells.
  - **Cytotoxic (Killer) T- Cells:** These cells attach to infected cells and produce chemicals which destroy the infected cell.
  - **Memory T-Cells:** Remain in the body and give long term immunity to certain antigens.
  - **Suppressor T-Cells:** They suppress the numbers of B and T-Cells once the infection is defeated.

- **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:**
  - The immune system is characterised into two parts, the **Anti-body mediated** and **Cell-mediated** immunity:
  - Each type of response made by these parts uses a different type of lymphocyte. The humoral (anti-body mediated) is controlled by B Cells, whilst the cell-mediated is controlled by T-cells.
  - Much of the interaction of different type of cells involved in the immune response is regulated by the secretion of chemicals known as ***cytokines***. A special type of cytokine chemical, ***interleukin*** signals or stimulates the other cells to differentiate in response to an antigen – e.g. B-Cell changing into a Plasma B-Cell
  - They are secreted by Helper T-Cells and macrophages.
- **Types of T-Lymphocytes:**
  - The four main types of T cells are:

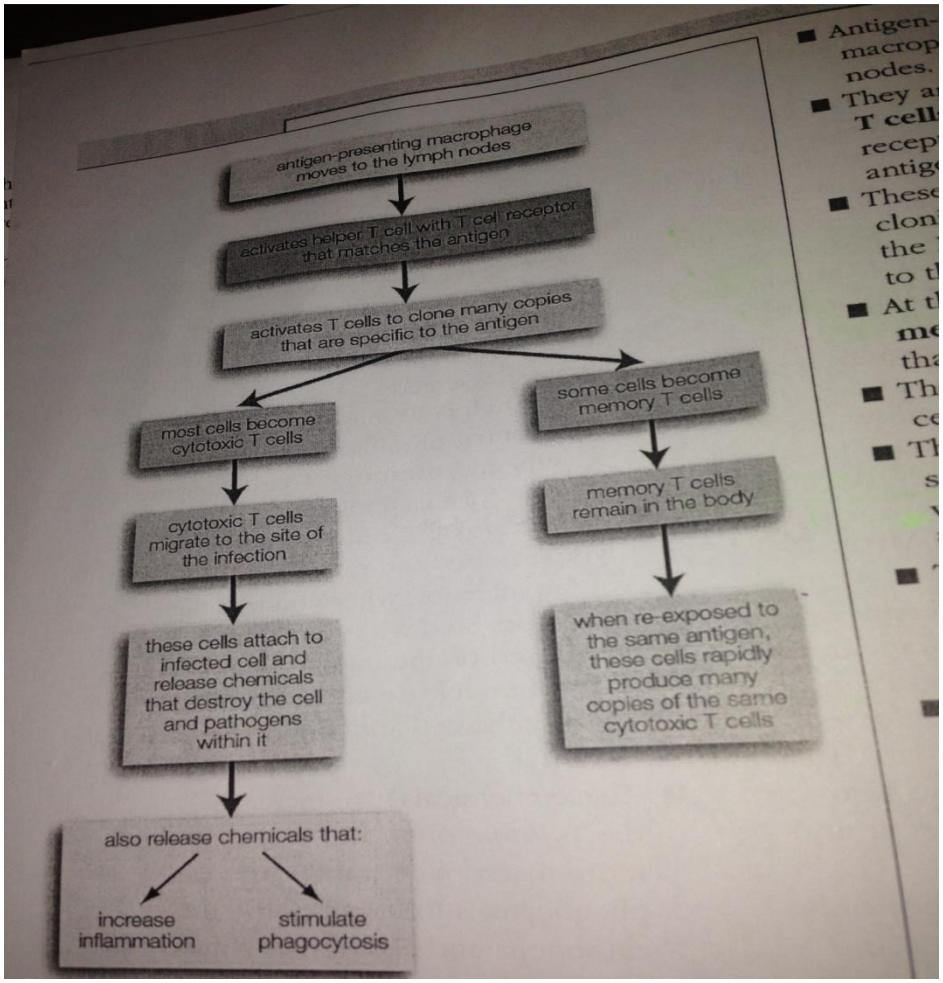
1. **Helper T Cells (Th cells)** – On the surface each of these cells has a receptor protein that will recognise only ONE type of antigen. When the cell is activated by the presence of a particular antigen or presented by a macrophage it releases a cytokine chemical (interleukin-2) that stimulates the B-cells and T-cells to differentiate into their different forms.
2. **Cytotoxic T Cells (Tc cells)** – When stimulated by helper T Cells it produces many copies (clones) of itself, its function is to recognise and kill body cells that are infected by pathogens (only works against infected cells, not directly against the pathogen). When they detect cells that have displayed on their surface antigens that match their own surface receptor protein. These cells move to the site of infection, bind with infected cells and release chemicals that destroy the infected cell.
3. **Memory T Cells** – These cells are produced at the same time as TC (Cytotoxic T cells) are multiplying and remain in the body so that the body can respond more quickly to future exposure to the same antigen.
4. **Suppressor T Cells** – These cells are responsible for stopping the immune response once the infection has been defeated.

- **Interaction between B and T lymphocytes**
  - Before an antigen enters the body, there are already many types of lymphocytes in the body that are active.
  - The entry of an antigen causes the selection of only ONE antigen-specific lymphocyte, meaning that the lymphocytes produced in response (T and B cells) are only specific to that antigen. E.g. Cytotoxic T-Cells and Plasma B-cells for influenza bacteria cannot kill pneumonia bacteria.
  - The process that occurs:

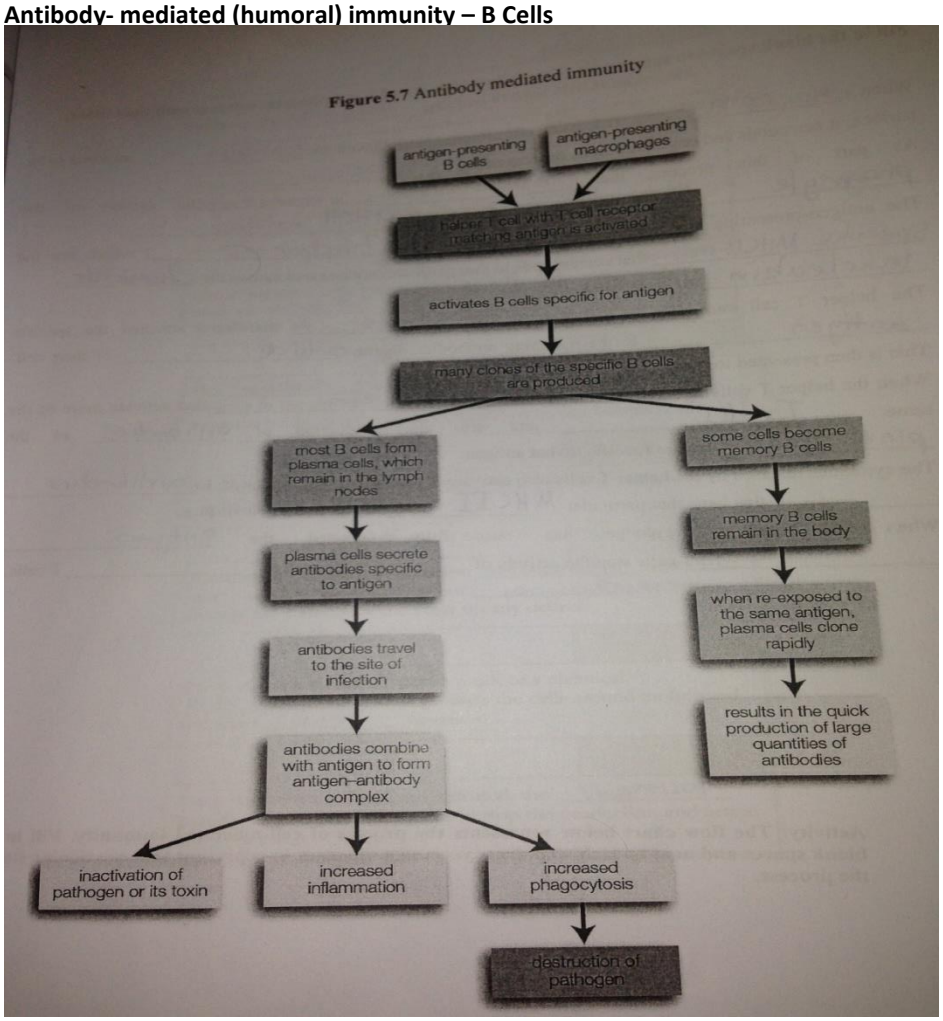
1. A macrophage encounters a foreign particle with an antigen attached to its surface, it then surrounds and engulfs it in the process of phagocytosis.
2. The antigen that was present on the surface of the pathogen is moved to the surface of the macrophage, which then transports it to the lymph nodes (This can also happen if a B-Cell encounters the foreign particle)
3. The macrophage then presents the antigen of the foreign particle on its MHCII molecule to a T-helper cell
4. Chemical signals in the form of cytokines are then secreted by Helper T cells to activate more of the same helper T cells and macrophages. A specific cytokine chemical (interleukin-2) produced stimulates T and B-cells to differentiate into their different types. The B-cells that detected the antigen can also stimulate the differentiation.
5. T- Cells differentiate into Killer (cytotoxic) T-Cells, Memory T-Cells and Suppressor T-Cells.
6. The B-Cells differentiate into Plasma B-Cells (That release antibodies that target the invading pathogen) and Memory B-Cells.
7. The memory T-cells are specific to that particular antigen and remain in the body in the lymph nodes, on re-exposure to the same pathogen they allow for the rapid production of more of the same cytotoxic T-cells for the certain pathogen (This prevents the body from developing the symptoms of the disease again).
8. When the immune response has successfully defeated the infection, suppressor T cells are responsible for suppressing the activity of the B cells and cytotoxic cells.

- **The mechanisms that allow the interaction of B and T lymphocytes:**
  - To help B and T cells interact successfully, there is a system that allows these cells to indentify that they belong to the body and prevent them attacking each other. On the surface there are glycoprotein molecules called MHC molecules.
  - MHC molecules allow for the identification of cells that are foreign. Foreign cells will have different MHC molecules on their surface.
  - B Lymphocytes can activate the T-Helper cell just like a macrophage can (through the display of a foreign particle on its MHCII molecule).
  - The T Helper cell then can activate more B and T-cells using the chemical interleukin.

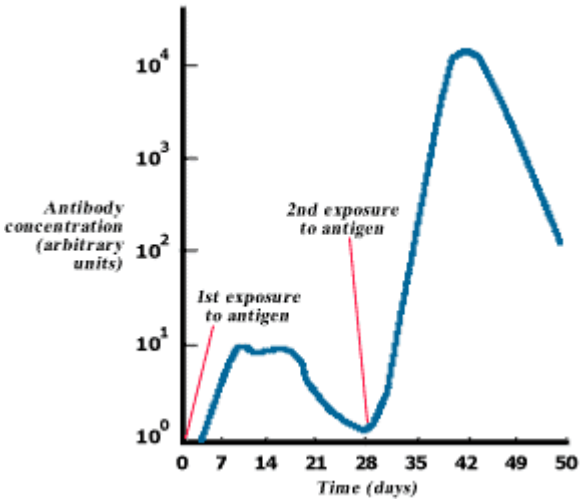
Cell Mediated immunity – T Cells


antigen-presenting macrophage moves to the lymph nodes
activates helper T cell with T cell receptor that matches the antigen
activates T cells to clone many copies that are specific to the antigen
most cells become cytotoxic T cells
some cells become memory T cells
cytotoxic T cells migrate to the site of the infection
memory T cells remain in the body
these cells attach to infected cell and release chemicals that destroy the cell and pathogens within it
when re-exposed to the same antigen, these cells rapidly produce many copies of the same cytotoxic T cells
also release chemicals that:
increase inflammation
stimulate phagocytosis

Antibody- mediated (humoral) immunity – B Cells



- **Outline the way in which vaccinations prevent infections.**
  - When an antigen is first encountered by the immune system, the time taken to fight the infection is quite long. This is because the body is unfamiliar to the antigen and must go through the long process of fighting the infection.
  - This is because once the antigen is indentified, appropriate T cells and B cells must be activated and then it takes time to build up clones of these cells. Time is also needed for the cytotoxic T cells to kill the infected cells and for the B cells to produce plasma B-cells which then secrete antibodies and bind with the antigen to neutralise it.
  - Once a person has had the infection, some of the B cells produced in response to the pathogen are stored in the lymphatic tissue. They are called *Memory B-Cells*. They are ready to provide a rapid response if the body were to be exposed to the same pathogen at a later time.
  - If sufficient antibodies are made to destroy the all of the infecting antigens the person recovers completely. This is known as **Primary response**. (First exposure to the antigen)
  - If the same antigen were to re-enter the body at a future time, the response would be a **Secondary response**. That is, the identification of the antigen and it being destroyed much faster due to memory B and T-Cells.



- **Vaccination (***immunisation***)** is the process of making a person resistant to infection caused by a pathogen by giving that person an injection of a weakened strain of a microbe of a certain disease (vaccines)
- **Vaccines** contain cultures of microorganisms which may be either: Live viruses (weakened and thus harmless), Dead or modified toxins called toxoids. These can be given orally or injection.
- **Vaccines** are harmless to the body and will not cause the disease they are specific for, but still contain the antigens that cause the body to undergo an immune response and produce memory cells for that particular antigen, so that if the body is exposed to that antigen in the future, the secondary response will be activated before the symptoms of the disease are experienced.

- **Active Immunity:** Involves the vaccine having weakened strains of antigen of the pathogenic virus that is injected to the person. This stimulates the whole immune response of T and B memory cells that are specific to that antigen. This means that *if the person acquires the certain antigen again it will be quickly irradiacted because the body has dealt with this pathogen before and the memory B and T-cells associated with it are still in the body.*
- **Passive Immunity:** Involves the injection of antibodies straight into the individual, in response to infection by a pathogen. These antibodies have been produced by another organism that has suffered the disease. It by-passes the whole immune response granting immediate protection, although it does not produce memory cells, meaning only short term protection.
- **Outline the reasons for the suppression of the immune response in organ transplant patients.**
  - When a patient receives a donor organ, it will have on its surface, 'marker' molecules that are different to the 'marker' molecules on the cells in the recipient's body.
  - The 'marker' molecules on the donor organ act as antigens that identify the organ as foreign material and the immune response is initiated. (To reduce the severity of the immune response, the tissue of the donor and recipient are matched as closely as possible. Perfect matches will only occur between identical twins.)
  - Meaning that the cytotoxic T cells become active and move to the transplanted organ and begin to destroy it.
  - **SUPPRESSION** of the immune system is needed to prevent the body rejecting and destroying the organ.
  - Drugs such as *cyclosporin* are given in order to suppress the immune system, so the risk of rejection is lowered. It reduces the activity of T-cells in fighting off the foreign; the disadvantage of immune suppressant drugs however must be taken for the rest of recipient's life and renders the individual to a greater risk of suffering from many more infections.

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

- **Identify and describe the main features of epidemiology using lung cancer as an example:**
  - **Epidemiology:** is the scientific study of patterns of occurrence of disease in human populations and the factions that affect these patterns. It describes, statistically analyses and hypothesizes as to the cause of the disease in the population.
  - Can be used to study both infectious and non-infectious disease, as well as events such as suicides, card accidents or work related accidents.
  - These results from epidemiological studies are used by public health authorities to develop strategies to control disease and improved health.
  - **Three Major types of Epidemiological studies:**

1. Descriptive
2. Analytical (Case-control/ Cohort studies)
3. Intervention

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- ♦ **Three Major types of Epidemiological studies:**

1. Descriptive
2. Analytical (Case-control/ Cohort studies)
3. Intervention

- **<Descriptive Studies>**
  - First type of study conducted when investigating the cause of a disease. Provide information about patterns of disease, including the frequency of the disease, which section of population is affected (*age, gender, occupation, etc*), the geographical location and whether there was a particular time period in which individuals were affected.
  - In an early epidemiological study to determine the cause of lung cancer, data collected included information about the *age, sex, smoking habits, diet, occupation and drinking habits of both smokers and non-smokers.*
- **<Analytical Studies>**
  - Are used to collect more data, which is statistically analysed to developed hypotheses as to the likely cause(s) of the disease. There are 4 indicators that can be used in these studies.
    1. **Morbidity:** Number of cases of the disease.
    2. **Mortality:** Percentage of population that dies from the disease.
    3. **Incidence:** Number of new cases in a specific period.
    4. **Prevalence:** Number of people affected at any time
  - **Case-control studies** and **cohort studies** are two types of analytical studies that can be used:
  - **Case-control studies:** compare people with the disease (case) to people without the disease (control) and look for differences in exposure to the possible cause of the disease. *In 1947 a case-control study was set up in London by Richard Doll, it compared patients with lung cancer to patients with other conditions. Information about many factors in their life including their smoking habits was collected. The results of the study showed that most of the individuals with lung cancer were smokers and suggested a link between the two.*
  - **Cohort Studies**: involve studying two or more similar groups of people who are free of the disease. These groups differ in one factor, that is, their exposure to the potential cause of the disease. *Following the 1947 case-control study a cohort study was set-up in England in 1951 by A.B Hill. It followed 40000 doctors over a 10 year period. One group were smokers (test group) and the other group were non smokers (the control). It was found that the test group had a higher incidence of lung cancer than the other control group.*

- **<Intervention Studies>**

- Are used to test the effectiveness of a treatment (e.g. clinical trial of a new drug) or campaign to change the behavior of the populations as a whole in order to decrease the incidence of the disease. *For example the effectiveness of campaigns such as the **'Quit'** campaign to decrease the number of people smoking is evaluated using a study such as this.*

♦ **Epidemiological studies should:**

- Be conducted over a long period of time
- Study very large sample sizes (thousands) from both affected and unaffected people.
- Participants must represent a broad range of society and lifestyles.
- Use control groups consisting of people who are not exposed to potential causes of the disease but similar in all other respects to the rest of the group (cohort studies).
- Collect data on the incidence, prevalence, mortality, morbidity.

- **Identify causes of non-infectious disease using an example from each of the following categories:**
  - **Inherited Disease**
  - **Nutritional Disease**
  - **Environmental Disease**
  - **Non-Infectious** diseases are not caused by pathogens, and are not contagious (they are not transmitted from one organism to another). Non infectious diseases include **inherited diseases** (caused by changes in genetic information)**, nutritional deficiencies** caused by an inadequate diet, and **environmental disease** that are the result of factors of the environment.
- **Inherited diseases:**
  - These are diseases that are genetically transmitted and are caused by errors in genetic information (such as gene and chromosome abnormalities).
  - They are transmitted by reproduction
  - **Example:** Down syndrome is an inherited disease that is caused by the inheritance of one extra chromosome 21. (Also haemophillia or cystic fibrosis.)
- **Nutritional deficiencies:**
  - Can be caused by diets lacking the proper balance of nutrients. A diet that is lacking a vital nutrient usually a mineral or vitamin can lead to a nutritional deficiency.
  - **Example:** Scurvy is a disease caused by the lack of vitamin C in the daily diet. Causes swelling of body parts and teeth start to fall out.
- **Environmental diseases:**
  - Many factors in the environment can cause disease. Lifestyle diseases (diseases caused by substance abuse – lung cancer from smoking), diseases cause by physical factors in the environment (skin cancer caused by excessive exposure to UV radiation in sunlight) or diseases caused by exposure to chemicals such as lead poisoning caused by exposure to high levels of lead.
  - **Example:** Disease where the muscles in airways contract and can cause severe breathing difficulties. Caused by pollen or dust.

7. Increased understanding has led to the development of 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 isolation of a diseased organism to prevent the spread of a contagious disease.
- The Australian Quarantine and Inspection Service (AQIS) has strategies in place to prevent the entry of unwanted pests and diseases into Australia, These include:

➢ **Border Control:**

- Involves the checking of passengers and cargo at entry points into Australia. A range of techniques are used by quarantine officers such as, x-ray machines, detector dogs and surveillance.

- This prevents people entering Australia bringing in things such as plant seeds, fresh foods, meat, eggs or even soil as these items can contain many dangerous plant and animal pests and diseases.
- In order to deter the entry of these products, large fines are in place and jail time imposed on those found guilty of purposely bringing in these harmful products into Australia.

➢ **Animal and Plant quarantine:**

- Many animals coming into Australia are left in stations for a period of time, where a number of tests are conducted to make sure the animal is free of disease before they are cleared to enter the country. Any pets brought in would have to be left in quarantine for a period of time until it is determined they are disease free.
- Plants aren't usually allowed into the country, this is because even if they are free from disease they might be inhospitable to Australian flora and fauna, and can cause disruption to the ecosystem.

➢ **Human Quarantine:**

- In aviation captains are required to notify the AQIS if any passengers show signs of major infective diseases (Malaria, SARS, Rabies, yellow fever).
- Also in all airports, there exists a mosquito trapping process after a flight has landed, preventing any vectors (transmitters) for diseases entering Australia.

➢ **Other Techniques:**

- 'Sentinel' animals such as cattle and pig are placed in certain locations, they act as early-warning signs to any pathogens that may have entered the country as if they develop symptoms of a disease they can halt the spread.
- Vehicles are inspected at certain checkpoints to ensure no soil/plant matter is spreading.

- **Explain how one of the following strategies has controlled and/or prevented disease:**

- **Public health programs**
- **Pesticides**
- **Genetic engineering to produce disease-resistant plants and animals**

➢ **Pesticides** are chemicals that are used to kill the pests of plants and animals, pathogens and vectors that transmit disease from one organism to another.

- If these pests and vectors are killed using pesticides then occurrence of disease will be prevented and the spread of disease throughout a population controlled.
- DDT is used to kill the *Anopheles* mosquito which carries the plasmodium that causes the disease malaria. This controlled the spread of malaria, as transmission of the pathogens was prevented by the death of the vector (being the mosquito). Eventually though the mosquitoes built up a pesticide-resistance hence reducing its efficiency.
- One problem associated with the use of pesticides is the ability of insect vectors and disease causing organisms building up resistance to the pesticide through the process of natural selection. This has the effect of decreasing the effectiveness of the pesticide and increased need for the use of different types of pesticides; also pesticides are discouraged more and more due to their damaging effects on the environment.