1. What is a healthy organism?

- **Discuss the difficulties of defining the terms ‘health’ and ‘disease’**

  **My definition of Health:** health is a combination of mental, physical, social and emotional wellbeing and is when one is free from disease or illness.

  **World Health Organisation:** A state of complete physical, mental and social wellbeing and not merely the absence of illness or disease

- **My Definition of Disease:** Disease is an infection diagnosed by health professionals and is when the human body tries to fight a problem though fails a disease is created and recognised.

  **World Health Organisation:** Any condition that impairs the normal functioning of the body.

- Everyone has different views when defining the terms ‘health’ and ‘disease’. Therefore it's always best to follow the world health organisation definition. To an elderly person health may mean being able to use their legs to walk to their letterbox, though to an athlete health may be eating healthy and maintaining optimal fitness to run a marathon.

- **Use available evidence to analyse the links between gene expression and maintenance and repair of body tissues**

  **Gene expression:** Is when proteins are created from chromosomes in order for cell to function.

  **Gene maintenance:** is the repair of cells, also known as mitosis.

  Genes control the activities of cells by directing protein manufacturing. It is a sequence of DNA, the building blocks of the Human body. Amino Acids join together to produce proteins. Genes carry cells which require proteins to survive, thus the gene must have protein in order for cells to work. The protein is essential for the everyday living of the human body. Cells are the controllers of protein manufacturing. If gene expression and maintenance are working and functioning then mitosis and gene maintenance together.

  A **tumor** occurs during mitosis and it is when there is an uncontrolled production of tissues. When genes mutate a tumor is the result as the genes lose control of their production levels. They are known as ‘oncogenes’ when the genes uncontrollably reproduce.

- **Outline how the function of genes, mitosis, cell differentiation and specialisation assist in the maintenance of health**

  The following all help play an important role in the maintenance of health:

  i) **The function of genes** - genes code for all the proteins necessary for normal functioning. If an error occurs in the expression of genes, incorrect proteins are produced and a number of issues can arise.

  ii) **Mitosis** - the production of identical cells aids the body in areas of injury where ‘bits’ need to be regrown or fixed. Mitosis can sometimes get out of control, leading to the production of tissue masses known as tumors.

  iii) **Cell Differentiation and specialisation** - we need many different types of cells to maintain normal functioning. The ability of the body to know which cells are needed to be produced at what times helps maintain health. This is especially important during the immune response when a range of white blood cells are needed.
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**

<table>
<thead>
<tr>
<th>Infectious</th>
<th>Non-Infectious</th>
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| - Those diseases that are caused by pathogens  
- Pathogens are organisms that cause contagious diseases  
- Bacteria, viruses, fungi, protozoan, prions and macroparasites are all types of parasites  
- Some examples of infectious diseases include: Influenza, Chickenpox, Measles, Ebola Malaria, Athletes foot and STIS | - Those diseases that are not caused by pathogens  
- can be caused by genetics, lifestyle, environment or psychological changes  
- Some examples of non-infectious diseases include: Scurvy, diabetes, anorexia, bulimia, anxiety, depression, many forms of cancer |

- **Identify data sources, plan and choose equipment or resources to perform a first-hand investigation to identify microbes in food or in water**

**Microbes in Food**

**Introduction:** A microorganism is an organism that can only be seen with a microscope. A microbe is something that can be seen under a microscope only. A colony is when a group of microorganisms reproduce under the right conditions and will become visible to the naked eye.

**Aim:** To culture microbes from various food types. To identify whether fungi or bacteria are found in different foods

**Materials:** bread, cheese, rockmelon yoghurt, agar plates, inoculating plates, permanent marker and incubator set to 30 degrees Celsius

**Method:**
1. Swab your bench with alcohol to sterilise it  
2. Sterilise your test tubes
3. In separate test tubes mash small amounts of each food with 2mL distilled water
4. Sterilise you inoculating loop by passing it through a flame
5. Dip the inoculating loop into your food type and wipe it gently over the surface of the agar plate. Sterilise the loop again and repeat the procedure twice so that three plates are prepared for each treatment. Remember to set aside three plates to act as controls
6. Close and seal each agar plate with sticky tape, then label it with a marking pen.
7. Place each plate in an incubator set at 30 degrees Celsius
8. Examine the plates every three days for 15 days. count the number of fungal colonies and the number of bacterial colonies on each plate and record your results.

Results:

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

Many ancient civilisations recognise the importance of cleanliness in maintaining health. The Romans built public baths, sewers and aqueducts over 3000 years ago, the Chinese and Hebrews supported cleanliness in food, water and personal hygiene.

As infectious diseases are caused by pathogens, control measures need to be able to maintain cleanliness to prevent pathogens from entering and then multiplying in water and on/in your body and to prevent the transmission of the pathogens from one person to another.

Examples of control measures include:
- Washing hands before preparing food or eating food
- Cooking food properly
- Effective sewerage treatment
- Providing uncontaminated water
- Not coughing over food
- Covering hair and open sores while preparing food.

- **Gather, process and analyse information from secondary sources to 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**

1. **Sedimentation, coagulation, filtration and disinfection are all used to purify water. Define these terms.**
   - **Sedimentation**: the process by which sediment, such as gravel accumulates
   - **Coagulation**: the process where semisolid lumps in a liquid form
   - **Filtration**: the action where solids in liquid are separated through a medium through which only liquid can pass though.
   - **Disinfection**: a treatment that destroys harmful microorganisms

2. **Outline the events of the 1998 outbreak of Cryptosporidium and Giardia in Sydney's water supply.**

In 1998, Sydney, Illawarra and the Blue Mountains suffered from severe drought conditions and also bushfires. During the drought, vegetation in the catchment areas were reduced. The vegetation was important as it was a natural barrier from contamination to the water supply.

As the drought and bushfire conditions decreased, there was an increase of heavy rainfall which fell into Sydney's drinking water catchment. this lead to large amounts of low quality runoff entering the dams. Due to the loss of vegetation and the heavy rainfall, natural filtration did not happen causing high levels of sediment, organic material, ash and microorganisms to flow into the dam. Due to this the dam water supply became polluted and the water quality was diminished, and there was an outbreak of Cryptosporidium and Giardia. These microorganisms are found in the stomachs of infected warm-blooded animals, it was likely that is appeared in the water supply through their droppings.

These two microorganisms are harmful to humans and can kill those with a weak immune system. Both are more resistant to disinfections than bacteria and viruses. A way to rid of Cryptosporidium is through the filtration process and Giardia is removed through high levels of chlorine used in the Sydney Water.

After three incidents between 21 July and 19 September 1998, Health alerts were sent out to NSW to warn all to boil their water before drinking it.
3. Describe the current procedures that Sydney Water uses to prevent any further outbreak of pathogens in Sydney's water supply

There are a number of treatments that Sydney Water take to ensure that it is safe for all to drink, these include the removal of particulate matter and inactivation of microbiological organisms. They also use the processes of fluoridisation and the adjustment of the water pH. Sydney Water regularly conducts tests to ensure that it meets the standards of the National Health and Medical Research Council (NHMRC) Australia Drinking Water Guidelines (2004).

The removal of particulate matter involves removing harmful pathogens by filtration and chemical addition. Coagulants are added to the water, the most common one added to the Sydney Water is ‘ferric chloride’. Ferric Chloride aids in the naturally occurring surface charges of particles in the water, which is called ‘floc’. Floc is a ferric hydroxide precipitate. A secondary coagulant is a polyelectrolyte, this also removes any flocs and particles. Filtration of the coagulant water removes the particulate matter.

Secondly the process of inactivation of microbiological organisms is used in Sydney Water supply. Disinfections are used to destroy microorganisms and pathogens. The disinfection also leaves a residual that protects the treated water from recontamination as it travels from the dam to the consumers taps’. Chlorine is the disinfection for Sydney water, the amounts are steady unless there is a need for a fluctuation.

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

Organisms are called pathogens when they cause disease:

- If they can cause a disease, they must:
  - Have a virulence, be present in significant numbers to cause 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

- **Viruses (influenza)**
  - Non-cellular pathogens, simply a protein coat around genetic material
  - Are found in eukaryotic and prokaryotic cells
  - Can only reproduce inside other cells (host cells), killing them.
  - No cure for viral diseases – vaccinations can reduce prevalence
  - **Example**: AIDS, smallpox, influenza

- **Bacteria** (tonsillitis, Diphtheria)
  - Unicellular, prokaryotic 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
  - **Example**: Tetanus, pneumonia, anthrax

**Tetanus** (lock-jaw)

- Found in the soil
- Not contagious
- Needs a deep wound and anaerobic conditions in the dead tissue to live
- Produces an exotoxin which is a potent nerve toxin
- Inflammation
- Phagocytes (white blood cells)
• Immune system – produces an antibody

**Symptoms**
• Spasms and seizures (mainly start in the mouth and the throat)
• High temperatures, high blood pressure and heart rate
• Strong seizures
• Untreated half will die

**Treatment**
• Antibiotics, cleaning of wound, tetanus antitoxin

**Prevention**
• Immunisation (booster shoots every 10 years)

**Protozoan (Malaria)**
  • Unicellular eukaryotic, animal-like organisms; no cell wall
  • Free-living, or parasitic.
  • **Example:** Sleeping sickness, amoebic dysentery

**Prions**
• They are NOT living things and 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)
• **Example:** Bovine spongiform encephalopathy, Creutzfeld Jacobs disease.

**Fungi**
• Eukaryotic organisms; have a cell wall made of chitin (not cellulose)
• Some are unicellular (e.g. yeast), most are multi-cellular
• They play an important role in decomposition of organic molecules, together with bacteria
• **Example:** Ringworm, tinea

**Macro-parasites:**
• Large disease causing organisms that can be seen with the naked eye
• External parasites are called ecto-parasites, internal are called endo-parasites
• **Example:** Ringworm, ticks, fleas, roundworms
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 contribution of Pasteur and Koch to our understanding of infectious diseases

Before Pasteur discovered germs, people believed that microbes generated spontaneously. They theory of spontaneous generation believed that cells were able to appear from nothing. It wasn’t until Italian scientist Francesco Redi conducted experiments with meat that this theory was disproved. Redi set up flasks with meat, some of which were covered and others exposed to the elements. It was only in those flasks that were left opened that the new organisms, in this case maggots, were generated.

Louise Pasteur:
In 1856, Louis Pasteur was called to help on one of his students wine businesses. M. Bigot manufactured alcohol by fermenting the juice from the roots of beet, yet sometimes the alcohol went sour and turned to vinegar, or if they tried to make vinegar it turned to lactic acid. They knew yeast cells were living organisms but thought they were probably at catalyst or a product of fermentation. Through a microscope, Pasteur discovered that good alcohol contained yeast that were round and budding. When lactic acid formed small rod-like microbes mixed with the yeast. He concluded that yeast caused fermentation of sugar from the beet juice into alcohol and that contaminating micro-organisms turned the fermentations sour. Also, sugar without yeast will not form alcohol and that lactic acid forms if the rod-like organisms are present. This spoilage of wine was discovered to be caused by infectious diseases and thus became a disease and known as the germ theory of disease.

He also discovered that if specific organisms cause fermentation, they can be eradicated by heating the liquids to moderately high temperatures (50 - 60) for a few minutes to kill the micro-organisms. This would ensure the batches do not go sour. Pasteur played a role in identifying the cause of disease by discovering that by heating the liquids for a short moment in intense heat that microorganisms that caused diseased will be killed. He also contributed to the elimination of spontaneous generation of disease. In this, Pasteur placed broth in a long neck flask in an 'S Shaped' and others that were normal. The ones that were exposed to the open air were found to have mould or bacteria growing in them, those that weren’t open found to have no trace of bacteria or mould as germs in the air were blocked.

Pasteurisation is the removal of harmful microorganisms in wine, beer and vinegar as well as milk. It is the heating of the liquids to moderately high temperatures for a few minutes then cooling them quickly. This sterilises the batch.

Louise Pasteur also developed a vaccine as he observed a deadly disease in sheep, horse and cattle. Working on Anthrax he added a drop of blood from a dying sheep of anthrax to 50mL of sterile culture and grew the culture. He repeated this dilution 100 times, so all the original culture was as active as the first. This shows bacteria causes disease only as reproducing bacillus could escape the dilution. Pasteur’s work on chicken cholera developed a vaccine through oxidisation and aging.

Robert Koch
Koch’s Postulates:
1. The organisms thought to cause the disease must always be present when there are symptoms of disease. (Diseased fruit with brown rot associated with fungi)

2. The organisms must be isolated from the diseased host and grow as pure culture (Fungi grow on agar plate)
3. Organisms from their pure culture must produce disease symptoms when injected into another healthy host

4. Organisms must be able to be re-isolated from the host, regrown as pure culture, and identified as the same organism culture

Koch’s Postulates identified the causative organisms having infectious diseases. He does this by extracting the Anthrax from an infected organism into another non-infectious animal. If the disease killed the animal then that would be identified as the infectious disease. He also used agar plates to discover that bacteria formed colonies on the agar plates and that was easier to isolate.

- Perform an investigation to model Pasteur’s experiment to identify the role of microbes in decay

F.H.I - 7.3.1
Modeling Pasteur’s Experiment

Introduction: Pasteur set out to prove that living microscopic organisms in the air were responsible for the transmission of disease. This experiment models his experiment that helped to support his germ theory

Aim: To model Pasteur’s experiment to demonstrate no microbes will grow in broth that is sealed off from air

Method:
1. Prepare a clear broth
2. Put 100mL of broth in each conical flask
3. Insert straight lass tubing in rubber stoppers in two conical flasks
4. Insert S-Shaped glass tubing in rubber stoppers in two conical flasks
5. Boil each flask gently for 15 minutes.
6. Leave the four flasks in the laboratory and observe their contents every two or three days
7. Record your results

Results:

<table>
<thead>
<tr>
<th>Day</th>
<th>Straight Tube</th>
<th>S-Shaped Tube</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Average Growth to no growth</td>
<td>No Growth</td>
</tr>
<tr>
<td>6</td>
<td>Average Growth (no change)</td>
<td>Little change</td>
</tr>
<tr>
<td>9</td>
<td>Mould formed</td>
<td>Minimal Change</td>
</tr>
</tbody>
</table>

Discussion:
The straight necked flask was the controlled. The straight necked flask still allows air to reach the broth, therefore it helps us to determine whether the S-shaped neck actually stop microbes from reaching the brother. What happened was that the s-shaped tube traps the microbes where as the straight does not. The broth was boiled to kill any existing microbes in it.
- **Distinguish between and name one example of a disease caused by each type of pathogen:**

- **Prions**

Prions are disease-causing agents that are neither bacterial, fungal or viral and does not contain genetic material. A prion is a protein that occurs normally in a harmless form. Prions are different from bacteria and viruses as they do not contain DNA or RNA. This altered structure is extremely stable and accumulates in infected tissue, causing tissue damage and cell death. Prions have been held responsible for a number of degenerative brain diseases, including scrapie (a fatal disease of sheep and goats), mad cow disease, Creutzfeldt-Jacob disease, fatal familial insomnia, kuru, an unusual form of hereditary dementia known as Gertsmann-Straeussler-Scheinker disease, and possibly some cases of Alzheimer's disease.

- **Bacteria**

A number of bacteria cause disease, these are called pathogenic bacteria. Bacteria are prokaryotes (single cells that do not contain a nucleus). Bacterium is the term for a single bacteria. There are different shaped bacteria, some bacteria are rod-shaped (these are called bacilli), some are round (called cocci, like streptococcus bacteria), and some are spiral-shaped (spirilli) or are incomplete spirals. Some bacteria need atmospheric oxygen to live (these are called aerobic bacteria), but others do not (these are called anaerobic bacteria; they get their oxygen from other molecular compounds). Bacteria are found almost everywhere on Earth, including in the seas and lakes, on all continents (including Antarctica), in the soil, and in tissues of plants and animals. Examples: Bacteria causes Cholera, Diphtheria, Scrub typhus, Tuberculosis and Typhoid fever.

- **Protozoans**

The protozoa are one-celled animals and the smallest of all animals. They do breathe, move, and reproduce like multi-celled animals. They live in water or at least where it is damp. Some protozoans are harmful to man as they can cause serious diseases. Others are helpful because they eat harmful bacteria and are food for fish and other animals. Protozoans are single-cell Eukaryotic organisms Protozoa exist throughout aqueous environments and soil, occupying a range of trophic levels. Protozoans are responsible for Trichomoniasis, Malaria, Giardia, Amoebic Dysentery and Sleeping sickness.

- **Fungi**

Any of numerous eukaryotic organisms of the kingdom Fungi, which lack chlorophyll and vascular tissue and range in form from a single cell to a body mass of branched filamentous hyphae that often produce specialized fruiting bodies. The kingdom includes the yeasts, molds, smuts, and mushrooms. Fungi is heterotrophic organisms possessing a chitinous cell wall. Sexual and asexual reproduction of the fungi is commonly via spores, often produced on specialized structures (mushrooms) Fungi causing diseases include Tinea Capitis (Head), Tinea Corporis (body), Tinea pedis (feet), Thrush and Aspergillosis

- **Macro-parasites**

Millions of parasites, including mites, worms, bacteria, fungi, and viruses are eating your flesh right now. The human race is subject to infestation by more than 1,000 types of parasites. Parasites are living beings that exist on the bodies of other living things. Inside the human body, parasites enjoy what we eat, sucking the nutrients from our food while we get the leftovers and the parasites’ waste products. In hookworm the parasites attach themselves to intestinal walls. Parasites cause hookworm, Hydatid Disease, Tapeworm, Elephantiasis and Schistosomiasis.

- **Gather and process information to trace the historical development of our understanding of the cause and prevention of malaria**

In Ancient History, 2700 BCE to 340 CE, Malaria was thought to have been recorded. Symptoms of Malaria were recorded in ancient Chinese medical writings. In 2700 BC, symptoms that were described were matching to those that were discovered later to be named malaria. By the 4th century BCE Greece had had its share of malaria, to the extent that is was responsible for the decline of many city-state populations. The symptoms were noted by Hippocrates, a Greek Physician in 400BC. Later in the Susruta, a Sanskrit medical treaties recorded that the symptoms of malaria were due to bites of certain insects. Some Roman writers attributed the malaria disease was due to swamps. In the 2nd century BCE, in China that Qinghao plant was referred to the Medical Treatise and...
then in the United State this plant was known as the annual or sweet wormwood. This plant was important in 1971 as it had an ingredient called artemisinins, which today is an antimalarial drug. The early 17th century, Quinine was an effective means of treating malaria. This came about by the ‘New World’, with medical advances. The Spanish Jesuit missionaries taught of a medicinal bark used for treating fevers. Today this bark is known as the antimalarial quinine.

Charles Louis Alphonse Laveran is responsible for the discovery of malaria, in 1879 he began his research at the military hospital of Bône in Algeria. There he aimed to identify and discover the black pigment particles that were unidentified in the blood of people suffering from malaria. At this time malaria was a serious problem amongst the Army, and given that Laveran was involved in the medical field of the war he was able to provide an understanding of malaria. After 1850, the particles were known as melanins, and measures were set to discover whether the particles would be found in patients suffering from malaria or if they were present in other diseases also. Laveran is an important contributor to the diagnosis of malaria through his research and findings. In his research Laveran found the unknown particles, though, in 1880, also discovered a completely unidentified body that had characteristics which led him to believe that parasites were involved. Theories earlier in history suggested, by the Italians, that it was caused by ‘bar air’ from marshlands. Louis Pasteur’s work during this period gave an intriguing angle to the origins of Malaria. Pasteur posed that most infectious diseases are caused by microbial germs, and so originated the ‘germ theory’. In relation to Malaria, the hypothesis that this disease was caused by bacteria became more believable.

As Laveran had expertise in anatomical pathology, he used those observations to help him in his research for the causal agent of malaria. Further research of infected or damaged areas in organs and blood of those with severe attacks and chronic malaria, it was evident that the black particles previously found in his research was consistently reappearing. Also, his discoveries show that the amount of these particles differed with the severity of the case. Laveran’s conclusion was that the black pigment particles were only specific to the Malaria disease, originating in the blood of an infected host. Laveran displayed immense patience whilst researching and examining freshly collected blood specimens as he used primitive methods of examinations without using chemical reactions or any staining processes.

The hospital in Bône was where Laveran noticed spherical bodies, either free or attached to red blood cells. They were either glassy and difficult to see while others had dark black pigment granules that had ameboid movements. This discovery led Laveran to his greatest findings at the military hospital in Constantine. On the 6th of November 1880, after monitoring and investigating the blood a patient who had been showing symptoms of malaria for 15 days, he saw “…on the edges of a pigmented spherical body, filiform elements which move with great vivacity, displacing the neighboring red blood cells.” Due to his patience whilst researching blood specimens, Laveran was able to link his patient to his research as he had seen the exflagellation of male gametocyte, which is a phase in the lifecycle of malaria parasites, that occurs in the stomach of the Anopheles mosquito. Evidently he was able to conclude that the agent causing malaria was a protozoan parasite. This illustration, drawn by Laveran displays the various stages of malaria parasites in fresh blood. The dark pigment granules are evidently in majority of the stages. The last row demonstrates the exflagellating male gametocyte which ‘move with great vivacity.’

In 1882, Laveran decided to move to the marshy regions of Italy to continue his discoveries and investigations as this was the scene of Malaria break outs. Here he was successful in his research as there was the same bodies in people infected with marsh fever, that Laveran discovered earlier in his research. His aim of discovering malarial parasites became a certainty. He looked for parasites in the air, water and soil of the marshlands. Sadly his efforts were unrewarded as he was unable to be successful in his findings. Though there was a negative outcome, history still recognises the large contribution and merit of his work on the malaria disease.

1 http://www.cdc.gov/malaria/about/history/laveran.html
Camillo Golgi, discovered that there was two species of the malaria disease. Firstly one with fevers every other day (tertian periodicity) and one with a fever every third day (quartan periodicity). His further observations are that there were differing numbers of merozoites which are new parasite. They differed when they matured and the fever occurred simultaneously with the release of these merozoites.

The mosquito vector was discovered by Ronald Ross in 1897 who was an Army surgeon in the Indian Medical Service. Ross undertook experiments and tests with reference to the mosquito-theory that was proposed by Laveran and the investigator, Patrick Manson. His interest in malaria came about in 1892, as he originally doubted the existence of the parasites, though soon converted after Patrick Mason explained their existence in the blood stream. Patrick Masons also was an important contributor to the history of malaria. He was named the ‘Father of Tropical Medicine’. In 1878, he was the first person to show that a parasite the caused disease in humans could infect a mosquito, it was the filarial worm that caused elephantiasis.

In 1895 Ross returned to Indian with the aim to prove Alphonse Laveran and Mason’s hypothesis that mosquitoes were responsible for spread of malaria. With constant reference to Manon’s findings he began his work. His work was almost compromised as the Indian medical Service ordered Ross to a malaria free-environment, though with Mason as his representative he was allowed special duty for a year to investigate malaria and Kala Azar (visceral leishmaniasis). The 20th of August 1897, Ross made an important discovery in Secunderabad in relation to the transmission of Malaria through mosquitoes. During a dissection of the stomach tissue of an anopheline mosquito that had previously fed, four days prior, on a malarious patient, he made this discovery. He found that the malaria parasite showed that Anopheles mosquitoes are able to transmit malaria parasites in human.

Continued research in India by Ross aims to prove his theory further. This time he used a different experimental body, malaria in birds. It was by July in 1898 that Ross was able to show that mosquitoes could carry bird malaria. This was after Ross fed mosquitos in infected birds, that he discovered malaria parasites could grow in mosquito’s salivary glands, and thus infect birds during their feeding process. This discovery was greatly helpful in history as it began to create an awareness for how easily malaria can be contracted through mosquitoes.

Through his research, in the late 1800s there was a decline of malaria break outs in the United states and Europe, this mainly was due to the draining of swamps and eradicating mil ponds.

The complete sporogonic cycle of Plasmodium falciparum, P. vivax, and P. malariae was demonstrated in 1898 to 1899 by a team of Italian investigators. This was led by Giovanni Batista Grassi, also with Amico Bignami and Guiseppe Bastianelli. They collected mosquitos and allowed them to feed on malarial patients. In 1899, those infected mosquitos were sent from Rome to London, where they fed two volunteers that both developed malaria. This was the discovery of the transmission of Malaria parasites Plasmodium.

In the early 1900s the construction of the Panama Canal heavily depending on whether malaria could be controlled in the area. Through Ronald Ross's discoveries of the transmission of malaria via mosquitoes helped the Isthmian Canal Commission discover preventative measures of the disease. At Panama, the antimalarial work was mostly that in rural areas, with a population of 80,000 living within half a mile of the railroad, and 30 villages around the area. A program of preventative measures of mosquitos was implemented, with seven basic step that were enforced.

Throughout history, by experiments and investigations, the knowledge of the 21st century has enable most countries to live free from the threat of malaria.
- Identify data sources, gather process and analyse information from secondary sources to describe one named infectious disease in terms of its:

**Diphtheria**

- **Cause**
  Diphtheria is a bacterial infection.

- **Transmission**
  Diphtheria is highly contagious and can be transmitted through air droplets from an infected person.

- **Host response**
  Bacteria toxins cause excessive membrane of mucus. Bacteria toxins cause excessive membrane of mucus to grow in the nose, throat or airway.

- **Major symptoms**
  Patients get fevers, sore throats, swelling of the neck, difficulties breathing or swallowing and Lethargy. If it spreads damage can be done to the heart, nerves and other organs, it can be fatal.

- **Treatment**
  Antibiotics can kill bacteria and neutralise toxins. Tracheostomy may be needed to inserted.

- **Prevention**
  Prevention is for infected people to remain isolated and for non-infected people there are vaccinations available.

- **Control**
  There are vaccinations available to help control the spread of Diphtheria.

- **Identify the role of antibiotics in the management of infectious disease**

  Antibiotics are chemicals made by microbes that can kill or stop the growth of bacteria and fungi. Alexander Fleming was responsible for the discovery of antibiotic penicillin in 1928. At the time there was only a few chemicals such as sulfa drugs called Sulfonamide that controlled bacterial diseases. This only worked on selective toxicity, as in they could only destroy or inactivate bacterial cells, but not the animal host they were living in. Penicillin was produced by a fungus, and was able to destroy bacterial cells, Staphylococcus colonies. By accident Fleming discovered that colonies that had contaminated a batch of Penicillin he was culturing became transparent. This meant that the chemical produced by mould was destroying bacteria. Howard Florey and Ernst Chain, showed that penicillin was effective in treating infectious diseases and could be produced in large quantities. During World War II it was frequently used and soon became available for civilian use after. Penicillin and other antibiotics such as: Cephalosporin, tetracylines and aminoglycosides have reduced infant mortality and eradicated several of the world’s most deadliest diseases.

  Antibiotics act against microbes in various ways. Penicillin destroys the cell walls of bacteria and some strains of fungi, Chlamydia, streptomycin disrupts protein synthesis in bacteria and amphotericin destroys bacterial cell membranes. They inhibit the cell wall formation, then damages the cell membrane and interfere with nucleic acid metabolism and cell division. Other antibiotics such as tetracycline and chloramphenicol act against some bacterial and fungi, this is known as ‘broad spectrum’ antibiotics. ‘Narrow spectrum’ antibiotics act against only one or two types of bacteria.

  Unfortunately, the effectiveness of antibiotics has reduced in recent years due to the appearance of resistant strains of bacteria through natural selection.
1. Describe some problems associated to antibiotic resistance

Eventually if people do not complete the full prescription of antibiotics their Doctors have given them, then their body will become immune to it and resistant. Due to this and through natural selection it is seen that antibiotics have become less effective as a means for curing bacterial infections. Bacteria becomes resistant to antibiotics due to the excessive use of them as well. If they are used too often the effectiveness of antibiotics will decrease.

2. Identify some bacteria that have become resistant to antibiotics

- Staphylococcus aureus (golden staph)
- Nellesia Gonorrhoeae (Gonorrhea)
- Methicillin resistant Staphylococcus aureus (MRSA)
- Vancomycin resistant Enterococcus (VRE)
- Multi-drug resistant Mycobacterium Tuberculosis (MDRMT)

3. Explain how the process of natural selection underpins the formation of antibiotic resistant strains of bacteria

The evolution of antibiotic resistance is due to the antibiotic interactions with various protein sequences within a bacterium. The interactions are very specific and as a result a high ratio of mutations interfere with or completely interrupt their interactions, thus antibiotic resistant occurs due to the likelihood of mutation, there is a rapid evolutionary process.

4. Explain why there is an increased chance of catching antibiotic resistant bacteria in hospitals

Due to a high concentration of sick people in hospital, who require powerful antibiotics, evolution and transmission of drug-resistant bacteria is encouraged. In a closed environment such as a hospital, resistance can travel in as little as 24 hours. Visitors are also at risk to catch this resistance when visiting those in hospital.

5. Justify why viruses are not treated with antibiotics.

Viruses are completely dormant outside the host, they can’t be attacked biologically unless they infect someone. The immune system can’t destroy the virus unless it’s in the body, so it cannot be destroyed by antibiotics. Also due to the current antiviral medicines only working when the virus is trying to reproduce in the body is also a reason why antibiotics do not work.

E.g. Bleach can rid HIV germs off a bench when the disease is external to the host. However, once it is internal to the host, the bleach cannot kill the HIV. Usually we allow natural immune systems to rid ourselves from the virus cells.
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:**
  - Healing takes different periods of time depending on the area affected
  - If the cut is washed and a band aid is applied, it will heal quicker due to pathogens being removed
  - Immune system then removes any invading pathogens.
  - There are three lines of defence:
    - First line: Barrier to entry, skin
    - Second Line: operates after invading the body if they have been successful to enter
    - Third Line: the immune response
  - The first and second line are **non-specific response**; they work regardless of the type of invader
  - The third line contains antibodies that are produced by white blood cells, they destroy **antigens** that are recognised from previous infections

### NON-SPECIFIC BARRIERS: FIRST LINE OF DEFENCE.
This prevents entry of disease causing pathogens. this includes: the skin, mucous membrane, cilia and natural body secretions.

- **Skin**
  An impervious barrier (waterproof) has natural bacteria. This has a dry, waterproof surface that limits bacterial growth and prevents the entry of other pathogens. Secretions from the sebaceous glands and sweat glands also inhibit bacterial and fungal growth. It fences you off form harmful microorganisms. The oil decomposes so that he skin has an acidity pH, inhibiting the growth of fungi and harmful bacteria. The Bacteria that covers the skin prevents pathogens from gaining a foothold.

- **Mucous membranes**
  These include the secretions of lysozymes (enzymes that can break bacterial walls) in tears, saliva and blood serum. Urine is another secretions that inhibits bacterial growth due to its acidity. The secretion of fatty acids from sebaceous glands in the skin also help to reduce microbial growth. Mucous acts as a trap for the pathogens and prevents them from entering your cells. Mucous membrane lines your excretory system, digestive system, respiratory and reproductive system. Mucous produced is effective in trapping bacteria. Tears and saliva contain lysozomes that cause bacterial cell wall to disintegrate

- **Cilia**
  These are small hairs that are found in the nose and upper respiratory tract. In the nose they are coated with mucous, which helps to filter out microbes and particles that have been breathed in. The hairs in the respiratory tract then move these particles to the throat where they are coughed or sneezed out of the body. Cilia trap dead and alive microorganisms to be expelled from the body.
- **Chemical barriers**
  Membranes that line the alimentary canal, the respiratory tract and the urinogenital tract. They secrete various substances that inhibit the growth of pathogens and can also trap pathogens until the body can get rid of them. Chemicals act as a barrier to disease. Sweat, tears, mucus and oil make your skin inhospitable to microorganisms.

- **Other body secretions**
  These include the anti-microbial secretions of the skin, mucous membranes, stomach wall and vagina. The pH of the stomach and vagina are acidic helping reduce the growth of microbes. Natural body secretions wash pathogens away or alter the pH of your skin, they also contain lysozymes, chemicals that cause bacterial cell wall to break down. Internally, hydrochloric acid in the stomach and bile in your small intestines destroys the growth of pathogens. Urine cleanses the urinary tract and secretions from symbiotic bacteria. E.g. Bacteria in the genital tract produces an acidic pH that prevents fungi and bacteria growth. Microflora is bacteria that controls diseases in the gut. An imbalance of numbers due to excess use of antibiotics will cause diarrhea due to microbes in food and water.

- **Gather, process and present information from secondary sources to show how a named disease results from an imbalance of microflora in humans**
  Human diseases that are caused by an imbalance of microflora:
  - Sore throat
  - Gingivitis
  - Gonorrhea
  - Whooping cough
  - Plaque on teeth
  - Pneumonia
  - Diarrhea
  - Cholera

**Pneumonia:**
Pneumonia is a disease that is caused by an imbalance of microflora in humans. The microorganisms that are responsible for pneumonia is streptococcus pneumoniae, staphylococcus aureus and streptococcus pyogenes.

**Symptoms:**
- Cough with mucus form the lungs
- Fever
- Shaking or Chills
- Fast Heartbeat
- Feeling tired and weak
- Fast often shallow breathing
- Chest wall pain that is worse when coughing
- Nausea and vomiting
- Diarrhea

**Prevention:**
Treatment and prevention of pneumonia is possible by the development of a vaccination against infections. Case management in the community, health centre or hospitals. Exclusive breast feeding in first 6 months. Nutrition and good diet. Maintaining healthy environment. Treatment going to hospitals or doctors. Antibiotics can be issued for pneumonia. Supportive care and rest from intense physical activity. The pain can be treated with aspirin.
- Identify antigens as molecules that trigger the immune response

THE SECOND LINE OF DEFENCE:

An antigen is a protein that is foreign to the body. Ideally, the body tried to stop these from entering the body (first line of defence), however, if they get in the body, it tried to 'deal with it'. The way the body deals with these foreign particles is to trigger the immune response.

The second line of defence involves non-specific response out by white blood cells.

ATTACK BY FOREIGN ORGANISM

\[ \text{Non-Specific Defence} \] \[ \text{FIRST LINE OF DEFENCE - barriers} \] \[ \text{E.g skin, cilia etc} \]
[Diagram of attack by foreign organism showing first line of defence with barriers and second line of defence with phagocytosis, inflammatory response, lymph system, cell death and third line of defence with immune response]

\[ \text{Specific Defence} \] \[ \text{THIRD LINE OF DEFENCE - immune response. Each antigen has specific chemical marker. Thus specific chemical need specific defence.} \]

An antigen is any molecule the body recognises as foreign and that triggers the immune response. On the surface of cells in the body, there are ‘marker’ molecules that identify the cells as belonging to the body (‘self’). This protects the cells in the body from attack by its own immune system. For example: organ transplant. When pathogens enter the body, they have chemical markers called ANTIGENS, on their surface; the immune system recognises these are not belonging to the body (‘non-self’). The presence of these antigens cause the immune response to be activated to destroy the foreign organisms. It is not only pathogens that have antigens on the surface. Any foreign cell, cell fragment, protein debris or toxin produced by bacteria can also contain antigens. Any foreign particle will be marked as an antigen.

- Explain why organ transplants should trigger an immune response

Organ Transplants: A body's immune system will identify the transplant organ as a foreign body (antigen) and thus stimulate the non-specific response such as the inflammatory response and phagocytosis. Specific response will also be triggered of B and T Lymphocytes. This can cause tissue rejection. Immunosuppressive drugs are often administered to prevent tissue rejection.
- **Identify defence adaptations, including**:
  
  - **Inflammation response**
    The area surrounding the pathogen becomes red, hot and swollen. Blood circulation is increased allowing more WBC, and oxygen to the area. It helps confine the pathogen. Mediated by histamines/prostaglandins form damaged cells tissues. These are locally active messengers that dilate vessels and increase the permeability of capillaries to WBC and proteins.
  
  - **Phagocytosis**
    Phagocytes are WBC that ingest and destroy foreign particles. Acute Phagocytosis is carried out by neutrophils which make up 50% - 70% of all WBC and don’t survive long. Chronic phagocytosis is carried out by macrophages. The dead material is collected (dead skin cells, WBC and bacteria) make up puss.
  
  - **Lymphatic system**
    The lymphatic system runs parallel to the circulatory system. The lymph nodes produce lymphocytes (B and T Cells) that also destroys foreign materials and cells. This system is able to distinguish between the body’s own cells and foreign ones, it recognises and destroys foreign materials.
  
  - **Cell death to seal off pathogen**
    In cases where the body is able to neutralise an antigen, a granuloma forms. This is a cluster of cells made up to a core of dead tissue surrounded by macrophages, lymphocytes and fibroblasts. This produces a tough lump that can be removed, taking the pathogen with it.

**Definitions:**

- **Antigen**: a substance that triggers the immune response, e.g. a virus, part of a bacteria or part of a toxic molecule.

- **The Lymph System**: is a system of vessels and lymph nodes that returns fluid and proteins to the blood. It is important for controlling tissue fluid balance, lipid transport and defence against disease.

- **Lymph**: a colourless fluid in the lymphatic system. Lymph drains from the interstitial spaces into lymph capillaries, blind-end tubes with valves which prevents lymph flowing back into the tissue. The fluid moves with the contraction of nearby skeletal muscles and smooth muscle in the walls of larger lymph vessels. The lymph passes through lymph nodes and eventually joins up with the circulatory system at the heart.

- **Lymph Nodes**: are located across the lymphatic vessels and act as filters, removing microbes, foreign particles, tissue debris and dead cells from circulation. Antibodies and memory cells formed in an activated lymph node ravel to the bloodstream to then circulate throughout the whole body.

- **Phagocytosis**: is a non-specific process, where white blood cells, called phagocytes, attack foreign microbes, toxins and abnormal cells. It is not always successful as some pathogens can repel phagocytes, some bacteria have special capsules which the phagocyte cannot grasp and some pathogens escape before being completely destroyed. Pus is a mixture of dead phagocytes, bacteria, tissue fluid and damaged body cells.

- **Macrophage**: are the largest phagocytic cells and are mobile, non-living and mononucleated. Macrophages are involved in wound healing, inflammation and the immune response when activated by the lymphokines released by T-cells. Macrophages engulf dead and damaged cells, debris, antibody-coated microbes and damaged fatty particles. They then release digestive enzymes and lytic enzymes to destroy the particles. There are fixed macrophages in lymph nodes and alveoli and wandering macrophages elsewhere. Once the pathogen is destroyed, parts of the partially digested antigen are displayed on the surface of the macrophage. Contact with T-cells stimulates the production of more helper T-cells for that particular antigen. Thus, macrophages are part of the non-specific response as well as the production of specific defence cells.
**Inflammation response**: Tissue damage followed by the invasion of a pathogen causes the inflammatory response which includes the release of histamine. The histamine causes the dilation of blood vessels, increased permeability of the blood vessels walls and the release of chemicals to attract phagocytes. This results in increased fluid leaving the blood flow and the area becomes red, hot, swollen and painful as there is an increased phagocytosis.

**Cell death to seal off pathogen**: a cluster of cells often forms around the pathogen and damaged cells. A cyst may even form. This area is sealed off. Other cells such as white blood cells and healthy cells may be sacrificed to make sure the pathogen is sealed off.

- The difference between blood and lymph is that lymph is a colourless fluid that drains from interstitial spaces into lymph capillaries and prevent lymph from flowing back into the tissues. Whereas blood is a red substance that carries protein and oxygen around the body as well as red blood cells. the lymphs carry white blood cells.
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:**
The third line of defence is called the IMMUNE RESPONSE. It involves the production of 2 lymphocytes. B cells and T cells. These cells work on one specific foreign particle. The lymphocytes work together to rid of pathogens. They remember specific antigens and are able to work quickly on subsequent invasions. This is known as ACQUIRED IMMUNITY. For example: chicken pox.

Lymphocytes are a special type of white blood cells. When an antigen enters the body, B-cells produce plasma, which in turn produces antibodies. Antibodies are a special type of protein called immunoglobin. They act by binding with their own particular antigen to form an antigen-antibody complex. This complex results in the destruction of the antigen by immobilising it or by blocking the active binding sites of the antigen. It can also allow macrophage to more easily recognise the destroy the antigen by phagocytosis.

When a particular antigen is detected, T cells stimulate the cloning of multiple copies of B cells and also the production of antibodies by B cells. This is brought about by either direct contact between the two types of cell, or by the secretion of chemical such as interleukins that target the B cells.

Memory B and T cells are the lymphocytes responsible for the production for immunity. They remain in the body for a long time and recognises it when it enters the body again, so they can quickly fight if off.

- This immunity is NOT present at birth – it is gained through the exposure to infection
- The specific immune response acts only against specific microbes or substances
- 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**
  - Antibodies are proteins, called IMMUNOGLOBINS, which are produced in response to the presence of an antigen in the body
  - They are produce by B-cells (antibody immunity)
  - They have antigen binding sites which match the shape of the antigen they are specific for
  - 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
  - Immobilises antigen, blocks and neutralizes the active site and can clump together antigens making phagocytosis easier

Antibodies are proteins produced by lymphocytes when antigens are detected in the body. Each one is specific for a specific antigen. These proteins combine with antigens to kill or inactivate them, or clump antigens together so they can be more easily recognised and destroyed by macrophages

- **Neutralisation**: Can stick to the binding sites of the virus, or disable bacterial toxins by coating them. They 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). Phagocytises follows
- **Complement activation**: The antibodies can stick to the surfaces of bacterial cells, acting as tags for destruction by complement proteins
- **T cells**
  - Mature in the thymus gland - each T cell has its own unique surface receptor protein to identify a specific antigen
  - Released into the blood, lymph nodes, spleen and tonsils
  - When activated cytotoxic (killer) T cells move to the site of the infection and release chemicals to destroy infected cells
  - Cell-mediated immunity
  - Defend against bacteria and viruses **inside** the cells
  - **Suppressor T-cells**: these inactivate B and T cells after infection has occurred
  - **Killer T-cells**: these destroy infected cells, cancer cells, graft cells or macrophages that have engulfed an antigen. They do this by binding with the cell and producing a toxin chemical. This acts to rupture the cell
  - **Helper T-cells**: these produce chemicals that stimulate the production of multiple copies of B and killer t-cells in response to the detection of an antigen. They also stimulate macrophages and other phagocytes to engulf antigens
  - **Memory T-cells**: these T-cells remain in the body and recognise later infections by the same antigen. They reactivate quickly when this occurs.

T-Cells are a lymphocytes that is produced in the bone marrow and matures in the thymus gland. Some of these lymphocytes are involved in ‘cell-mediated’ immunity, in which they help to destroy body cells that have been infected by a virus or other pathogen. Others help in the production of antibodies by B-cells and the activation of phagocytes.

- **B cells**
  - Mature in the bone marrow - each B cell has its own unique antibody on its surface that will only identify the antigen it matches with
  - Released into the blood, lymph nodes, spleen and tonsils
  - When activated produce plasma cells which secrete antibodies that combine with the antigen to deactivate it
  - Antibody-mediated immunity
  - Defend against - bacteria and viruses and their toxins **outside** body cells
  - B cells divide to form plasma cells, which produce antibodies
  - **Memory B-cells**: remain in the body for a long time and will detect a later infection by the same antigen. The required antibody will then be produced quickly, and in large amounts.
B- cells are lymphocytes that is made in the bone marrow. These lymphocytes produce plasma cells when they recognise an antigen. The plasma cell in turn produce antibodies to destroy or inactivate the antigen.

- Process, analyse and present information from secondary sources to evaluate the effectiveness of vaccination programs in preventing the spread and occurrence of once common diseases, including smallpox, diphtheria and polio

**Secondary Source Investigation 7.5.1**

**Effectiveness of vaccination programs for smallpox, diphtheria and polio**

**Aim:** to evaluate the effectiveness of the vaccination programs for smallpox, diphtheria and polio.

**Discussion Questions:**

1. **Identify the age groups most at risk of contracting smallpox, diphtheria and polio.**
   - Smallpox: Over 18 years of age and below 65.
   - Diphtheria: Over 18 months are susceptible
   - Polio: 2-4 months and above is susceptible

2. **Discuss how vaccination programs are implemented in Australia**
   In Australia there is the Immunise Australian Program which looks to increasing total number of the population’s immunisation rates. This will be done by funding free vaccination programs, administering the Australian Childhood Immunisation register and promoting and educating the public about immunisations and health professionals.
   The National Immunisation Program began on the 1st July 2007, which outlines the fully funded and recommended vaccine for each age group. This vaccination program is implemented through local GPs, health centers and commonly through schools. Immunisations are provided at all ages and the doses are given for those currently funded under the National Immunisation Program.

3. **Identify the microorganisms that cause smallpox, diphtheria and polio**
   - **Smallpox:** Variola major is the bacteria
   - **Diphtheria:** Bacillus bacteria - Corynebacterium diphtheriae
   - **Polio:** poliovirus. RNA virus *Picornaviridae* and genus *enterovirus*.

4. **Evaluate the effectiveness of vaccination programs in preventing the spread of smallpox, diphtheria and polio**
   In relation to preventing the spread of smallpox, diphtheria and polio, the Australian Health Department has formed the Immunise Australian Program which aims are early vaccination. By vaccinating people at a younger age will aid as the spread of these diseases. The dosages will depend on the age.

5. **Evaluate the effectiveness of vaccination programs in preventing the occurrence of smallpox, diphtheria and polio.**
   - **Smallpox:** Smallpox vaccination provides high level immunity for 3 to 5 years and decreasing immunity thereafter. If a person is vaccinated again later, immunity lasts even longer. Historically, the vaccine has been effective in preventing smallpox infection in 95% of those vaccinated.
   - **Diphtheria:** The diphtheria vaccination program involves mass immunisation of the population which usually administered as a booster injection to children. The diphtheria vaccination program had been relatively successful with no catastrophic outbreaks worldwide. In 2000, 30000 cases of diphtheria were reported worldwide with 3000 fatalities.
   - **Polio:** The Inactivated Polio Vaccine (IPV) is a highly effective in preventing poliomyelitis. In three-dose series IPV results in high titres of serum in 99% to 100% of patients. Immunity is prolonged, perhaps life long.

   It is evident that the smallpox vaccination is effective as it provides high levels of immunity for children 3 to 5 years, and if backed up with another dosage can last even longer. 95% of those that immunised themselves did not die from Smallpox which demonstrates that the vaccination is effective. Diphtheria proves to be less effective
as in 2000 there was still 3000 deaths worldwide, though out of the 30,000 cases there was 3000 deaths, it is a 1 in 10 will die from this disease.
Polio is a highly effective vaccine as within three doses immunity is prolonged and a longer life is available.

- SMALLPOX
  - **Cause and symptoms:**
    - The smallpox virus
    - Enters through the throat and lungs, then undergoes a 12-day incubation period
    - Symptoms of the disease include obvious vesicles on the skin, headaches, backaches and fever
  - **History:**
    - First appeared in Asia or Africa around 10,000 BC
    - Spread around the world by explorers, traders and crusades
    - Responsible for 1 in 10 of all deaths in the 19th century in Europe
    - Reached Australia in 1789, with early European settlers, having a devastating effect on Aboriginal communities
  - **Vaccination programs:**
    - Edward Jenner performed the first smallpox vaccination by inoculating people with cowpox (after noticing milkmaids who caught cow pox did not contract smallpox, as they had developed resistances)
    - 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:**
    - Bacterial infection which is spread through the air into respirator surfaces, or by close physical contact
    - 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 ‘Diphtheria Vaccine’
    - 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 outbreaks 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
    - No longer thought of as a ‘child killer’

- POLIO
  - **Causes and symptoms:**
    - Attack by the polio virus on the motor neurons 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—→ injections
- 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 numbers 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 and reduced by 80%.

**Describe and explain the immune response in the human body in terms of:**
- interaction between B and T lymphocytes

1. A macrophage engulfs foreign particles via phagocytosis. The antigen on the foreign particle moves to the outside of the macrophage. The macrophage transport the antigen to the lymph nodes. (it is like pacman, it eats foreign particles, then takes to lymph nodes.

2. The macrophage activates helper T-cells, which are specific to an antigen. (Helper T-cells. Memory T-cells [immunity])

3. T-cells may also be activated by the B-cells. The B-cell bind itself to the antigen and takes it to the T-cells.

4. Cytokines activate more T-cells, macrophages and B-cells which help to deactivate the foreign particles. (chemical signals created by T-cell create more T-cells [helper])

**Antibody-mediated (humoral) immunity**
- Antigen-presenting **B cells** or macrophages move to lymph nodes
- These antigen-presenting cells are inspected by **helper T cells** that have the antigen receptor that correspond to the antigen being presented
- Helper T cells release cytokines to stimulate the cloning of millions of the **B cells** that are specific to the antigen being presented
- Millions of **memory B cells** that are specific for that antigen are also cloned
- The activated **B cells** produce plasma cells that remain in the lymph nodes
- Plasma cells secrete antigen-specific **antibodies** that then move via the blood and lymph to the infected areas
- The antibodies then combine with the antigens to form the **antigen-antibody complex**, which inactivates the pathogen or its toxin
- The pathogen is then destroyed in a variety of ways depending on its type
- The **inflammatory response** is activated, attracting phagocytes and leading to the clearing of the debris

**Cells-mediated immunity:**
- Foreign materials is engulfed by **macrophage** which then display the **fragment** attached to their MHCI molecules
- The antigen-presenting macrophages move to the lymph nodes where they are inspected by the Helper T cells that have the antigen T cell receptor that corresponds to the antigen being presented.
- These helper T cells activate the cloning of millions of cytotoxic T cells and memory T cells, that are specific for this antigen.
- The helper T cells leave the lymph nodes and migrate to the site of the infection where their antigen receptor binds with the antigen displayed on the infected cell.
- They then release chemicals that destroy the cell and any pathogen within it.
- These chemicals also increase the inflammation and attract more macrophages that carry out phagocytosis to help destroy the pathogen and clear up any debris.
- Some of these cytotoxic T cell produce a chemical interaction which protects the cells around an infected cell from viral invasion.
- Once the infection has been defeated the suppressor T cells release other chemicals to stop the production and action of the cytotoxic T cells.

- 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 the 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.
- The T-cells are activated by infected cells displaying the antigens.
- The B-cells are 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.

- The mechanisms that allow interaction between B and T lymphocytes.

  The mechanism of interaction:
  - Clonal selection:
    - Before an antigen enters the body, there are already many types of lymphocytes in the body.
    - The entry of the antigen causes the selection of only one of the types of lymphocytes – the one that has the binding site that matches the antigen.
    - This results in the lymphocyte cloning itself into large numbers of this same lymphocyte, so it produces the antibody that matches the antigen.
    - This means, for example, the cytotoxic T-cells for influenza bacteria cannot kill the pneumonia bacteria.
  - Cytokines and Interleukins:
    - Cytokines are a group of SIGNALLING COMPOUNDS made of proteins or polysaccharides that are used for communication between cells.
    - The co-ordinate the function of cells so that they can act together as a whole, such as the immune response.
    - Interleukins are a type of cytokine that are secreted by helper T-cells and the macrophages.
    - This is the main mechanism that is used for intercellular interaction.

- The range of T lymphocyte types and the difference in their roles.
Types of T-cells:

- **Helper T-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
  - Produce interleukin2 - causes the production of cytotoxic killer T-cells

- **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 the pathogens
  - Are produced in response to helper T-cells, or free antigens
  - The cytotoxic T-cell has receptors which 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
  - Function – To recognise the antigen rapidly if it appears 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 for a short period
  - Secrete chemicals to suppress the actions of the B and T-cells after the immune response has ended

**T-cells**

- **CREATION:**
  - Multiply in the thymus gland

- **DISPERSAL**
  - Released into the:
    - Blood
    - Spleen
    - Tonsils
    - Lymph nodes
  - Patrol the body looking for antigens

- **ATTACK**
  - Directly or indirectly cause the destruction of antigens and their accompanying pathogens
  - Defence is called CELL MEDIATED IMMUNITY because the T-cell is directly involved

**Outline the way in which vaccinations prevent infection**

Vaccination is a method of providing artificially acquires immunity without the need for a person to have suffered the disease initially. It involved the injection or swallowing of a substance that triggers the immune response so that memory B and T cells are produced. These will rapidly detect and respond to a subsequent infection by the same antigen, producing antibodies in large numbers so that infection is dealt with quickly and effectively.

Active immunisation stimulates a person to make his or her own antibodies. It involves the introduction of killed bacteria or viruses, weakened live pathogens (as in the polio, measles and whopping cough vaccine) or modified toxins into the body. The body recognises these substances as antigen, and B cells are stimulated to produce plasma cells and memory cells. The person does not actually acquire the disease, but memory cells have been manufactured and are stored in the lymphatic system so that the immune response can be fast and effective if a later infection by the same antigen occurs. Example of active acquired immunity include immunity acquired though tetanus and diphtheria injections, and the polio vaccine which is taken through the mouth as syrup.

Passive immunisation involved the injection of antibodies produced by another person, and produces only short-term immunity. An example of this is the injection of immune serum globulin as a temporary protection against
hepatitis when people are traveling to areas where this disease is widespread. Passive acquired immunity also occurs when antibodies present in a mother’s placenta cross over to the blood for the foetus, or when a baby takes in the antibodies present in its mother’s milk.

- **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** is gained through injecting the antigen of the pathogen in the vaccines. This stimulates the whole immune response, including antibodies and B and T memory cells that are specific to that antigen, without the symptoms of infection. The production of memory cells has two implications:
    - If the pathogen does enter the vaccinated individual, the memory cells initiate 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** 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 the 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**

  When a patient receives an organ transplant, the body’s immune system recognises the foreign tissue as an antigen, and the immune response is triggered. This often happens despite the fact that the tissue proteins of the donor are matched as closely as possible with those of the recipient. Killer T cells, macrophages and antibodies being to attack the tissue that has been distinguished as ‘non-self’ by the lymphocytes, and tissue rejection usually follows. As a result, special ‘immunosuppressive’ drugs need to be administered to organ transplant recipients to prevent this rejection process. Drugs such as antilymphocyte globulin (ALG) act to suppress the action of the B and T lymphocytes, allowing the transplanted tissue to remain in the body. A side effect of this treatment, of course, is that the immune system will no longer protect the patient from other infections of antigens such as cancer cells.

  Immunosuppressive drugs can create other side effects; steroids such as Prednisolone can cause weight gain, fluid retention, raised blood pressure, diabetes, thinning of the skin and osteoporosis. Cyclosporins, used in organ transplants and kidney disease, interfere with interleukin production by helper T cells. They can cause side effects such as tremors, excessive hair growth, kidney damage and the increase risk of tumours and serious infections.
There is also a need to suppress the immune system in certain ‘auto-immune’ disease such as Lupus and Goodpasture’s disease. In these conditions, the immune system begins to attack the patient’s own kidneys, causing inflammation and tissue damage. Immunosuppressive drugs are also of use here, but again there is a risk of serious side effects occurring.

- A transplanted organ is recognised as foreign tissue by the immune system, it is identified as ‘non-self’.
- 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 and try to destroy the organ
- The chances of rejection is reduced by matching the transplant organ tissue with the tissue of the patient, and by providing immunosuppressant drugs
- The danger of this therapy is the inability of the patient to fight off any infections, since the immune system is suppressed.
- This is known as IMMUNOSUPPRESSION
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 disease that affect many people and it is statistics that are used to detect this. Smoking evidently causes lung cancer and epidemiology can explain this. Statistics show that with an increase of the prevalence of smoking amongst females and males, 10 or 15 years down the track is an increase in lung cancer statistics. Likewise if there is a decrease in smoking a decrease in lung cancer will result.

- **Gather, process and analyse information to identify the cause and effect relationship of smoking and lung cancer**

  **Secondary Source Investigation 7.6.1**
  *(See page - 487)*

**Aim:** to analyse information to identify the cause and effect relationship of smoking and lung cancer.

**Discussion Questions:**

2. **Identify the trends in these data**
   The trends show male smokers and decreasing where as female smoking is slowly decreasing. The number of male lung cancer rates are decreasing though female lung cancer deaths are increasing dramatically.

3. **Explain these trends**
   Male smokers are decreasing as many have given up smoking in the in the 1990s. The graph shows that the smoking prevalence are reflective of the lung cancer rates. As smoking rates increase the lung cancer prevalence increasings, if smoking decreases the number of lung cancer incidents decrease as well. Though this chance is not immediate, it is a gradual fall and drop of numbers, it is evident that there is a 10 to 15 year gap, if smoking level drop changes in lung cancer numbers will be evident 10 to 15 years later.

7. **Identify possible tobacco control procedures that could help reduce smoking in the general population.**
   The most obvious tobacco control initiative is the National Tobacco Campaign, that the Australian Government has introduced to raise an awareness of the ramifications of smoking. The introduction of alarming television ads have raised an awareness about smoking. From 1 March 2006, a new system of health warnings came into full effect requiring all Australian-manufactured and imported tobacco product packaging to be printed with new graphic health warning labels.
   Laws that have restricted the purchasing of cigarettes, the legal age to buy and to sell cigarettes to is those over 18 years of age, and a person seen selling of giving a person tobacco under this age will incur a fine. Soon plain packaging will be implemented in all stores which will hopefully cause a further decline in smoking.

9. **Identify the risk factors associated with smoking that could increase the chances of lung cancers**
   - Wed-locked with a person that smokes increases your chance by 30% of getting lung cancer
   - Emphysema will result and a shortness of breath due to restricted airways.
   - smoking puts a person in risk of onset of the pancreas, kidney, bladder, esophagus, oral cavity, pharynx and larynx.
   - Hair-like cilia cleanse the lung by sending the untoward substances pushing out of the lungs through bronchi. The efficiency of cleaning mechanism gets affected due to smoking with the disappearance of cilia. Hence the carcinogenic substances gets accumulated in the bronchial lining and also absorbed, which may get transformed into the blood system.
10. Explain the following statement: ‘We have known that lung cancer has consistently been the number one cancer killer in Tasmania men for decades, ahead of bowel and prostate cancers. An increase uptake of smoking by women in the later 1960s means that we are now beginning to see a similar effect in the number of female deaths from this lung cancer’. There is an evident link between tobacco smoking and lung cancer, those who smoking have increased their chances of developing lung cancer. The 1960s was a year of sexual revolution and for females to explore and defy the conventions of a stereotypical women. Trends take many decades to be identified, which is why today we can see, through epidemiology that there has been an increase in smoking and thus an increase of lung cancers for females.

- Identify causes of non-infectious disease using an example from each of the following categories:
  - inherited diseases
    Inherited disease: genetically passed on from a familial ground. Recessive and polygenic inheritance.
    Example: Ureteric reflux (URV) or vesico-ureteral reflux
    Detail of the cause: A dominant polygenic gene inheritance. Thus only one gene is needed in order for it to be passed on and to get the disease.
    Symptoms: Valves between ureters and bladder don’t form properly, and this causes a back flow of urine.
  
  - nutritional deficiencies
    Nutritional deficiencies: relates to a person’s diet, excess deficiency or imbalance of nutrients
    Example: scurvy
    Detail of the cause: cause by a deficiency in vitamin C
    Symptoms: Swelling and bleeding of gums and tissue, teeth fall out and spots on skins/thigh or legs.

  - environmental diseases
    Environmental disease: related to the abiotic or biotic factors
    Example: mercury poisoning
    Detail of the cause: consumption of fish that have levels of mercury of heavy metals in their systems
    Symptoms: brain damage, convulsions, blurred visions, even birth deficiencies
Identify data sources, plan and perform a first-hand investigation or gather information from secondary sources to analyse and present information about the occurrence, symptoms, cause, treatment/management of a named non-infectious disease.

<table>
<thead>
<tr>
<th>Features</th>
<th>Non-infectious disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Down Syndrome</td>
</tr>
<tr>
<td>Type of disease</td>
<td>Inherited</td>
</tr>
<tr>
<td>Occurrence</td>
<td>In mothers over 35 years old, chances are 85% that causes down syndromes. 1 in 800 will develop this with 3000 to 5000 diagnosed each year</td>
</tr>
<tr>
<td>Symptoms</td>
<td>Flat face, upwards slant of the eyes, deep crease of the palm, poor muscle tone, loose ligaments, small hands and feet. Many suffer from hearing problems, thyroids dysfunction, skeletal problems, cataracts or intestinal problems</td>
</tr>
<tr>
<td>Cause</td>
<td>Down syndrome is due to an extra copy of chromosome 21. Also called trisomy21. It is common in birth/pregnancies in women 35 years plus</td>
</tr>
<tr>
<td>Treatment</td>
<td>As down syndrome can not be cured, control of symptoms is managed. Regular check ups, screenings, medication and surgery. Also counseling and support should be offered. Often parents hire a person to encourage brain activity and engaging in their child</td>
</tr>
<tr>
<td>Management</td>
<td>Down Syndrome cannot be prevented, though can be detected before birth. To prevent an intellectually impaired child, births should happen before 35 years old. Symptoms of the disease can be managed and prevented, like growth, hearing, obesity, cardiac disease etc.</td>
</tr>
</tbody>
</table>
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 helps prevent the spread of disease and plants and animals into Australia and across regions of Australia. As an island continent, the flora and fauna of Australia evolved in isolation so the introduction of other species can be dramatic impact on native organisms. Items or organisms which are to be brought into the country are kept in isolation to reduce the likelihood of the spread of contagious diseases.

‘Quarantine’ comes from the Latin *quaranti giorni*, which means forty days. Ships used to be isolated and passengers remain aboard for forty days when they came into port. Present day travelers do not have to follow these old rules, but here are stringent rules about entering the government.

**AQIS** - Australia Quarantine and Inspection Service - administers the Quarantine Act of 1908, inspecting all goods and organisms taken in or out of the country. Australia’s highly favourable animal, plants and human health status is due to inspection of exports, check on good safety standards, quarantine of all plants and animals and a check on all passengers of infectious disease. The main sims of AQIS using their certification systems, inspection systems and quarantine systems are to:

1. Keep worldwide markets access for Australian exports
2. Protect Australia’s agricultural production, consumers and environment.
3. Protect human health and the health of Australian flora and fauna

Some of the activities of AQIS include:

- Certification of commodities for export (e.g. Meat, dairy, fish, grains, horticultural, wool, hides, skins and live animals)
- Supervision of first-port ship arrivals, first-port aircraft arrivals, process cargo containers, airfreight consignments and mail articles, for example, through the use of tracker dogs and X-rays
- A major public awareness campaign about the importance of quarantine to all Australian
- AQIS issues fines and other penalties for breaches of the Quarantine Act
- Management of ballast water from visiting international ships

Within Australia there are different quarantine requirement with checkpoints to stop the spread of animal and plant disease form one state to another. For example, near the Queensland boarder there are checks where travelers are not allowed to bring fruit and potentially fruit fly into the fourth. There are also checks between South Australia and NSW

- Perform an investigation to examine plant shoots and leaves and gather first-hand information of evidence of pathogens and insect pests

<table>
<thead>
<tr>
<th>Pathogens</th>
<th>Insect pests</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Bacteria cause spots on the surface of the leaves (rust on the Banksia leaves)</td>
<td>• Insects (‘Azalea lace bugs’) feed on the plant itself creating holes and damage</td>
</tr>
<tr>
<td>• Fungal infections are shown by dark growths on the stems (black stem rot) or on the underside of leaves</td>
<td>• Caterpillars, snails, aphids (feed on plant sap)</td>
</tr>
<tr>
<td>• Magnesium deficiency → (gardinia) due to insufficient nutrients growth becomes abnormal</td>
<td>• Other insects such as psyllids, reproduce on the plants, and leave behind egg shells and holes</td>
</tr>
<tr>
<td></td>
<td>• In lilly-pilly’s, ‘Pimple Psyliid’s’ suck the sap of new leaves- plant develops lumps on the upper surface and depressions on the lower surface</td>
</tr>
</tbody>
</table>
- Explain how one of the following strategies has controlled and/or prevented disease:
  - public health programs
  The public health programs have define diseases as ‘notifiable, and others requiring a quarantine period’. Other procedures include Occupational Health and Safety laws in workplaces supporting good health and maintaining a healthy environment. Further programs include the immunisation program that has controlled disease from an early age and also the elderly influenza and drink driving prevent preventable diseases. Screening programs can identify potential disease.

- Prevention is the stopping of the occurrence of the disease
- Control is the decreasing of incidences and spreading of the disease
  o Safe sex campaigns have both prevented and controlled the spread of sexual diseases
  o Quit Campaign is aimed at decreasing the incidence of lung cancer
  o The ‘Protect yourself in 5 ways’ campaign is aimed at decreasing the incidence of skin cancer

- pesticides
Pesticides are chemicals that destroy organisms considered to be pests (for example, insects that damage crops or disease vectors). Most pests are insects, but other pest groups include: ticks, mites, worms, slugs and snails. DDT (Dichloro-diphenyl-trichloroethane) is a pesticide that was used during WWII to destroy body lice in order to control typhus fever. It was then used extensively to kill mosquitoes in an effort to control malaria. However, natural selection led to DDT-resistant concentrations. DDT is an example of biomagnification; the pesticides accumulates in body tissues, is not easily broken down and last for many years. DDT levels in the high order consumers caused serious problems. For example: egg shells of Australian peregrine falcons broke before the young could hatch. DDT was banned as a pesticide.

- 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
- Was extremely effective in the beginning, and numbers of malaria sufferers went down, but then pesticide-resistance reduced its efficiency
- DDT was also used to kill lice on the bodies of soldiers in WWII
- The lice carried diseases such as Typhus fever
- The pesticide prevented thousands of deaths

- genetic engineering to produce disease-resistant plants and animals
Genetic engineering is the alteration of chromosomes by adding or removing genes. One of the first uses of recombinant DNA technology involved the insertion of the gene to make human insulin into strains of the bacteria E. coli so that large amounts of human insulin would be available to people suffering from the disease diabetes. The techniques have been applied to produce disease-resistant plants and animals. For example, some cotton varieties have been made which are more resistant to pesticides than other varieties, and transgenic tomatoes have been created which ripen fully on the plant and can be transported without becoming soft and squashed. Scientists are now trying to insert the DNA code to form a new variety of the myxoma virus that would cause infertility in rabbits.
- Process and analyse information from secondary sources to evaluate the effectiveness of quarantine in preventing the spread of plant and animal disease into Australia or across regions of Australia

Secondary Source Investigation 7.7.1
Effectiveness of quarantine in preventing spread of plant and animal disease
(See page____)

Aim: To evaluate the effectiveness of quarantine in preventing the spread of plant and animal disease into Australia of across regions in Australia.

Discussion Questions:
3. Compare early and current Australian quarantine procedures
Early Australia, before the First Fleet was free from disease and quarantine was not around. With the Fleet, brought disease from the convicts such as Cholera, dysentery, smallpox, typhoid fever etc. As the Australian colonies developed, each used quarantine as a primary safeguard of the community's health. Initially the spread of disease on ship was not of great concern to many as during the travel if one was infected would spread to the whole crew. The first quarantine measures was in 1884 when the Government of New South Wales convened a conference of representatives from each colonial government, known as 'The Australasian Sanitary Conference of Sydney, NSW, 1884'. This created a scheme of quarantine for both Australia and the nearby Pacific Islands. They insisted on a co-ordinated quarantine system be accompanied by effective internal sanitation measures. There was an establishment of two quarantine stations -- one at Albany in Western Australia and the other at Cooktown in Queensland. It was is known that each state was in control of their own quarantine procedures and health was in the hands of the states as well. Today this is changed as to keep each state as a whole, the Commonwealth looks after quarantine in Australian and the states look after health. The Department of Health and Ageing is responsible for developing and maintaining human quarantine and public health policy in Australia. Today if people who may be displaying symptoms of quarantinable diseases and that may be a serious public health threat to Australia will be reported by officials. Australian quarantine laws require that the captain of an international aircraft or vessel must report any passengers or crew who display certain disease symptoms or who are ill with particular quarantinable diseases. The report must be made to an AQIS officer prior to the vessel's arrival in Australia. This is known as 'pratique'.

4. Evaluate the effectiveness of quarantine in preventing the spread of plant and animal diseases in Australia
With the tight restrictions on immigration, Australia has proven to be effective in preventing the spread of plant and animal diseases in Australia. In the airport, customs have strict procedures for what migrants or visitors can bring into the country. For example, wood, soil, foods and nuts that are brought from overseas will be assessed and must be declared in order to determine whether it is detrimental to the country. Also, objects that may be a threat can be kept in quarantine areas for a period of time until it is cleared of being a threat. This procedure is effective in reducing plant and animal diseases.

5. Evaluate the effectiveness of quarantine in preventing the spread of plant the animal disease across all regions Australia
With the tight restrictions on immigration, Australia has proven to be effective in preventing the spread of plant and animal diseases in Australia. Before this the spread of fruit flies was common amongst states. To reduce this spread there was border control between the states. Though today most disease have already spread to most states so there is not a need for the border control. So this has proven to be ineffective as there has been a spread of diseases.
6. Identify natural migrants that influence the effectiveness of quarantine control in Australia
Items that must be controlled include: birds, fish, insects, fruit, food, nuts, wood, animal skin

8. You may be familiar with the TV show *Border Security*. Discuss the procedures used to prevent the spread of exotic organic pests into Australia
Procedures used in the TV show include:
- the sniffer dogs. They have sensitive noses that are able to detect any unwanted or suspicious substances.
- The Scanners of the bags. This shows an x-ray vision of the bags to identify concealed objects
- Officials. They seek out suspicious people in the airport and inspect people’s bags for suspicious items
- Arrival cards. Upon arrival in Australia it is require for each passenger to collect a card that enables you to declare your goods so that they can be checked by officials. If one does declared they have a more likely chance that they can keep it. If you do not declare something and get caught serious penalties will be imposed

- Gather and process information and use available evidence to 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 instance 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
- **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 other 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% effective 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 smokers has reduced the number of cancers
- **Plant diseases:**
  - These include diseases such as fungal root infections, pests such as aphid and disease causing organisms.
  - The usual treatment is spraying with pesticides; however this has a detrimental effect on the environment.
  - Preventative measures are used, especially quarantine measures, biological control (introducing species to control pests) and genetic engineering.
1. Most organisms are active in a limited temperature range

- **Identify the role of enzymes in metabolism, describe their chemical composition and use a simple model to describe their specificity on substrates**

The body undergoes thousands of chemical reactions at one point. In order to survive, it must be able to perform the reactions very quickly. Most reactions are very slow, thus the cells need some way to speed them up, thus an enzyme. The first thing that is done is heat, the reaction will go faster with heat. A small amount of catalyst can make a large amount of product.

* **Enzymes**: are naturally occurring chemical substances in the body that help a chemical reaction take place. They are biochemical catalysts, produced by living things.
* They are a biological catalyst that lower the energy required to state a chemical reaction in a cell.
* Enzymes are globular proteins that form temporary bonds with substrates.
* A **catalyst** is a substance, usually needed and used in small amounts relative to the reactants, that modifies and increases the rate of reaction without being consumed in the process.
* It is the job of the catalyst and therefore the enzymes, to lower the energy barrier (activation energy) of a reaction.
* The enzymes **do not** form a chemical bonds with the substrate.
* **Enzymes are specific** for the substrates.
* Substrates are substances that are affected by the action of an enzyme.
* When an enzyme acts on a substrate, is readily forms its **transition state** and the reaction proceeds quicker.
* Temperature, pH and substrate concentration all have an effect on enzymes as they all have an optimum range for each of these three.
* **Denaturation** is when an enzyme is exposed to extreme temperature, pH or substrate concentration, they can ‘denature’ causing them to alter their shape and rendering them useless.

**Models:**

**LOCK-KEY MODEL:**
* This is where only one small part of the enzyme molecules can form a complex with the substrate. This part of the molecule is called the **active site**.
* An enzyme-substrate complex form when the enzyme’s active site binds with the substrate like a key fitting a lock.
* Only a **specific substrate(s)** can bond in the site, hence ‘enzyme specific’.
**INDUCED-FIT THEORY:**

* This theory refers to the active site slightly changing its shape to accommodate the substrate perfectly.
* The shape of the enzyme must match the shape of the substrate.
* Enzymes are therefore very specific, and will only function correctly if the shape of the substrate matches the active site.
* Products are released and the enzyme will return to its normal shape.
* Enzyme molecules can be reused.
* Only a small amount of enzyme is needed because they can be used repeatedly.

**Identify the pH as a way of describing the acidity of a substance**

* The substance that makes a solution acidic is hydrogen ions.
* pH is a measure of the alkalinity or the acidity of a substance.
* pH is a measure of the concentration of hydrogen ions per litre of solution.

* The pH scale →
  * 0-14
  * pH of 7 is neutral (pure distilled water)
  * above 7 is alkaline (Basic)
  * below 7 is acidic

**Identify data sources, plan, choose equipment or resources and perform a first-hand investigation to test the effect of: Increased temperature**

**Aim**
To investigate the effect of temperature on the activity of rennin.

**Method**
1. Prepare water baths at various temperatures. Starting at 10°C and increasing at 10°C intervals.
2. Get 3mL of milk in test tubes (2 test tubes for each beaker).
3. Make one of the test tubes in each beaker the control and add rennin to the other test tube.
4. Time on a stop watch how long the milk takes to curdle at different temperatures.
5. Record results in a table.

Results

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>1 minute</th>
<th>2 minutes</th>
<th>3 minutes</th>
<th>4 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
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</table>

Conclusion

The experiments show the optimum temperature for which rennin to act is 50°C, followed by 40°C. At lower temperatures it is unable to acts; however it remains the ability to do so.

- Change in pH

Aim
To observe the effect of PH in enzyme activity

Method
1. Prepare and maintain a water bath of 45°C
2. Get 6 test tubes with 5mL of milk in each. Keep one as a control and put different amounts of acids and bases in each of them.
3. Add universal indicator and stir
4. Place test tubes in water bath so that the milk reaches the 45°C.
5. Add 3 drops of rennin and start the stop watch and measure the time it takes for the milk to curdle.
6. Record in a table

Results

<table>
<thead>
<tr>
<th>PH</th>
<th>0.5 minutes</th>
<th>1 minute</th>
<th>1.5 minutes</th>
<th>2 minutes</th>
<th>2.5 minutes</th>
<th>3 minutes</th>
<th>3.5 minutes</th>
<th>4 minutes</th>
<th>5 minutes</th>
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</tr>
</tbody>
</table>
Conclusion
The optimum PH for rennin to produce clotting in milk is 6.5, followed by the slightly more acidic 6.

- Change in substrate concentrations on the activity of named enzyme(s)

Aim
To observe the affect in changing substrate concentration on the action of enzyme activity
Method
1. Prepare a 45oC water bath in a polystyrene cup
2. In six test tubes make up the following milk/water solutions

<table>
<thead>
<tr>
<th>Test tube number</th>
<th>%milk</th>
<th>%water</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
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<td>20</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

3. Place in water bath and wait until the solutions reach 45oC
4. Add 3 drops of rennin to each test tube and time
6. Record the results

Results

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>4.5</td>
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<td>No change</td>
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<tr>
<td>5.0</td>
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<td>No change</td>
<td>No change</td>
<td>change</td>
<td>change</td>
<td>Change</td>
</tr>
</tbody>
</table>

Conclusion
The enzyme (rennin) worked most efficiently with a concentrated solution of its substrate (milk).

- Explain why the maintenance of a constant internal environment is important for optimal metabolic efficiency
  → A constant internal environment is important for optimal metabolic efficiency.
  → A constant internal environment is important for optimal metabolic efficiency because enzymes only work efficiently within certain ranges
  → Enzymes are essential for proper metabolic function in an organism
  → Enzyme efficiency is affected greatly by certain factors including:
    * Temperature
    * pH
    * Substrate concentration
  → Enzymes work best within a limited range under optimal conditions
  → If the constant internal environment is not kept, then this can lead to denaturing enzymes.
  → Therefore, a constant and stable internal environment is needed so that enzymes will always be working at an optimal rate, and thus metabolism will be at optimum efficiency
- Enzyme activity increases with increases in **temperature**, until the optimal temperature. Too far above the optimal temperature, the enzyme will denature.
- The rate of enzyme activity increases as **substrate concentration** increases, until the active sites become fully occupied.
- If an enzyme’s temperature, pH or substrate concentration is altered too much, the enzyme will denature (change shape beyond repair).

- Gather, process and analyse information from secondary sources and use available evidence to develop a model of a feedback mechanism.

A Feedback Loop:

In a feedback loop the receptors detect the response and send messages back to the control centres to stop further adjustment. This is often referred to as ‘negative feedback’ because it results in a negative response by the effector, e.g. accumulation of hormone in the blood automatically cuts down it’s production.

A feedback mechanisms OR loop shows the links between receptors/effectors

**Negative Feedback Mechanisms:**
- Result in a response opposite to the initial situation
- Examples: a decrease in body temperature (stimulus), causes shivering (response) in the muscles, (effector) which increases body temperature (new stimuli), and you stop shivering (new response that is opposite to original response).
Positive Feedback Mechanisms:
- Reinforce and amplify the situation, resulting in more of the same the happen.
- Example: during child birth, pressure of the baby's head on the uterus (stimulus), cause the release of oxytocin and contractions occur (response). The body continues to push causing contraction to continue and increase dilation of the uterus.

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Receptor organ - detects change</th>
<th>Coordination organ e.g. hypothalamus</th>
<th>Effector organs - bring about a change</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in the variable Increase of water intake causing hydration</td>
<td>Osmoreceptors - that are responsible for maintaining levels of water and mineral salts in the body.</td>
<td>Hypothalamus</td>
<td>Kidneys</td>
<td>More urine and diluted urine causes blood concentration to rise, thus causing blood concentration to return to normal</td>
</tr>
<tr>
<td>Decrease in the variable Dehydrated</td>
<td>Osmoreceptors reach as there is a lack of a water balance</td>
<td>Hypothalamus</td>
<td>Kidneys and thirst reflect</td>
<td>The thirst reflects causes the drinking water to be absorbed by the colon. Less urine and concentration urine cause the blood concentration to fall</td>
</tr>
</tbody>
</table>

- Describe homeostasis as the process by which organisms maintain a relatively stable internal environment
Homeostasis is the process by which organisms maintain a **steady internal environment**. A steady internal environment is essential for optimal enzyme activity. Remember that enzymes work in a limited temperature and pH range. Enzyme action is essential for metabolic process to proceed.

Two stages of homeostasis:

- **Detecting** changes this is done by receptors.
- **Counteracting** changes that is done by effectors.

* It is a condition within the body that must be maintained at a constant level in order to achieve optimal metabolic efficiency.
* Enzymes control metabolic activities within the cell, only working in a limited range of temperature and acidity.
* Solute concentration is the process by which organisms maintain a relatively stable environment.

**STIMULUS**

- **Thermoreceptors**: sense temperature change
- **Mechanoreceptors**: sense pressure, gravity and sounds
- **Photoreceptors**: sense changes in light
- **Chemoreceptors**: changes in the concentration of blood chemicals such as glucose, amino acids, CO₂, oxygen and dissolved ions.

**EFFECTORS**:

- **Muscles**: Examples include contraction to produce movement, blood vessel constriction and shivering
- **Gland**: Secretions of hormones or other chemicals; examples of their action include control of solute levels in the blood, diverting blood to the muscles, secondary sexual characteristics
- **Plant hormones**: Responses include control of flowering and fruiting, growth of buds, stem elongation.

---

Explain that homeostasis consists of two stages:

- **Detecting changes from the stable state**
  * Detecting changes this is done by receptors. Is when changes are detected from the stable state. The presence of receptors enable this. Receptors include the nerve cells that detect stimuli. In plants the receptors are shoot or root tips.
  
  • A sensor detects a change in a specific variable from the desired stable level
  "Receptors detect stimuli: organisms then react to the change"
  "There are two types of receptors:
  - **Disturbance receptors**: usually in the skin, detect changes caused by the external environment
  - **Misalignment receptors**: detect changes from the body’s stable state
  - Examples of external stimuli: light, day length, sound, temperature
  - Examples of internal stimuli: levels of CO₂, Oxygen levels, water, wastes etc.

- **Counteracting changes from the stable state**
  * Counteracting changes that is done by effectors. They are counteracting changes from the stable state. The effectors in animals are muscles or glands. In plants this is the auxins or cytokinins.

**An effector receives the message that the undesirable change must be counteracted and the variable is stored to the desired level**

- **EFFECTORS** bring about responses to stimuli
- Effectors can either be muscles or glands
- Muscles bring about a change by movement
- Glands bring about a change by secreting chemical substances

  Body tissue- Hypothalamus in the brain- Blood Vessels- body temp
  i.e. For regulating body temp

Mammals (when cold) - Nerves- brain- nervous system-muscles-shiver (muscles contract to produce excess energy which increases body temp)
Outline the role of the nervous system in detecting and responding to environmental changes

**ROLE:** The nervous system works to regulate and maintain an animal’s internal environment (homeostasis) and respond to the external environment.

**The nervous system is made up of two parts:**

- **CNS – Central Nervous System:**
  - Consists of the **brain and spinal chord**
  - Acts as a control centre for all the bodily functions

- **PNS – Peripheral Nervous System:**
  - A branching system of nerves that transmits messages from the central nervous system and back
  - Receptors-specialised cells which detect stimulus
  - Sensory nerves-carry messages from receptor to CNS
  - Motor nerves-Carry messages from CNS to the effector
  - Effectors-muscles or glands

The nervous system works with another system called the **endocrine system**

**Endocrine system:** This system produces hormones in response to certain stimuli.

The hypothalamus is an area of the brain involved in both nervous and hormonal control. It contains sensory receptors that receive stimuli from thermoreceptors in the skin and from temperature changes in the blood. The hypothalamus then sends information via the peripheral system to produce heating response such as vasoconstriction and shivering and cooling response such as vasodilation, sweating and panting.

**Hypothalamus:** area of the brain that regulates internal temperatures

**Thermoreceptors:** specialised heat sensitive neurons located in the skin

**Endotherm:** an organism capable of regulating its internal environment

**Vasoconstriction:** a mechanism in which blood vessels constrict to prevent heat loss

**Peripheral Nervous System:** the neurons outside the central nervous system

**Ectotherm:** an organisms that cannot regulate its body temperature internally

**Blood temperature:** stimulates sensory receptors in hypothalamus to respond to heat and cold.

**Vasodilation:** a mechanism in which blood vessels dilate to allow heat loss to occur.
- **Identify the broad range of temperatures over which life is found compared with the narrow limits for individual species**

Life in some form, can be found at extremes ranging from -40°C to 120°C. However the great majority of living organisms are found between -2°C to approximately 50°C range and for each individual species, the range is even narrower. Below 0°C, cells risk ice crystals forming in them and above 45°C, proteins within cells may denature. In order to survive organisms must possess a range of adaptations to cope with the temperature changes.

Some examples of approximate environment temperature ranges in which particular species are able to survive:

* Alpine groundsel (Australian plant) = -10°C to 5°C
* Acorpora coral in Great Barrier Reef = 29°C to 32°C
* Human (without clothing or shade) = 27°C-43°C
* Platypus = -8°C to 34°C
* Water-holding frog = 3°C to 29°C

- **Compare responses of named Australian ectothermic and endothermic organisms to changes in the ambient temperature and explain how these responses assist temperature regulation**

**Ectothermic:** Organisms whose body temperatures is determined by their surrounding. Their body temperature is approximately the same as the ambient temperature. They have a limited ability to maintain their body temperature level alone, as it fluctuates with the external environment. They are referred to as ‘cold blooded’. E.g. Plants, invertebrates, amphibians, reptiles and fish.

**Endothermic:** The ability of animals to maintain a warm and constant body temperature. The animals have physiological structures that enable them to maintain, within a narrow range, irrespective of the ambient temperature. They heat produced from their metabolism helps maintain body temperature. They are referred to as ‘warm blooded’ e.g. Birds and mammals.

- **Identify some responses of plants to temperature change**

Temperature changes are one of the main factors that control germination, the growing season, flowering and seed dispersal. Gene expression in plants can also be influenced by the temperature. E.g Primroses that are red-flowered at room temperatures are white-flowered above 30°C. The leaves of plants in the Desert are usually small with reduced surface area: volume ratio to decrease heat gain. E.g the Australian Eucalyptus have leaves which hang vertically and are covered in a thick waxy cuticle to reduce the exposure to the heat of the midday sun and increase heat reflectivity.

**Warmer temperatures**
Warmer temperatures, for some plants, initiates the growing response. Extreme heat will cause many herbaceous and non-woody plants to die back, leaving only dormant seeds with thick woody coats. Also in extreme heats, the underground bulb and tubers will stay dormant until temperatures and rainfall are suitable. During a fire, the Banksia and the broadleaved paperbark’s seed will be triggered and dispersed. As the fire rages through the bush, the extremely high temperatures cause the seeds to be released form the canopy. The nutrient-rich ash is perfect for the seeds to fall as it is fertile and give the seeds a good chance of survival. If the plants temperature rises too high enzymes can denature, metabolism is disrupted and the plant can die. Plant can transpire as a cooling mechanism. Plants can close their stomates when the plant temperature is above 30°C to reduce water loss.

Colder Temperatures
Colder months will send plants into a period or dormancy. Though there are some plants e.g tulips, that will not flower until they have been exposed to certain degrees of coldness. This response is called vernalisation. It is important that tulips only come out in the cold as they are not suited for warmer conditions. In Australia farmers, place the tulip bulbs in the freezer for several days to stimulate the growth quicker. Maple trees will drop their leaves in winter to reduce heat loss and growth is minimal. If the temperature drops below a critical level the lipids in the bilipid layer start to crystallise and the cell membrane lose their fluidity. As water forms ice crystals below 0°C and the ice can pierce the cell membrane and the organelles, killing the cell. Due to this, many plants have an ‘anti-freeze’ chemical which prevents ice forming at this temperature.

- Analyse information from secondary sources to describe adaptations and responses that have occurred in Australian organisms to assist temperature regulation

Structural
Structural adaptations are those that have a connection with the morphology or physical features of an organism. For example: the length of a bird’s beak or the shape of an animals body. The Bottle-nose Dolphin has adaptations, structure that allows it to survive in cold ocean temperatures. It’s tapered small shaped limbs mean less surface for heat loss. The thick layer of blubber under the skin, insulates form the cold. The circulatory system is structured so that it allows a counter-current exchange of heat between arteries and veins. Arteries in the flippers are surrounded by veins. In cold months, warm blood is sent around the flippers and the heat is released into the environment. When diving into cold water, dolphins can shunt the blood away from the extremities of blood vessels underneath the blubber.

Behavioural:
Behavioural adaptations are the way an animal acts that enable them to survive the natural environment. For example: migrants and nocturnal activity. Ectotherms behaviour will help reduce exposure to extreme temperatures. The Spade Foot Toad lives in dry habitats in Eastern Australia. It is usually buried underneath the ground to escape from the heat and only emerges after rain.

Physiological:
Physiological adaptations are features that help regulate the function within an organism. It is the functioning of biochemical reactions within cells and tissue of an animal. Endotherms will usually speed up metabolic process to create enough heat to maintain their body temperature. The Pygmy Possum, in the winter months at Mt Kosciusko, Alpine Region will use torpor, which is similar to hibernation, to escape the below freezing temperatures. It reduces metabolism by 98 per cent during these conditions. Body temperature can fall as low as 6 degrees Celsius. It can stay in this state for up to 6 days, conserving energy and reducing the amount of food it requires.
2. Plants and animals transport dissolved nutrients and gases in a fluid medium

- **Identify the form(s) in which each of the following is carried in mammalian blood:**
- Plants and animals require a transport system to distribute food and oxygen to active cells and remove wastes
- Unicellular organisms can rely on the process of osmosis, diffusion and active transport for substances to be exchanged directly with the environment
- Multicellular organisms, however, require specialised transport systems
- Common features of transport systems are:
  - A suitable transport medium (fluid)
  - The presence of vessels in which substances can be carried
  - A driving mechanism to ensure that substances move in the correct direction
- Plants have what is known as vascular systems for transport
- Mammals possess a cardiovascular system to transport substances around their bodies

Composition of Blood:
**Human Blood:**
* Plasma - liquid component that is about 90% water
* Cellular parts - red blood cells, white blood cells and platelets

<table>
<thead>
<tr>
<th>Blood Components</th>
<th>Description</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma</td>
<td>- Straw coloured liquid</td>
<td>Transports substances around the body.</td>
</tr>
<tr>
<td></td>
<td>- 90% water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Contains dissolved substances</td>
<td></td>
</tr>
<tr>
<td>White Blood Cells</td>
<td>- Few in number</td>
<td>Fights disease</td>
</tr>
<tr>
<td>- Leucocytes</td>
<td>- Contains a nucleus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Is larger than red blood cells</td>
<td></td>
</tr>
<tr>
<td>Red Blood Cells</td>
<td>- Biconcave discs (donut shape without the hole)</td>
<td>Transports oxygen and small amounts of carbon dioxide</td>
</tr>
<tr>
<td>- Erythrocytes</td>
<td>- Doesn't have a nucleus</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Higher in number</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Contains haemoglobin</td>
<td></td>
</tr>
<tr>
<td>Platelets</td>
<td>- Small cell fragments</td>
<td>Helps to clot the blood</td>
</tr>
<tr>
<td></td>
<td>- Made from bone marrow</td>
<td></td>
</tr>
</tbody>
</table>

To maintain homeostasis, there needs to be a transport system within the body to enable nutrients that are needed by particular cells or wastes produced by particular cells to be delivered to specific sites to that their concentration remains constant. Nutrients includes:

- **Carbon dioxide**
  * About 70% of the carbon dioxide reacts with the water in the blood (plasma) to form carbonic acid and this increases the acidity of the water/plasma
  * To maintain a constant pH in the blood, the carbonic acid reacts with a buffer so that the pH is maintained between 7.3 and 7.45
  * CO2 is a product of respiration, carried from site of production, via the blood to the lungs where it is removed
  * Increased CO2 levels in the blood stimulates the breathing centre in the brain, sending messages to the ribs and diaphragm to increase breathing rate
  * 23% combines with haemoglobin, forming carbaminohaemoglobin
  * 7% dissolves directly into the plasma
- **Oxygen**
  * Oxygen is carried around the blood as an oxygen-haemoglobin combination in the RB
  * In the cells, oxygen is needed for respiration
  * Oxygen does not readily react to form an acid and can only be held in water in solution
  * The cells need a good supply of oxygen and if oxygen was only carried dissolved in solution in the blood, it would only be able to carry a small amount.
  * Haemoglobin increases the oxygen carrying capacity of blood
  * The haemoglobin molecules attach loosely to the oxygen molecule so that when it reaches the respiratory surfaces, it can be released.
  * In red blood cells in mammals, the nucleus is lost from the cells and the cells acquire haemoglobin (loss of nucleus may be a biological advantage as the cell has more space for haemoglobin)
  * Each haemoglobin molecule carries 4 oxygen molecules which increases at a rate at which oxygen can enter the blood
  * At high altitudes people become drowsy, develop headaches and suffer mental fatigue and can fall into unconsciousness.
  * Long term response to living in high altitudes includes: increase in lung ventilation, an increase in haemoglobin production, increase in total blood volume and an increase in the number of capillaries in tissues and after long periods can develop massive chest sizes.

- **Water**
  * Water is carried around the body in the form of PLASMA
  * Blood plasma is around 90% water

- **Salts**
  * Sodium, potassium, magnesium, chloride ions, sulphate ions and phosphate ions are transported as positive or negative ions in solution in the plasma
  * Iron forms a loose combination with a plasma protein to form a ‘transferrin-iron’ complex

- **Lipids**
  * Many are water-insoluble and only travel in blood when they are coated with proteins, becoming lipoproteins
  * These are carried as fatty acid and glycerol suspended in the blood plasma

- **Nitrogenous waste**
  * These form as a waste product from the breakdown of proteins by the liver
  * They are mostly in the form of urea, with a small amount of creatinine and uric acid
  * They are carried via the blood to the kidneys where they are removed and excreted by the body in urine
  * When the level of nitrogenous wastes is high, a more concentrated urine is produced or copious amounts of urine are produced in the body has a good supply of water

- **Other products of digestion**
  * Travel as separate molecules
  * These include amino acids, glucose and other types of sugars
  * These nutrients are dissolved or suspended in the plasma
  * Glucose and other sugars are needed as energy sources
  * Amino acids are the building blocks of proteins
  * Vitamins are needed to regulate processes throughout the body
SUMMARY:

<table>
<thead>
<tr>
<th>Substance</th>
<th>What it is carried by</th>
<th>Form it is carried in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen</td>
<td>Red Blood cells</td>
<td>Oxyhaemoglobin (oxygen and haemoglobin)</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>Plasma</td>
<td>Mostly as bicarbonate ions, with a small percentage dissolved directly in the plasma</td>
</tr>
<tr>
<td></td>
<td>Red Blood Cells</td>
<td>Carbaminohaemoglobin (carbon dioxide and haemoglobin)</td>
</tr>
<tr>
<td>Water</td>
<td>Plasma</td>
<td>Water molecules</td>
</tr>
<tr>
<td>Salts</td>
<td>Plasma</td>
<td>Ions</td>
</tr>
<tr>
<td>Lipids</td>
<td>Plasma</td>
<td>Chylomicron (a package of digested lipids and cholesterol wrapped in protein)</td>
</tr>
<tr>
<td>Nitrogenous wastes</td>
<td>Plasma</td>
<td>Mostly urea</td>
</tr>
<tr>
<td>Other products of digestion</td>
<td>Plasma</td>
<td>Whole molecules: e.g. Glucose</td>
</tr>
</tbody>
</table>

- **Perform a first-hand investigation to demonstrate the effect of dissolved carbon dioxide on the pH of water**

To observe the effect of dissolved carbon dioxide has on the PH of water.

**Method:**
1. Add 2-3mL of water to your test tubes
2. Add two drops of universal indicator to test tube, record colour of pH
3. Using the straw, carefully blow into the water
4. After 1 - 2 minutes, record the new colour and pH of the solution

**Results:**
Limewater turns milky after 2 -3 minutes, indicating the presence of the gas carbon dioxide in exhaled air

<table>
<thead>
<tr>
<th>Solution</th>
<th>pH</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td>7</td>
<td>Neutral</td>
</tr>
<tr>
<td>Distilled water + carbon dioxide</td>
<td>4</td>
<td>Acidic</td>
</tr>
<tr>
<td>Change in pH</td>
<td>-3</td>
<td>Neutral -&gt; acidic</td>
</tr>
</tbody>
</table>

Co2 (aq) + H2O----> H2 CO3 (aq)  
H2CO3 (aq) ----> H+ (aq) = CO3 (aq)
Conclusion
Dissolved carbon dioxide causes water to become acidic. Carbon dioxide causes pH to decrease and turn acidic.

When carbon dioxide dissolved in water, it forms hydrogen carbonate. They hydrogen carbonate then breaks down into hydrogen ions and carbonate ions. Its the hydrogen ions that change the pH, therefore causing it to become acidic.

If the body does not removed CO₂, changes to pH levels in the blood will occur. If pH changes too dramatically enzymes can be altered and therefore not work properly leading to disruption homeostasis.

- Explain the adaptive advantage of haemoglobin
Inside each red blood cell are millions of haemoglobin (Hb) molecules, which bind and store oxygen. Haemoglobin is a large structurally complex molecule consisting of two alpha subunits and two beta subunits. Each subunit is made of a heme group and a long polypeptide, called globin, which coils around the heme group. Holding the heme in position within the folds of the globin are two histidine molecules. In the centre of the heme group is an atom of ferrous iron (Fe²⁺). A ring of nitrogenous compounds which is derived from porphyrin surrounds the iron atom. The iron atom can reversibly bond with one molecule of oxygen (O₂). Because it has four subunits, a haemoglobin molecule can reversibly bond with up to four O₂ molecules. When not bonded to O₂, deoxyhaemoglobin stays in a tensed state or conformation. The first O₂ molecule to bond causes the oxyhaemoglobin to shift to a relaxed state. This change in shape makes it easier for additional O₂ molecules to bind to the other hemes, a property called cooperatively.

Haemoglobin is found in red blood cells which possesses important properties that are able to combine loosely with oxygen molecules. As a result of the property, haemoglobin is able to collect oxygen in the lungs and release it in the tissue when it is needed

Haemoglobin + oxygen = oxyhaemoglobin
(Hb + 4O₂ = Hb(O₂)₄)

Oxygen is relatively insoluble in blood plasma and the presence of haemoglobin helps to raise the oxygen carrying capacity of blood by more than sixty times its normal ability. Although some invertebrates also use haemoglobin as a respiratory pigment, it is not found in red blood cells, but carried in a less efficient dissolved form in the plasma. One red blood cell can in fact contain up to 256 haemoglobin molecules, and each haemoglobin molecule can bind with four oxygen molecules. This presents an evolutionary advantage over the oxygen binding pigments present in some invertebrates and primitive fish. These organisms also possess myoglobin, a pigment with only one polypeptide chain and only one oxygen binding site, as opposed to four in haemoglobin.

Besides its high oxygen carrying capacity, haemoglobin is also capable of adapting to certain extent, to the individual oxygen demands of an organism. A build up in blood acidity is due to a build up of carbon dioxide from respiration, for instance, triggers a decrease in haemoglobin’s affinity for oxygen. As a result, oxygen is released in cells and sued for further respiration. The presence of oxyhaemoglobin in the lungs also triggers the reaction of carbon dioxide to the lungs to be excreted. These features enable individuals to respond to changes in surrounding oxygen levels such as those experiences on aeroplanes. Those living in high altitudes have adapted to low oxygen levels by manufacturing more red blood cells, developing a faster breathing rate and heart rate. The heart muscle can also increase. These adaptations result in more haemoglobin molecules carrying more oxygen.
- Compare the structure of arteries, capillaries and veins in relation to their function

<table>
<thead>
<tr>
<th>Feature</th>
<th>Arteries</th>
<th>Capillaries</th>
<th>Veins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carries Blood</td>
<td>Away from the heart</td>
<td>To all cells/tissues</td>
<td>Back to the heart</td>
</tr>
<tr>
<td>Oxygenate/deoxygenated</td>
<td>Oxygenated</td>
<td>Both depending on location</td>
<td>Deoxygenated</td>
</tr>
<tr>
<td>Wall thickness</td>
<td>Thick</td>
<td>One cell thick</td>
<td>Thinner than arteries</td>
</tr>
<tr>
<td>Elastic tissue present</td>
<td>Yes</td>
<td>No</td>
<td>Very few</td>
</tr>
<tr>
<td>Size of lumen</td>
<td>Larger than capillaries, smaller than veins</td>
<td>Small</td>
<td>Largest</td>
</tr>
<tr>
<td>Movement through vessel provided by</td>
<td>Heart</td>
<td>Heart</td>
<td>Contraction of muscles</td>
</tr>
<tr>
<td>Pressure inside vessel</td>
<td>High</td>
<td>Depends on location</td>
<td>Lower</td>
</tr>
<tr>
<td>Valves present</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Labelled diagram</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Perform a first-hand investigation using the light microscope and prepared slides to gather information to estimate the size of red and white blood cells and draw scaled diagrams of each.

Estimating the size of red and white blood cells

Results:

<table>
<thead>
<tr>
<th>Type of blood cell</th>
<th>Shape</th>
<th>Other distinguishing features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Blood cells</td>
<td>Small and round</td>
<td>Tight and together, small, red and round circle formation</td>
</tr>
<tr>
<td>Neutrophil</td>
<td>Round</td>
<td>Looks like a honeycomb and is red</td>
</tr>
<tr>
<td>Eosinophil</td>
<td>Round</td>
<td>Large granules and two lobed nucleus</td>
</tr>
</tbody>
</table>

Estimating size:
Field size: 1.3mm x 1000
= 1500
Low power = 1500
High power = 375
<table>
<thead>
<tr>
<th>Type of blood cell</th>
<th>Diameter of field of view</th>
<th>Estimated no. Of cells across diameter</th>
<th>Estimated size of one cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Blood cells</td>
<td>375</td>
<td>68</td>
<td>5.51</td>
</tr>
<tr>
<td>White Blood cells</td>
<td>375</td>
<td>39</td>
<td>9.62</td>
</tr>
</tbody>
</table>

Therefore white blood cells are double of red blood cells

**Scale Drawing:**

**Red Blood Cells (x400) - (4 - 6 million/mL blood)**

**White Blood cells - (4000 - 11000/mL blood)**

**Discussion**

The most common type if RBC, this is because they are needed to carry oxygen to cells and take carbon dioxide from cells. WBC have more than one function as each have specific functions in the immune system. Also white blood cells are double of red blood cells.

- **Describe the main changes in the chemical composition of the blood as it moves around the body and identify tissues in which these changes occur**

Excess amino acids are broken down in to the liver from urea. The liver also stores excess glucose in the form of glycogen. Alcohol, old red blood cells and vitamins are also broken down by the liver, and it is therefore to be expected that there are less of these in the blood leaving the liver.

Urea leaves the blood via the kidneys. Glucose and amino acids are reabsorbed back into the blood from the kidneys as they are useful substances needed by the body cells.

Carbon dioxide, in the form of dissolved bicarbonate ions, leaves the blood through the lungs because it would otherwise make the blood too toxic.

Blood entering the right side of the heart is high in carbon dioxide and low in oxygen, I is sent to the lungs where it picks up oxygen and deposits carbon dioxide. Blood leaving the left side of the heart is oxygen and low in carbon dioxide.

<table>
<thead>
<tr>
<th>Organ</th>
<th>Blood Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lungs</td>
<td>Less CO2, more oxygen</td>
</tr>
<tr>
<td>Left side of heart</td>
<td>More oxygen, less CO2</td>
</tr>
<tr>
<td>Right side of heart</td>
<td>Less oxygen, more CO2</td>
</tr>
<tr>
<td>Muscles tissue</td>
<td>Less oxygen, more CO2, less glucose, less amino acids</td>
</tr>
<tr>
<td>Liver</td>
<td>Less glucose, less amino acids, less urea</td>
</tr>
<tr>
<td>Kidney</td>
<td>Less urea, less salts, less water</td>
</tr>
<tr>
<td>Intestines</td>
<td>More glucose, more amino acids, more fatty acids and glycerol, more vitamins, less oxygen</td>
</tr>
<tr>
<td>Endocrine glands (e.g. Pancreas, testes, adrenal gland, thyroid gland)</td>
<td>More hormones</td>
</tr>
</tbody>
</table>
- **Outline the need for oxygen in living cells and explain why removal of carbon dioxide from cells is essential**

* Cells require oxygen in the process of respiration: Glucose + oxygen → carbon dioxide + water + energy (in the form of ATP)

* Carbon dioxide is a waste product and must be removed to maintain the normal pH balance of the blood. By removing excess carbon dioxide, it prevents a build up of carbonic acid, which causes the lowering of the pH, and therefore increasing breathing rate and depth. Carbonic acid forms when carbon dioxide dissolves in water. At normal levels, (after excess removal of carbon dioxide) the carbon dioxide - bicarbonate ion (HCO₃⁻) equilibrium is an important mechanism for buffering the blood to maintain a constant pH.
- Analyse information from secondary sources to identify current technologies that allow measurement of oxygen saturation and carbon dioxide concentrations in blood and describe and explain the conditions under which these technologies are used

**Pulse Oximeters:**
Oxygen and Haemoglobin for oxyhaemoglobin. The colour of blood changes from a dark red, which is unsaturated, to a bright red which is saturated. Before oximeters, doctors observed a patient on how ‘blue’ their skin was. Development of Oximeters was in 1930s and 40s, with the first pulse oximeter designed in 1975. This device measures the amount of oxygen in arterial blood, which is how much blood is pumped from the heart to body cells.

Light from two light-emitting diodes pass through usually the finger. The amount of light is detected by photodetector. Light energy will carry depending on the level of oxygenation of haemoglobin in the blood. Two diodes include: emitting red light and infrared. There is a large difference in red light absorbed by oxyhaemoglobin as opposed to normal haemoglobin. All measurements are processed by the electronic component of oximeter. The signal is amplified, then the oxygen saturation is calculated and the results are displayed on the screen. Light emitting diodes are semiconductor diodes the emit infrared or visible light when charged with electric current.

**Arterial blood gas (ABG) analysis:**
Electrochemical methods are used for arterial blood gas analysis. Measurements from this include, pH, the partial pressures of oxygen (PO2) partial pressure of carbon dioxide (PCO2) in arterial blood. Partial pressure is measured by concentration of gas in a medium.

**Measuring pH:**
The pH sensor is often gas electrode. The glass bulb contains sodium of a known pH. A sensor is placed in a solution of the pH that is unknown and the difference between the two solutions is compared and measured.

**Measuring oxygen:**
First blood gas sensor was the Clark oxygen sensors, in 1953. Still used today with modifications. Oxygen from a sample is diffused through a gas-permeable membrane where is causes an electrochemical reaction with the sensors and an electric current is generated. The amount of current generated is proportional to the concentration of oxygen in the sample.

**Measuring Carbon Dioxide:**
1965 was the year that carbon dioxide sensors were invented by Servinghaus. The sensor detect pH changes in a small volume of bicarbonate solution that is separated from the sample by a gas-permeable membrane. As carbon dioxide crosses the membrane the following process occurs

\[
\text{Carbon Dioxide + Water \rightarrow Carbonic acid + hydrogen ions + hydrogen bicarbonate ions}
\]

\[
\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CO}_3 + \text{H}^+ + \text{HCO}_3^-
\]

Changes in hydrogen ion concentration changes the pH. Internal pH sensors measure this, which is a measure of the concentration of hydrogen ions, which is related to the concentration of carbon dioxide. Modern blood gas analysis machines combine all three sensor - pH, the partial pressures of oxygen (PO2) partial pressure of carbon dioxide (PCO2). Ranging from laboratory machines where blood samples are processed to minaturised sensors that are inserted into patients.
- Analyse information from secondary sources to identify the products extracted from donated blood and discuss the uses of these products

<table>
<thead>
<tr>
<th>Product extracted from blood</th>
<th>Use(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plasma</td>
<td>Plasma contains very important proteins, nutrients and clotting factors that help to prevent bleeding when the skin is cut. Plasma can be processed into a variety of products and each product can be used to treat a number of potentially life-threatening conditions. They last for up to 1 year in shelf life.</td>
</tr>
<tr>
<td>Platelets</td>
<td>Are used to clot the blood and seal the wound in surgical and cancer patients. People that require platelets include: Leukaemia and chemotherapy patients. They only last for up to 5 days in shelf life.</td>
</tr>
<tr>
<td>Red Blood Cells</td>
<td>Red blood cells carry oxygen from the lungs to all the cells of the body and remove waste products such as carbon dioxide. They help with treating people with severe anaemia, those whose red blood cells do not function adequately. Also people experiencing severe bleeding such as accident victims and patients undergoing surgery.</td>
</tr>
</tbody>
</table>

5. Outline the main steps involved in the process of blood donation
The process is quick and efficient, only taking no more than 45 minutes.
* Blood is taken from the median cubital vein, inside of the elbow (450 - 500mL is usually taken, it is referred to as ‘one unit’ of blood)
* Antiseptic will be used to clean the area.
* Tourniquet may be used to elevate blood pressure, or the patient will be given something to squeeze repeatedly, which speeds the process up.
* A needle with a larger guage will be used to minimise the shearing forces that can damage RBSs
* **Whole blood** involves collected in a plastic bag that contains anticoagulants and preservatives such as sodium citrate, phosphate, dextrose or adenine.
* This is separated into its components (RBC and plasma) and stored
* **Apheresis** is drawing blood form the donor, separating the components using a centrifuge, storing the components required for transfusion and returning the remaining components to the donor. RBC are transferred back to the donor while the plasma and platelets are put to good use.
- Analyse and present information from secondary sources to report on progress in the production of artificial blood and use available evidence to propose reasons why such research is needed.

**Artificial blood:** is a life-saving substance that carries oxygen to the body when there is a shortage of red blood cells. It is created to mimic the functions of real blood. Artificial blood is more versatile than real blood as it contains certain properties that real blood does not. This includes a long shelf life, no need for refrigeration and the ability to be sterilized.

The two most common types of artificial blood are:

- **HBOCs (hemoglobin-based oxygen carriers)**

  HBOCs are artificially made blood substitutes that carries out the main function of red blood cells, to carry oxygen to the cells. It comprises about 33% of the cell mass.

- **PFCs (perfluorocarbons).**

  Will not and are not mixed with blood, therefore emulsions must be made by dispersing small drops of PFCs in water. This is the mixed with antibiotics, vitamins, nutrients and salts, in the end this mixture will contain around 80 different components. It will then carry out the natural functions of natural blood. They are 1/40 the size of a RBC and travel to capillaries which no RBCs are flowing through. It is beneficial as it flows through blood-starved and damaged tissue which normal WBC cannot pass through.

Research into artificial blood has made slow and difficult progress. It is evident that small organizations devote their resources to blood substitute research and are forced to focus on very expensive clinical trials. There is a need for research into artificial blood to continue as if major companies devoted their time and money to blood substitute research, millions of lives could be saved. These companies do suffer from certain limitations to their research. For example, most of the hemoglobin-based products last no more than 20-30 hours in the body. This compares to transfusions of whole blood that lasts 34 days. In the future, it is anticipated that there will be new materials to carry oxygen to the body cells as will laster lasting products that will perform the same functions as blood. It is important to continue researching about blood as this will help to save millions of lives.

There was no real progress was made in the development of a blood substitute until 1616 when William Harvey described how blood is circulated throughout the body. Following from this, there was many attempts and materials used as a blood substitute, few had success. Milk was one of the first of these materials. In 1854, patients were injected with milk to treat Asiatic Cholera. It was believed that the milk would regenerate white blood cells. It was a successful for of blood substitute, though milk injections never found widespread appeal, and thus was discarded and forgotten as a blood replacement. Another substitute that was used over history was salts or saline solutions. In frogs this was tested; scientists would be able to keep the frog alive for some time if
they removed blood and replaced it with salts and saline solution. It was soon deemed misleading as it was concluded that frogs could survive for a short time without any blood circulation. After research, it was concluded that saline solution was developed as a plasma volume expander.

During the 1800s, haemoglobin was used and animal plasma. In 1868, researches found that solutions containing haemoglobin isolated from red blood cells could be used as blood replacements. 1871, it was found that animal plasma and blood could be substitutes for human blood. Though both methods were hampered by significant technology problems. Scientists found it hard to isolate large volumes of haemoglobin and that animal products were toxic to humans. The removal of these toxins were restrictive in the nineteenth century.

In 1883 there was the creation of Ringer's solution—a solution composed of sodium, potassium, and calcium salts. The research of the frog's heart lead to scientists finding that the heart can continue to beat by applying the solution. This eventually led a discovery that the reduction in blood pressure caused by a loss of blood volume could be restored by using Ringer's solution. This product evolved into a human product when lactate was added. While it is still used today as a blood-volume expander, Ringer's solution does not replace the action of red blood cells so it is not a true blood substitute.

Next Landsteiner looked at the lack of safety and effective-ness of blood transfusions. Prior to his work, blood transfusions were dangerous and underutilized because the donor's blood frequently clotted in the patient. He was intrigued by the fact that in blood from different subjects was mixed, the blood did not always clot. After much research into this he determined that human beings could be separated into blood groups according to the capacity of their red cells to clot in the presence of different serums. He named his blood classification groups A, B, and O. A fourth group AB, was discovered the following year.

In 1966, experiments with mice suggested a new type of blood substitute, perfluorochemicals (PFC). It was found that mice could survive even after being immersed in PFC. Scientists concluded that PFC could be used as a blood thinner. There was a decline in the research of blood substitutes, due the established blood bank system working so well. Though there was a decline later in the blood bank system during the Vietnam conflict. This prompted some researchers to begin looking for hemoglobin solutions and other synthetic oxygen carriers

Dr. Leland C. Clark was responsible for more than 80 inventions, one of which is the Clark Oxygen Electrode created in 1956. This has revolutionized the field of medicine for the past 50 years. Allowing a monitoring of a patient's blood oxygen level, Clark's electrode has made surgery safer and more successful for millions of people throughout the world. Since then, its remarkable versatility has helped trigger advances in cell culture, molecular genetics, aviation and space flight, soil chemistry and even in wine and beer production.

Haemopure is a new class of agents that enables an increase in oxygen delivery to cells. It is known as Oxygen Therapeutics, that are biological and chemical compounds, intravenously administered into the circulatory system. The aim of this is to increase oxygen delivery to cells, tissues and organs. This splits into hemoglobin-based oxygen carriers and Perfluorochemicals. It came as a response to the need for oxygen-carrying solutions needed at war where many soldiers were dying as a result of insufficient oxygen levels caused by blood loss. In the 1980s insufficient there was poor purification methods as a result of a lack of understanding of the physiology of oxygen delivery. In the decade to come there was improvements to this, a better understanding of how to modify native haemoglobin allowed OPK Biotech to overcome the plagued HBOC development programs

- Describe current theories about processes responsible for the movement of materials through plants in xylem and phloem tissue

Vascular tissue in plants and their functions:
In plants the main parts of the vascular tissue are made of they xylem and phloem. The xylem transports water around the plant through a dead of thick cell. Cross-walls are broken which allows a continuous steam of tubes. There is no cytoplasm. The phloem transports sugars + water. They are alive but do not have many organelles. There is a cytoplasm. There is a column of sieve tubes with perforated end walls. Organic mater moes up and down, this is called translocation. Plants also have vascular bundles.

Current theories on translocation:
* Translocation - movement of materials through a plant
* Takes place in xylem and phloem under different mechanisms
* Chemicals needed for photosynthesis are carried by xylem form roots to leaves
* Organic material/nutrients products of photosynthesis are carried by phloem from leaves to other parts of the plant
Movement in the xylem:
* Water and dissolved nutrients from an ascending sap
* Movement occurs as a result of TRANSPERSION STEAM = as water evaporates, more is dragged up the xylem from the roots
* Movement is PASSIVE, therefore there is no pumping mechanism present
* Theory known as COHESION-ADHESION-TRANSPERSION (CAT)
  
Transpiration happens in the xylem as water molecules leave the stomata, more water molecules move into xylem. Adhesive forces, attraction of water and the wastes of xylem lead them to capillaries, moving UP the narrow lumen. Cohesive forces attract water molecules to each other which gives a constant stream. The movement is bi-directional. There is a pumping mechanism, making it passive. It is driven by osmotic pressure.

Movement through phloem:
* Movement is bi-directional
* How: along a concentration gradient, so there is no pumping mechanism. Thus it is a PASSIVE movement
* 90% of the dissolved substances is glucose
* It is driven by osmotic pressure (difference in sugar and water concentration)
* Theory known as ‘SOURCE TO SINK’ or ‘PRESSURE FLOW’. From leaves to wherever it is needed.
The osmotic pressure of the phloem drives sap flow. The direction of the phloem movement depends on where the sink area is in relation to the source. The flow is continuous as sucrose is being added at one end and removed at the other. The phloem draws water from the xylem as the concentration of phloem sap increases and osmotic pressure at a source increases. Sugar at the sink and other materials are removed by active transport. Water is drawn out to decrease osmotic pressure in the phloem at the sink.

Source to sink/Pressure flow
* The difference in osmotic pressure drives phloem sap flow (pressure flow)
* Direction of movement depends on where the sink area is in relation to the source
* Flow is continuous as sucrose is being added at one end and removed from the other

- Choose equipment or resources to perform a first-hand investigation to gather first-hand data to draw transverse and longitudinal sections of phloem and xylem tissue
  
  □ Transverse section: is also known as a cross-section, where you cut across the object
  
  □ Longitudinal section: when you cut long ways down the object
3. Plants and animals regulate the concentration of gases, water and waste products of metabolism in cells and in interstitial fluid

- **Explain why the concentration of water in cells should be maintained within a narrow range for optimal function**

  □ Water is the solvent for metabolic reactions in living cells. Many molecules and all ions important for the life of the cell are carried in an aqueous solution and these diffuse to reaction sites through the water in the cell.

  □ Metabolic reactions within the cell can occur only in solution where water is the solvent. It is critical for proper functioning of these reactions that the amount and concentration of water in the cell be kept constant. Most cells die when the water content is changed significantly.

- **Explain why the removal of wastes is essential for continued metabolic activity**

  □ The **respiratory system** controls oxygen and carbon dioxide levels in the body and regulates breathing rates. Oxygen is used in respiration to release energy for the body. Carbon dioxide is produced as a waste product to be excreted by the lungs. Respiratory surfaces of multicellular organisms need to have a large surface area for gas exchange, a concentration gradient across the membrane so diffusion will occur, a good blood supply to transport oxygen, carbon dioxide, and water to and from the respiratory surface, and need to be kept moist to assist the dissolving of gases so they pass across the membrane.

  □ The **excretory system** involves several different organs that remove wastes products from the body. They also regulate water and salt levels and maintain homeostasis which is necessary metabolic reaction to occur with maximum efficiency. The main metabolic waste products are excess water, carbon dioxide excess salts and nitrogenous wastes such as, urea and ammonia. The main excretory organ in the kidney.

  □ Water is an important molecule because of its properties as a solvent and many substances e.g. Nutrients, oxygen and wastes, are carried to and from cells in water. Almost every chemical reaction in cells involves water and the concentration of water must be kept relatively constant to maintain pH, substrate concentration and the other conditions necessary for metabolic reactions. Water has a very high heat capacity which means it can absorb and retain heat and thus help maintain a constant body temperature, and heat can be transported around the body by the water in the plasma in the blood. Water in the body can also act as lubricant, preventing friction between two opposing surfaces e.g between internal organs like the heart and lungs, or between opposing body surfaces of the skeleton.

- **Identify the role of the kidney in the excretory system of fish and mammals**

<table>
<thead>
<tr>
<th>Organism</th>
<th>Role of the Kidney</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammal</td>
<td>Are able to regulate water and ion concentration and excretion of urea. Amount of water released is dependent on environment and water in the body</td>
</tr>
<tr>
<td>Freshwater fish</td>
<td>Have a higher salt concentration than the water they live in. Water diffuses IN by osmosis. To counteract, they produce a dilute urine almost continuously. All salts absorbed</td>
</tr>
<tr>
<td>Saltwater fish</td>
<td>Body fluids contain less salt concentration than their environment. Water diffuses OUT by osmosis. To counteract, they constantly drink. Salts are excreted and water is retained. They excrete very little urine.</td>
</tr>
</tbody>
</table>

In mammals, the kidneys have two major roles: a) filtration in which the toxic nitrogenous compound urea, formed by the deamination of proteins in the liver is removed; b) Osmoregulation or reabsorbing water and salts. These two processes occur in millions of microscopic structures called nephrons.

In fish, highly toxic ammonia, the initial product of deamination, is released directly into the surrounding into the gills. There is consequently no need for the kidney to act as a filter here. The kidneys, however, still performs an
osmoregulatory role by altering salts and water levels so that the constant internal solute concentration are maintained.

In saltwater fish there is a tendency for water to move OUT of the fish by osmosis. Fish respond to this by drinking large amounts of water and their kidneys and gills excrete excess salts. The Kidneys also reabsorb water, resulting in concentrated urine.

In freshwater fish there is a tendency for water to move into the fish by osmosis because the surroundings are more dilute than the fluid inside the fish. For the same reason, salts tend to move out of the fish. The kidneys of the fish respond to this by excreting large volumes of water in the urine and reabsorbing mineral salts into the blood.

- Explain why the processes of diffusion and osmosis are inadequate in removing dissolved nitrogenous wastes in some organisms.

Problems relying on diffusion:
* The rate of movement is too slow to maintain homeostasis
* Nitrogenous wastes and toxins must be dissolved when they are removed
* Wastes would only move if they were more concentrated inside the cell than in the blood steam, as concentration equalises, movement would slow down
* When equalised, no further wastes would be removed and would accumulate
* Not all wastes can be removed by diffusion

Problems relying on Osmosis:
* Too much water may be lost
* If urine contains high concentrations of nitrogenous waste - water will be drawn out to equalise concentration, which causes too much water loss
* Movement of water may make wastes too dilute for excretion
* Excretion of dilute urine = large loss of water and therefore dehydration
* In freshwater fish - osmosis results in water moving into cells, diluting toxic wastes and slowing excretion by diffusion

Solutions to these problems is combining active and passive transport
Active transport is quicker and much more effective than passive
Active transport pumps salts from the urine back into the kidneys and in turn draws water with them by osmosis
This ensures the amount of water lost in the urine does not affect the body’s water balance
NOTE: water cannot be moved directly by active transport.

- Distinguish between active and passive transport and relate these to processes occurring in the mammalian kidney

<table>
<thead>
<tr>
<th>Active</th>
<th>Passive</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Requires the input of cellular energy (ATP)</td>
<td>* Does not require any energy</td>
</tr>
<tr>
<td>* Movement occurs AGAINST the concentration gradient</td>
<td>* Movement occurs ALONG the concentration gradient</td>
</tr>
<tr>
<td>* Reabsorption of sodium ions form the urine</td>
<td>* Osmosis and diffusion</td>
</tr>
</tbody>
</table>

Passive Transport:
- Diffusion - the movement of any molecule from a HIGH concentration until equilibrium is reached
- Osmosis - the movement of water from HIGH to LOW concentration through a selectively permeable membrane
- Passive transport moves water (via osmosis) and same nitrogenous wastes, such as urea an ammonia (via diffusion)
- Unicellular organisms reply on passive transport for the sole excretion of nitrogenous wastes
- Only excess water and salts are excreted
Limitations of using passive transport is the need for a difference in concentration of substances and is relatively slow.

**Active Transport**
- Involves a carrier protein that spans the membrane and actively moves chemicals
- Moves mainly sodium, glucose, amino acids and hydrogen ions across the wall of the nephron
- It is a movement from HIGH to LOW concentration and against the concentration gradient
- A sodium pump mechanism operates in the kidney tubules, actively transporting ions form urine back to the kidney cells, this process conserves salts and brings about the conservation of water as the active transport of salts draws water out of the urine by osmosis.

- **Explain how the processes of filtration and reabsorption in the mammalian nephron regulate body fluid composition**

  **The kidneys:**
  - Renal artery - brings blood in kidney
  - Renal vein - takes blood from kidney
  - Ureter - to bladder
  - Calyces - collecting structure
  - Renal pelvis - funnels urine into ureter
  - Medulla - contains nephrons

  **Filtration**
  - Filtration of the blood occurs in the BOWMAN’S CAPSULE, where high blood pressure in the GLOMERULUS forces all small molecules out of the blood into the capsule.
  - Water, urea, ions (Na+, K+, Cl-, Ca2+, HCO3-), glucose, amino acids and vitamins are all small enough to be moved into the glomerular filtrate.
  - Blood cells and proteins are TOO large to be filtered.
  - This filtering process is non-selective and therefore many valuable components must be recovered by reabsorption.

  **Reabsorption**
  - Reabsorption takes place selectively at various points along the proximal tubule, loop of henle and the distal tubule.
  - All glucose molecules, amino acids and most vitamins are recovered, although the kidneys do not regulate their concentration
  - The reabsorption of the ions occur at different rates depending on feedback form the body
  - In some cases, active transport is required
  - Water is absorbed in all parts of the tubule EXCEPT the ascending loop of henle
  - The amount of water reabsorbed, humans would soon dehydrate, losing water at a rate of about 7.5L per hour.
  - The chemical composition of the body fluids is precisely regulated by the control of the solute reabsorption from the glomerular filtrate.
Secretion
- Secretion is the third process that contributed to urine formation
- It involves the removal of toxic substances form the capillaries and tissue
- Metabolic wastes (urea, uric acid, ammonia) and H+ ions are secreted into the fluid within the nephron
- Movement of urea and ammonia is by mans of diffusion, while all other tubular secretions involves active transport
- H+ and drugs are secreted into the proximal part of the nephron and urea is secreted into the descending limb of the loop of Henle

Perform a first-hand investigation of the structure of a mammalian kidney by dissection, use of a model or visual resource and identify the regions involved in the excretion of waste products

Dissection of Mammalian Kidney

Aim: to perform a dissection of mammalian kidney and identify structures involved in excretion

Risk Assessment:
1. Scalpel: when making an incision in the kidney make sure you do not cut yourself with the scalpel.
2. Wear safety glasses: reduce juices from kidney to squirt in the eyes
3. Disinfect area: before and after the experiment to eradicate contamination

Method:
Procedure
1. Examine the kidney (wear gloves for this); take note of the shape, size, weight and feel. Observe the presence (or not) of the adrenal gland, adipose tissue (storage tissue containing fat cells) and renal capsule.
2. Notice the pinched in area of the kidney where the renal blood vessels and ureter are attached to the kidney.
3. Use the dissecting microscope to help identify and compare the wall thicknesses, of the ureter, renal artery and renal vein. Generally the tube with the most adipose around it is the ureter.
4. Place the kidney back on the dissecting tray so a demonstrator can slice the kidney in half lengthwise.
5. Use the dissecting microscope to examine the internal structures of the kidney.
6. Identify the following structures:
   - Cortex
   - Pyramid
   - Renal columns
   - Calyx
   - Pelvis
   - Medulla
   - Ureter (if present)
   - Papilla
   - Draw and label a diagram of a dissected sheep’s kidney
7. Obtain a slide of the longitudinal section of a mouse kidney.
8. Refer to your notes on setting up a compound microscope and observe the slide under low and high power.
9. Identify the kidney structures listed above.
10. Dispose of the kidney waste in the appropriate biological waste bin

Results:
Discussion:

<table>
<thead>
<tr>
<th>Region of Kidney</th>
<th>Blood Supply</th>
<th>Excretory structure found within</th>
<th>Function of excretory structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortex</td>
<td>Renal artery</td>
<td>Glomerulus, bowmans capsule, kidney tube</td>
<td>Filtration</td>
</tr>
<tr>
<td>Medulla</td>
<td>Loop of Henle and capillaries that surround it</td>
<td>Nephron and Loop of Henle</td>
<td>Reabsorption</td>
</tr>
<tr>
<td>Pelvis</td>
<td>The collecting ducts, does not have blood supply</td>
<td>Collecting ducts</td>
<td>Secretion</td>
</tr>
</tbody>
</table>

- **Outline the role of the hormones, aldosterone and ADH (anti-diuretic hormone) in the regulation of water and salt levels in blood**

Like most of the body, the functioning of the mammalian kidney is controlled by the nervous system and the endocrine system. There are two main hormones involved in osmoregulation in the kidney:

- **Aldosterone**
  Aldosterone hormone produced by the adrenal gland just above the kidney. It regulates the transfer of sodium from the nephron to the blood by acting primarily on the distal tubule. When sodium levels fall, aldosterone is released into blood causing more sodium to pass from nephron to the blood, in turn causing water to move by osmosis. This leads to a retention of water and therefore an increase in blood volume and pressure. In the absence of Aldosterone, sodium is excreted and therefore decreases. Water follows, so there is a decrease in blood volume and pressure

- **Anti-Diuretic Hormone (A.D.H), aka Vasopressin**
  Is a hormone produced by the hypothalamus and stored in the posterior pituitary gland. ADH works by increasing the permeability of the distal convoluted tubule and collecting duct. It controls water reabsorption in a negative feedback loop when reduced water levels in the blood signal its release. ADH increases water reabsorption in the kidneys, putting water BACK into the blood and increases the concentration of the urine. When too much fluid is in the blood, sensors signal the hypothalamus to reduce the amount of ADH being release, therefore increasing the amount of water being absorbed by the kidney - producing large amounts of dilute urine. Alcohol inhibits release of ADH, therefore increasing water loss. Diuretic drugs increase water loss and decrease blood pressure

- **Present information to outline the general use of hormone replacement therapy in people who cannot secrete aldosterone**

Secondary Source Investigation 5.4.3 - Hormone Replacement therapy for Aldosterone

**Aim:** to present information that outline the general use of hormone replacement therapy in people who cannot secrete aldosterone

2. **Explain what Addistons disease is and outline its symptoms**

Addistons disease is a chronic condition that results when the adrenal glands are unable to produce enough of certain and important hormones. As a result, symptoms or effects of Addistons disease is fatigue, low blood pressure, loss of appetite and darkening of the skin. It is an endocrine or hormonal disorder that can occur in all age groups, affecting men and women equally. When the body is unable to produce the right amount of
hormones, these hormones are cortisol and sometimes the hormone aldosterone. It is referred to as adrenal insufficiency or hyporortisolism. Symptoms include: nausea, vomiting, salt cravings and painful muscles and joints.

3. Describe what is involved in hormone replacement therapy for low aldosterone levels.
Current therapies for low levels of aldosterone is the replacement of glucocorticoids and mineralocorticoids, however, available drugs do not restore the normal diurnal variations in serum hormone levels. More treatment includes: replacement of corticosteroids for the control of the symptoms of Addison’s disease. A substitute for aldosterone disease is fludrocortisone. Hormone replacement enables patients to manage the symptoms (such as fluid retention and high blood pressure). It also causes the kidney to conserve water by concentrating urine and reducing urine volume.

4. Discuss any disadvantages or risks of having this treatment
Hormone replacement therapy is an estrogen combination estrogen (progestin medicines). This medicine contains synthetic hormones that can be applied to exact diagnosis. Due to the synthetic hormones it contains, it can be very dangerous to your health. The replacement hormone, fludrocortisone is used to treat low aldosterone levels, if it is not monitored or maintained fluid retention and high blood pressure can result. This happens as the drugs cause increase in fluid and high blood pressure.

5. Outline the prognosis for people with Addison’s disease
The prognosis for Addison disease can be detected in a test that shows:
- Increase potassium
- Low blood pressure
- Low cortisol level
- Low serum sodium
- Normal sex hormone levels
Prognosis is that the person, so long as the medication is taken on a regular basis and is monitored, they can live a normal life.

- Define enantiostasis as the maintenance of metabolic and physiological functions in response to variations in the environment and discuss its importance to estuarine organisms in maintaining appropriate salt concentrations
  Enantiostasis: is the maintenance of normal metabolic and physiological functioning, in the absence of homeostasis in an organism experiencing variations within their environment
  Estuary: is an environment that experiences both fresh water and saline conditions such as the tidal mouth of a large river or coastal inlet e.g mangroves
  Organisms living in an estuary experience large changes in salt concentration over a short time span due to the tidal movements. Organisms that must deal with this fluctuation are known as eurhaline
  In estuaries many organisms have a whole tolerance to changes in salinity, however, others do not and thus require a number of adaptations to overcome this
  Simple strategies include - moving away from the mouth of estuaries, enclosing the shell of mollusks and burrowing into mud and sand.
  One strategy that organisms who have a narrow salinity tolerance employ is to allow the body’s osmotic pressure to vary with the environment. Organisms that do this, and therefore do not maintain homeostasis, are known as osmoconformers.
  Most marine invertebrates are osmoconformers.
  In contrast, marine mammals and most fish are osmoregulators, maintaining homeostasis regardless of the osmotic pressure of the environment.
  However, as the salt concentration inside an osmoconformer changes, various body functions are affected - e.g. the activity of enzymes. To function normally, they need to alter another bodily function to deal with this.
  Organisms can do this by changing the pH of the body fluids, which increases the efficiency of the same enzyme.
Mangroves and Enantiostasis:
A mangrove is a plant species that grows in a swampy forest environment. The waterlogged soil makes it hard for the roots to obtain oxygen for respiration and growth. Pneumatophores extends above the low water tide line and absorbs oxygen from the air.
Mangroves deal with the salty conditions by:
1. The leaves excrete salt onto upper surface of their leaves
2. Salt is accumulated in older leaves and bark of roots and stem

Wheat Plant:
In a wheat plant, the salt accumulates in the older leaves so that when older leaves die, the salt goes with it.

- Describe adaptations of a range of terrestrial Australian plants that assist in minimising water loss.

<table>
<thead>
<tr>
<th>Adaption</th>
<th>advantage</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Needle-like leaves</td>
<td>Reduce surface areas and water loss</td>
<td>Mulgas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>She oak (casuarinas)</td>
</tr>
<tr>
<td>Photosynthetic stem</td>
<td>Reduce surface area and water loss</td>
<td>She oak (casuarinas)</td>
</tr>
<tr>
<td>Woody fruits</td>
<td>Less water loss than fleshy fruits</td>
<td>Banskias</td>
</tr>
<tr>
<td>Waxy leaves</td>
<td>Reduce water loss as cuticle prevents evaporation but also reflects radiation from the sun, reducing heat gain</td>
<td>Salt bush</td>
</tr>
<tr>
<td>Ephemeral growth</td>
<td>Plants have a very small life cycle growing and reproducing is response to rain that benefits survival</td>
<td>Paper daisies, Yellow tops</td>
</tr>
<tr>
<td>Partially deciduous</td>
<td>Some eucalyptus lose most of their leaves during extended dry spells reducing water loss</td>
<td>Eucalyptus</td>
</tr>
<tr>
<td>Leaf curling</td>
<td>Leaves roll up, forming a cylinder, which reduces surface area and traps a humid layer of air which reduces water loss</td>
<td>Hummock grass</td>
</tr>
<tr>
<td>Sunken stomata’s</td>
<td>Stomata’s lie in a cavity in the leaf which results in humid air being concentrated above the stomata’s which reduces water loss</td>
<td>Hakas</td>
</tr>
<tr>
<td>Water storage</td>
<td>Water is stored in trunk, leaves or roots</td>
<td>Baobab trees stores water in its trunk</td>
</tr>
<tr>
<td>Hanging leaves</td>
<td>Leaf hangs down rather than being horizontal to the ground which reduces exposure to the sun</td>
<td>Eucalyptus</td>
</tr>
<tr>
<td>Hairy or shiny leaves</td>
<td>Hairy under surface reduces air movement and increases humidity over stomata’s reducing water loss on the upper leaf, the shiny or hairy surface reflects radiation from the sun</td>
<td>Banksias, Paper flowers</td>
</tr>
<tr>
<td>Water directing leaves and stems</td>
<td>Stems and leaves are shaped so that water runs down towards the roots</td>
<td>Mulgas</td>
</tr>
</tbody>
</table>
- **Gather, process and analyse information from secondary sources to compare the process of renal dialysis with the function of the kidney**

Renal Dialysis reflects the functions of the kidney. If the kidney is failing to process and filter the blood, renal dialysis does this. The dialyser has a partially permeable membrane, similar to kidneys, that allows the waste products to pass through with water and prevents proteins in the blood to go through.

* **Heparin** is administered to prevent blood clotting as blood passes back into the blood

* **Body’s buffer system**: maintains homeostasis, a solution of all the extracellular ions, hydrogen carbonate and acetate.

Renal dialysis is needed for:

**Acute**: emergency situations when potassium levels are high, causing fluid overload and pulmonary oedema. It removes medications or toxins in the blood

**Chronic**: life or long term renal failure

It is important that toxic products are remove out of the body and the good components are moved back so that the purpose of the dialysis isn’t conflicted with. It is also important that wastes are removed as the body can be poisoned if they are left.

**Haemodialysis**
- Removes excess waste products and water from the blood
- Drawn from the vein and passed into an external dialysis solution
- Blood travels through a plastic tubing to dialyser
- Dialyser is a bundle of hollow fibres made from partially permeable membrane
- The membrane allows wastes to pass through, but stops red and white blood cells, platelets or proteins
- Similar to filtration
- Diffusion takes place from blood to dialyser solution
- After diffusion, the clean blood is returned to the body without any wastes
- Anti-clotting agent heparin is added to stop the blood from clotting
- Haemodialysis can only be used: 4 - 5 hours at a time and three times a week. Too much heparin can damage blood cells as they pass through tubes

The advantages of haemodialysis is that it prevents plasma proteins from being lost, only allowing excess waste products and excess water to pass through.

The disadvantage of haemodialysis is that high quantities of heparin cause damage to blood cells.

**Peritoneal dialysis**
- It is undertaken internally
- Dialysis solution is introduced to the peritoneal (abdominal) cavity through a catheter.
- The natural membrane is partially permeable, this allows waste products and water form the body to pass through, into dialysis solution
- The solution is drained from the abdomen into a disposable collection bag
- Peritoneal dialysis can be carried out daily, using four lots of dialysis solution, 2 liters in volume

**Oedema**: is the swelling from excessive accumulation of watery fluids in cells, tissues or serous cavities

**Pulmonary Oedema**: is the fluid accumulation of the lungs. It leads to impaired gas exchange and can cause respiratory failure, breathlessness or fatigue

- **analyse information from secondary sources to compare and explain the differences in urine concentration of terrestrial mammals, marine fish and freshwater fish**

- Different animals excrete different products according to their environment.
- Aquatic animals (fish and invertebrates) excrete ammonia
- Terrestrial animals convert ammonia to urea (less toxic) so it can stay in the body longer so water can be conserved
As the products are different, so is the role of the kidney in each animal

**Marine Fish:**
Body fluids contain less salt concentration than their environment. Water diffuses OUT by osmosis. To counteract, they constantly drink. Salts are excreted and water retained. They excrete little urine.

**Freshwater Fish:**
Have a higher salt concentration than the water they live in. Water diffuses IN by osmosis. To counteract, they produce a dilute urine almost continuously. All salts are absorbed.

**Mammal:**
Regulate water & ion concentration & excretion of urea. Amount of water released is dependent on current environmental conditions & amount of water already in the body.

- **Use available evidence to explain the relationship between the conservation of water and the production and excretion of concentrated nitrogenous wastes in a range of Australian insects and terrestrial mammals**

**Ammonia:**
- Very toxic (removed immediately)
- Excreted through diffusion or in dilute urine
- Waste product of most aquatic animals
- Immediate product of break down of amino acids (no energy required to make it)
- Highly soluble - diffuses rapidly across cell membrane
- Needs large quantities of water to be safely removed
- Does not diffuse quickly in air

**Urea:**
- Toxic (10 000 less toxic than ammonia) - can be safely stored in body for limited time
- Waste products of mammals, terrestrial animals, amphibians, sharks and some bony fish
- Made from amino acids (require more energy than ammonia)
- Highly soluble (water) can be stored in a more concentrated solution
- Source of mater loss

**Uric Acid:**
- Less toxic than ammonia or urea (can be safely stored for extended periods of time)
- Waste products of terrestrial animals (birds, reptiles, insects, land snails)
- Requires more energy to be produced.
- 1000 less soluble than ammonia or urea
- Low toxicity (needs less water to be removed)

**Salt Regulation:**
Plants that live in high salt concentrated areas need to regulate their salt levels. This is due to the fact that a high concentration of salts in soil and water reduces the difference in concentration between the plant cells and soil water. If there isn’t a regulation, less water will enter the plant, by osmosis, the stomates may close and photosynthesis will reduce. Growth and development will slow and lead to death of the plant.

The Process for salt regulation in plants:
- Salt exclusions: plants who are able to stop salts from entering, by remaining in the roots
- Control of salt movement: salt levels are maintained by it remaining in roots or entering older parts of the plant, done by the xylem
- Salt excretion: halophytes excrete salt. Salt glands move salts from the leaf tissues to the surface of the leaf. The salts then crystalise and blow or wash away. Some plants haves salt bladders where salt accumulates, they burst, releasing the contents on the surface of the leaf.
<table>
<thead>
<tr>
<th>Type of animal</th>
<th>Urine components and concentrations</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrestrial mammal</td>
<td>Concentrated urine, usually composed of urea, salts other wastes and water (mammals adapted for desert</td>
<td>Excess salts and other wastes are excreted dissolved water. Water needs to be conserved so urine is concentrated unless water is in excess. Nitrogenous wastes are present as urea because it is less toxic than ammonia and can be present in higher concentrations.</td>
</tr>
<tr>
<td>(e.g Bilby)</td>
<td>conditions have very concentrated urine - to conserve water)</td>
<td></td>
</tr>
<tr>
<td>Freshwater fish</td>
<td>Large quantities of very dilute urine, usually composed of ammonia, small amounts of salts and large</td>
<td>Freshwater fish absorb large volumes of water through gills and mouth linings so much water must be excreted. Ammonia is a suitable nitrogenous wastes because there is sufficient water to make it very dilute. Salts are low in concentration in fresh water and fish have to use energy to take up salts form water to replace lost salts.</td>
</tr>
<tr>
<td>(e.g Native Bass)</td>
<td>volumes of water</td>
<td></td>
</tr>
<tr>
<td>Marine Fish</td>
<td>Small quantities of concentrated urine, usually composed of trimethylamine oxide, other wastes and</td>
<td>Marine fish constantly lose water to their high-salt environment. They excrete little water in concentrated urine, which contains high levels of non-toxic trimethylamine oxide and salts. (Marine fish also excrete salts through their gills)</td>
</tr>
<tr>
<td>(e.g Whiting)</td>
<td>small volumes of water</td>
<td></td>
</tr>
</tbody>
</table>

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**Perform a first-hand investigation to gather information about structures in plants that assist in the conservation of water**

**Experiment: Conservation of water in plants**

**Aim:** to observe structures in plants that assist in conservation of water

**Method:**
1. Set up equipment. All must have water then Paraffin oil.
2. Weigh each leaf before placing into water.
3. Allow to sit in sunny position for at least 24 hours.
4. Re-weigh leaves and calculate percentage of water loss in each leaf.

**Variables:**
- **Independent:** The side that has vaseline and the quantity of leaves
- **Dependent:** amount of water loss form test tubes, the weight of the leaf
- **Controls:** Type of plant, brand of vaseline, amount of paraffin oil, amount of water

**Results:**

<table>
<thead>
<tr>
<th>Leaf</th>
<th>Treatment</th>
<th>Initial weight (g)</th>
<th>Final weight (g)</th>
<th>% weight loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No vaseline</td>
<td>59.02</td>
<td>57.93</td>
<td>1.85</td>
</tr>
<tr>
<td>2</td>
<td>Vaseline on top</td>
<td>59.98</td>
<td>57.67</td>
<td>6.42</td>
</tr>
<tr>
<td>3</td>
<td>Vaseline on bottom</td>
<td>59.58</td>
<td>57.02</td>
<td>4.30</td>
</tr>
<tr>
<td>4</td>
<td>vaseline on both side</td>
<td>57.34</td>
<td>54.22</td>
<td>5.44</td>
</tr>
</tbody>
</table>
Discussion:
Why was the paraffin oil used:
1cm of paraffin oil was used to that is would be a valid test and that no water would evaporate out of the test tube. Only through the leaf

Were the results reliable:
The results are not 100% reliable as water would be lost through evaporation out of the leaves, altering the proper weight

Advantages of increased number of stomates on lower surface of leaves than upper surface
Most stomates are better on the lower side of the leaf as it avoids water loss. This is an advantage so the plant can retain as much water as needed, especially in hot environments and different sunlights.

Conclusion:
In observing the structures in plants that assist in the conservation of water it is noted that the greatest loss of water was in with the vaseline on the bottom. Vaseline on top caused the greatest water loss as the under leaf side has more stomates for water loss.
9.3 Blueprint of Life

1. Evidence of evolution suggests that the mechanisms of inheritance, accompanied by selection, allow change over many generations

- **Outline the impact on the evolution of plants and animals of:**
  Evolution Theory:
  - All living species come from pre-existing species and all living things have a common ancestor in some initial form of primitive life
  - Changes in the environment in which living organisms live can lead to the evolution of plant and animal species
  - Changes in the environmental condition may be physical (temperature), chemical (water salinity, and also competition (for resources or mates for reproduction)

  - **Changes in physical conditions in the environment**
    - The earth has continually changed since life first evolved
    - Various changes in sea levels, the splitting of continents and great changes in climate are just some changes that life on Earth has had to cope with, or became extinct
    - Changes in the environment force species to either die out or survive and diversity (e.g Australia’s mega fauna)
    - E.g. The industrial evolution in the late 19th century caused the peppered moth that was polluted making the trunks dark and sooty. Dark moths survived to maturity whereas the white moths stood out and were eaten by predators. Those that had the dark gene passed on this selective gene.

  - **Changes in chemical conditions in the environment**
    - In the early years of life the environment on Earth was chemically unable to support life as we know it today
    - However, as organisms evolved, special pigments that allow them to exploit the carbon dioxide in the atmosphere (and therefore photosynthesis) many new organisms appeared
    - Chemical changes in the environment also impact on the evolution of organisms
    - E.g. DDT in insecticide used to kill mosquitoes which reduced the population greatly. Those that did survive is due to natural resistances to the insecticides, were able to reproduce a ‘DDT resistant gene’. Today this insecticide is now only effective in high concentration.

  - **Competition for resources**
    - Competition can be between individuals of the same species
    - Resources can include food, water, nesting sites, males for reproduction
    - In Australia, introduced species (rabbits and foxes) have caused competition for resources with native species. The competition has led to the extinction of several species and many others are on the endangered list.
    - E.g. Scientists believe that not all giraffes have such long necks, some in fact had far shorter necks. The longer neck giraffes were able to compete more successfully and ate the leaves high on the tree. Those animals with ‘long neck’ gene were able to compete for successfully for resources and thus long necked giraffes emerged

- **Describe, using specific examples, how the theory of evolution is supported by the following areas of study:**
  - **Palaeontology, including fossils that have been considered as transitional forms**
  Palaeontology is the study of fossils.
  - Show a historical sequence of life, where the oldest fossils are at the bottom and the youngest at the top.
  - Shows transition from simple to complex organism, a gradual process over time.
  Limitations:
  - Records are incomplete and biased towards organisms that are easily fossilised. E.g. Those with hard body parts
Only some parts of organisms become fossilised, making it hard to compare organisms

Examples:
- Transitional forms show features ‘intermediate’ between 2 groups
  E.g. Archaeopteryx
- Between reptiles and birds
  - Reptilian - teeth and long tail
  - Birds - feathers and keel bones on sternum
- Horses
  - Early - small with 4 toes and narrow cheeks
  - Modern - large with 1 toe and narrow cheek span
- Transitional form - fossilised remains with three toes and intermediate cheek span
- Other e.g lobe finned fish, seed ferns, whale transitional form.

- Biogeography
  Biogeography is the study of global distribution of organisms, both living and extinct.
  - Species show close relationship even though continents apart - evidence of a common ancestor as continents joined
  - Organisms that separated later are more similar
  - When separated by physical barriers, new species may arise - supports ideas of evolution and speciation

Limitations
- Limited to species that was isolated at some points in time
Examples:
- Darwin’s finches: birds on islands became adapted to environment, therefore supporting the idea of a common ancestor before isolation
- Flightless birds (ratites) emus, ostriches, cassowary, kiwi and Thea are all found on souther continents

- Comparative embryology
  Comparative embryology demonstrates a shared ancestry for all vertebrates and shows which species are more closely related. It is a comparison.
  - Similarities can be used to support the idea that organisms have evolved from a common ancestor
  - Species that are more closely related share more similarities.
Examples:
- All vertebrate embryos have gill slits which in some cases (Fish and amphibians) develop into gills but in others (mammals, reptiles and birds) seem to disappear
- Human and chimpanzees have more similarities than human and fishes.

- Comparative anatomy
  Comparative anatomy is the study of similarities and differences (comparison) in structure (anatomy) of different species
  - Structures that share common features (homologous structures) have the same basic plan in their structure but with modifications to perform different structures to support the idea of divergent evolution
  - Analogous structures are evident of convergent evolution.

Limitations
- Many structures must be compared, not based on homologies in only one structure
Examples:
- Forelimbs of vertebrates show the same basic arrangement of bones - termed a ‘pentadactyl’ (five digit limb) but modifications exist according to function of limb (e.g bat, bird, whale, cat, humans)
- Vestigial organs, those that serve important functions, in ancestors but irrelevant in modern forms. E.g. The appendix is now redundant in humans but used in digestion for Apes
- **Biochemistry**

**DNA HYBRIDISATION**

DNA Hybridisation is the comparison of nucleotide base sequence of two or more species to determine evolutionary relatedness

- The fact that all living things share a common biochemistry, supporting the idea of common ancestors. All living things share the same basic DNA components
- Species more closely related are more chemically similar

Limitations:
- DNA - DNA hybridisation has many variables affecting results.
- It is thought to be less accurate than other biochemical methods

Examples:
- A Chimpanzee’s genetic make up is 98.5% identical to that of the human and a gorilla is 87.4%.

**AMINO ACID SEQUENCING**

Amino Acid sequencing is a comparison of amino acid sequence within a protein common to two or more species to determine relatedness

- Comparison of amino acid sequence in species that may share evolutionary relatedness show the more closely they are related the more similar their amino acid sequence is.

Example:
- Human haemoglobin has 674 amino acid arrangement in 4 chains
- Amino acid sequence are identical in humans and chimpanzees, gorillas have two different and old-world monkeys (barboons) have 12 differences

- **Explain how Darwin/Wallace’s theory of evolution by natural selection and isolation accounts for divergent evolution and convergent evolution**

Both convergent and divergent evolution involve a change in a population over time due to the mechanisms of natural selection and isolation. Changes in the environment (chemical, physical and for resources) act as selecting agents for evolution.

**Divergent evolution:**
- When different groups arise from a common ancestor due to ADAPTIVE RADIATION.
- Leads to populations that look different to each other
- E.g. Adaptive radiation from the ancestral Kangaroo has leg to the Musky- Rat Kangaroo, Tree kangaroo and Wallabies.
- E.g. The Galapagos Island finches arose from one common ancestral species.

**Convergent evolution**
- leads to superficial similarities due to organisms living in the same habitat or having the same lifestyle although are closely related
- E.g. The dolphin (mammal) and shark (cartilaginous fish) look superficially similar, although body temperature, mode of reproduction and other bodily functions are quite different.
- E.g. Placental mammals and marsupials have developed superficial similarities.

Darwin and Wallace stated that within any population of a species, there exists genetic variation. Divergent evolution arises when members of a species develop different adaptations in different environments. Examples of divergent evolution include the Finches in the Galapagos Islands. The 14 different species of this bird have developed different beaks and diets on each island. In order for completely new species to have developed from original finches on the mainland, genetic isolation must have occurred. Divergent evolution can also bee seen in the kangaroo family, with the Tree kangaroo evolving form rainforests and the Rat kangaroo evolving in deserts.

Convergent evolution occurs when different species develop similar adaptations in similar environmental niches. Examples include the shark, turtle, dolphin and penguin, which all possess streamline bodies, flippers or fins. Other examples of convergent evolution include kangaroos, wallabies and grazing ungulates such as the cow from the northern hemisphere.
- **Plan, choose equipment or resources and perform a first-hand investigation to model natural selection**

**Aim:** to use a model to demonstrate natural selection

**Hypothesis:** if natural selection is modelled in an investigation, the data recorded will reflect changes in populations similar to evolutionary change by natural selection

**Discussion:**
- As each round was complete the proportions of ‘organisms’ that are not camouflaged (red, white, yellow) decreased. This is because the other camouflaged ‘organisms’ were suited to their environment and not eaten. The proportion of these (green and brown) increased with each breeding event.
- The organisms whose colours matched the environment were better able to survive. This indicates that they were adapted to their environment.
- Because of the different surfaces that could be found around the school different organisms would be better suited to different areas. For example, the white organisms may be better suited to an environment made of concrete.
- Over time changes to the proportions of organisms could change due to the things like changes to the physical environment (e.g. Grass dying, soil erosion) or competition.
- In the original population there was variation amongst the organisms. Some of these organisms were better suited to the environment than others. Those that were better suited, survived predation and were able to reproduce. This meant that the population of organisms better suited to the environment survived and passed on the favourable traits while those not suited died out.

- **Analyse information from secondary sources on the historical development of theories of evolution and use available evidence to assess social and political influences on these developments**

- Leonardo da Vinci (1452-1519) - Found fossil shells high up on mountains and decided they were once living organisms that had been buried before the mountains were raised.
- George-Louis Buffon (1707-78) - Suggested life was older than 6000 years and though that organisms had changed over time.
- Carolus Linnaeous (1707-78) - Founded the binomial naming system. He suggested that organisms changed through hybridisation. He grouped organisms together that show similarities. He did not infer there was evolution form one form into another.
- Erasmus Darwin (1731-1839) - Suggested that the strongest and most active individuals would survive and continue a species.
- Jean-Baptist Lamarck (1744-1829) - Suggested that features acquired during the life could be passed on to offspring (acquired characteristics) E.g. Giraffe stretching it’s neck to get food. This theory was later discredited.
- James Hutton (1769-1832) - Suggested that geological change happen gradually over time (gradualism); for example: A river can gradually carve a valley.
- Curvier (1769-1832) - Documented fossil in rock strata and noted each layer was characterised by different types of fossils. Deeper layers show most different fossils and modern species and they moved closer. Noted that extinction was common.
- Charles Lyell (1797-1875) - Geological processes occurred at the same rate in the present as they did in the past (uniformitarianism).
- Alfred Russel Wallace (1823-1913) - Independently came up with the theory of natural selection and wrote to Darwin to discuss it. This prompted Darwin to public his theory.
- Charles Darwin (1809-1882) - Developed his theory of evolution based on observations he mad on the HMS Beagle. By early 1840s he documented the main points of his theory but was reluctant to public his work because of the political and religious upheaval it would cause. He published *On the origin of species by means of natural selection* in 1859. It highlighted: species were not created in their modern function, an natural selection is the mechanism of change.

- Theory of evolution questioned the time by life has been on earth, fundamental creationism states that organisms have not changed but were created by God in six days. Though the theory of evolution states that change in organisms has occurred over millions of years.
- It threatened the power of the religious institutions, that had a long and upheld political and social power.
Analyse information from secondary sources to prepare a case study to show how an environmental change can lead to changes in a species

Darwin argued that all members of a single species were not identical and that some varieties would be more likely to survive and reproduce than others. Variation is a species allow the species to survive in the changing environment.

In England, the peppered moth occurs in two variations; a white form and a black form. The white form was once much more common than the black form as they camouflaged more easily on the white trees. With the industrial revolution the trees got stained with soot and turned black, the black moth now had the favoured characteristic and survived to reproduce. This resulted in the population of black moths increasing and the population of white moths decreasing.

Perform a first-hand investigation or gather information from secondary sources (including photographs/diagrams/models) to observe, analyse and compare the structure of a range of vertebrate forelimbs

When we compare the anatomy of different animals we find many of them possess organs that are similar, although used in different ways. Such similar structures are said to be homologous. An example of this can be seen when we examine the forelimbs of a number of vertebrates. The limbs of many vertebrates, including humans, are based on an arrangement of bones called the pentadactyl limb. The fact that such a structure is present strongly suggests that these vertebrates share a common ancestor whose descendants evolved in different ways. We call this divergent evolution. The favoured characteristics in each case would have survived to reproduce becoming more abundant in the population.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Forelimb structure related to environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat</td>
<td>Digits very close, strong to stand impact of walking</td>
</tr>
<tr>
<td>Bat</td>
<td>Long digits for flying, which are covered by a membrane</td>
</tr>
<tr>
<td>Whale</td>
<td>Stocky and compacted to utilise fin for swimming</td>
</tr>
<tr>
<td>Human</td>
<td>More slender, doesn’t have to withstand much impact, good for manipulation</td>
</tr>
<tr>
<td>Lizard</td>
<td>Similar to human, but short and stockier to walk on</td>
</tr>
<tr>
<td>Bird</td>
<td>3 digits and compacted for flying</td>
</tr>
<tr>
<td>Frog</td>
<td>Longer digits for webbing and swimming</td>
</tr>
</tbody>
</table>

Use available evidence to analyse, using a named example, how advances in technology have changed scientific thinking about evolutionary relationships

Classification is based on structural characteristic of organisms. Those with similar structures are placed in the same groups as it’s assumed they are closely related to each other and have a relatively recent common ancestor. Also, comparing structural characteristics is not generally helpful when species are very different. The study of biochemical similarities is possible due to new evidence on evolutionary relationships. Biochemical studies have made it possible to compare the biochemicals (proteins and nucleic acids) in various species. The degree of difference between the same protein or nucleic acid in different species provides a measure of the length of time since the two species shared a common ancestors. This is due to mutations occur relatively regularly. So, the longer it is since a common ancestor, the greater the difference between molecules. This information is used with fossils and other evidence to piece together evolutionary relationships.

Cytochrome C is a protein that first appeared in ancient bacteria about 2 billion years ago. It is part of the biochemical pathway of aerobic respiration and is present in all modern organisms except anaerobic bacteria. Cytochrome C molecules each contain 100 amino acids and the exact sequence of those amino acids is known for about 60 species.
New technologies: DNA sequencing and DNA-DNA hybridisation

<table>
<thead>
<tr>
<th>DNA-DNA hybridisation</th>
<th>DNA gene sequencing</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA hybridisation is when DNA from one species is unzipped and added to a single strand of DNA from another. It is then observed what base pairing occurs.</td>
<td>DNA sequencing is when DNA is taken from the nucleus, mitochondria and chloroplast or a species an compared to the DNA of another. Similarities and differences are observed.</td>
</tr>
</tbody>
</table>

These new technologies are providing evidence that is changing longer-held ideas about the family trees of many organisms from single-celled organisms to primates. For example, the elegant flamingo was found to be more closely related to the squat grebe than any other species of water bird. This suggests that long legs and web feet evolved independently in many water birds.
2. Gregor Mendel’s experiments helped advance our knowledge of the inheritance of characteristics

- **Outline the experiments carried out by Gregor Mendel**
Mendel chose garden peas to investigate the natural laws that govern plant hybrids. Mendel established traits that were similar to true breeds and cross breeds of the plants. Mendel let the plants both self fertilize and cross breed plants to create hybrids. He took numerous notes and observed patterns in the traits that were inherited in each plant.

- **Describe the aspects of the experimental techniques used by Mendel that led to his success**

<table>
<thead>
<tr>
<th>Valid Scientific technique used</th>
<th>Mendel's experimental procedure</th>
<th>Why he was successful</th>
</tr>
</thead>
</table>
| Controlled Variables            | - He studied a large number of characteristics but studied them one at a time, each as a separate, identifiable characteristic.  
- He studied seven characteristics in 34 varieties of garden peas, each of which he bred for one of the particular characteristics e.g. Height (tall or short) or seed colour (yellow or green) or shape (round of wrinkled) | - He used a controlled experiment and only changed one variable at a time  
He identified:  
- An independent variable: the characteristics (e.g. Height) that he chose to study in each experiment  
- A dependent variable: the resulting appearance of the offspring. |
| Ensured Accuracy                | - He started each experiment with pure-breeding lines by ensuring self-pollination for many generations over a period of two years (placing bags over the plants to ensure self pollination)  
- To ensure cross pollination, he removed the stamens of flowers and then brushed pollen from another plant onto the stigma, using a paintbrush or forceps | - He ensured that the variables in the plants that he crossed were carefully and accurately controlled and not subject to experimental error  
- He avoided accidental cross-pollination of self - pollinaiton |
<p>| Quantitative results            | He performed many repetitions of each genetic cross and used large sample sizes (thousands of plants for each genetic cross to be trialled) | He ensured reliability of results by using large sample sizes and many repetitions which all gave similar results |
| Ensured reliability            | He made precise observations and counts and meticulously recorded exact numbers of plants showing each characteristic - that is, he gathered quantitative data that could be analysed objectively | He did not merely gather result by observation, he counted exact numbers of plants to obtain objective and accurate data |
| Applied mathematical formulae   | He analysed the quantitative data that he collected and applied mathematical formulae and statistical to arrive at his conclusion | He looked for statistical patterns and ratios to use his data as a basis for valid conclusions (that contained no inferences) |</p>
<table>
<thead>
<tr>
<th>Valid Scientific technique used</th>
<th>Mendel’s experimental procedure</th>
<th>Why he was successful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Justified inferences and</td>
<td>He used his initial experiments to formulate a new hypothesis, make predictions and test them and then applied critical thinking to solve the problem</td>
<td>He used mathematical model to explain the phenomenon of inheritance (showed a cause and effect relationship) and to make predictions for future crosses to establish generalisations that became laws</td>
</tr>
</tbody>
</table>

**Describe outcomes of monohybrid crosses involving simple dominance using Mendel’s explanations**

Monohybrid crosses result in the dominant characteristic being shown as the phenotype on the organism, while the recessive gene is only expressed in the genotype. This makes the organism a carrier of the trait, and hence can pass the trait on to their offspring.

Mendel’s work has helped us to understand how characteristics in living things and, in certain cases, to predict the genetic and physical outcomes of sexual reproduction. Mendel concluded that ‘factors’ were responsible for the inheritance of characteristics occurred in discrete units, and that they were inherited in pairs with one factor coming from each parent. This was Mendel’s first law, ‘principles of segregation’. Each alternate member of a gene pair is known as an ‘allele’ and these alleles separate from each other during gamete formation. From his experiment with pea plants, Mendel discovered that with each experiment, when pure breeding forms were crossed, one of the alternate traits completely disappeared in the F1 generation but reappeared in offspring whenever two F1 plants were crossed.

The purple flower is the **dominant** trait because it was the only factor expressed in the F1 generation and the white colour is **recessive** trait as is disappeared for a generation.
- **Distinguish between homozygous and heterozygous genotypes in monohybrid crosses**

**Genotypes** - refer to the *allele combination* that an organism has. This can be either homozygous or heterozygous. It is the genotype that determines what trait an organism is going to have.

**Homozygous genotypes** - occur when an organism has two of the SAME alleles present. Remember that the prefix HOMO means same e.g. TT or tt

**Heterozygous genotypes** - occur when an organism has two DIFFERENT alleles present. Remember that the prefix HETERO means different e.g. Tt

- **Distinguish between the terms allele and gene, using examples**

**Allele** - an alternative form of a gene (one of a pair) that is located at a specific position on a specific chromosome. Organisms have two alleles for all traits. They are represented by a letter of the alphabet when completing genetic exercises

**Gene** - units of hereditary information that consists of DNA and are located on chromosomes. They are the parts of DNA molecules that code for proteins. Genes exist in alternate forms called alleles.

Alleles produce a variation of inherited characteristics, such as eye colour or blood type. Genes, however, are a sequence of DNA that is transcribed to make mRNA in the nucleus and then translated at a ribosome in the cytoplasm to make a protein. An allele is an alternate form for a gene. A person gets one gene in a pair from each parent.

- **Explain the relationship between dominant and recessive alleles and phenotype using examples**

Recall that the genotype is the allele combination an organism has that expresses a certain trait. That trait that is expressed is known as the **phenotype** - the outward expression of a genotype

For example - Mendel’s pea plants have a TT ‘genotype’ and have a ‘phenotype’ that is tall

When an organism has a homozygous genotype - both alleles are the same - their phenotype is easy to determine e.g. TT = Tall and tt = Short

The two alleles that make up a genotype are classified as a **DOMINANT** and **RECESSIVE**. The dominant gene is represented by a *capitalised* letter and the recessive is by a *lower case* letter.

As the name suggest, the dominant allele ‘dominates’ the recessive, overpowering it. Therefore heterozygous organism, the dominants phenotype is always expressed.

E.g. TT = Tall and tt = short

Tt = tall (as T is dominant over t)

This explains why Mendel got the 3:1 ratio when crossing the F2 generation of tall plants.

We can draw a Punnet square to see how the original parents passed their genetic information on to the F1 generation.

<table>
<thead>
<tr>
<th>T</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>Tt</td>
</tr>
<tr>
<td>t</td>
<td>Tt</td>
</tr>
</tbody>
</table>

We can cross the F1 generation of Tt plants to get the F2 generation
Plants are both tall (Tt and TT) and short (tt)

<table>
<thead>
<tr>
<th></th>
<th>T</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>TT</td>
<td>Tt</td>
</tr>
<tr>
<td>t</td>
<td>Tt</td>
<td>tt</td>
</tr>
</tbody>
</table>

From our understanding of dominant and recessive alleles, we know that both TT and Tt mean that the plant will be tall. Therefore, in Punnet square 3 boxes contain tall plants to one box containing short, giving us a 3:1 ratio of monohybrid cross

- **Outline the reasons why the importance of Mendel’s work was not recognised until some time after it was published**

  Gregor Mendel (1822-1884) is referred to as the ‘father of genetics’ and has two laws: ‘Principles of Segregation’ and ‘Law of Independent Assortment’. Mendel did not know the existence of genes at the time, though called them discrete ‘factors’ that existed. These factors were passed intact from generation to generation.

  Mendel read his paper, ‘Experiments on Plant Hybridisation’ at the Natural History Society of Brunn, Bohemia in 1965. Despite this, his work was hardly noticed and has little impact until the early 20th century. Reasons for this:
  - He was an Abbot in a monastery, and was not a high profile member of the scientific community, thus did not exert influence to ensure his paper was read.
  - During this period, science was not strongly encouraged as cultural activities and religions overruled.
  - Mendel’s findings were not understood by other scientific members.

  It was not until 1900 that Mendel’s work was recognised by Hugo de Vries, Carl Correns and Erich von Tschernak. Tschernak realised that his findings were significant and resembled similar breeding investigations of his own.

- **Perform an investigation to construct pedigrees or family trees, trace the inheritance of selected characteristics and discuss their current use**

  The squares are males, the circles are females. Coloured shapes have the disease. Some pedigrees half colour the boxes to indicate the individual is a carrier.

  Remember that there are generations that must be labelled. If a question says there are two girls and one boy then it is done in order.

  In this picture, the disease is recessive as it appears to have skipped a generation. Males are affected. Either the female or male could be carriers.

- **Solve problems involving monohybrid crosses using Punnett squares or other appropriate techniques**

  In mice, the gene for straight tail is dominant to the gene for wavy tails. A mouse with straight tail had a parent with a wavy tail.

  1. **What is the genotype of this straight tailed mouse?**

     Genotype of straight tail offspring = Tt or TT

     Parent is wavy = tt

     Because the wavy parents can only give t, the straight tail mouse genotype must be Tt

  2. **If this mouse is crossed with a wavy tailed mouse, is there a chance of any offspring having straight tailed? Include probabilities in your answer**
**Tt x tt**

<table>
<thead>
<tr>
<th></th>
<th>T</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
<td>Tt</td>
<td>tt</td>
</tr>
<tr>
<td>t</td>
<td>Tt</td>
<td>tt</td>
</tr>
</tbody>
</table>

Wavy tail and straight tail can have offspring with straight tails.
Phenotype = 1:1, 50%
Genotype = Tt : tt

* CAPITAL IS THE DOMINANT GENE AND THE LOWER CASE IS THE RECESSIVE

- **Process information from secondary sources to describe an example of hybridisation within a species and explain the purpose of this hybridisation**

Hybridisation is the breeding of two different types of plants or animals together. A mule is an example of a hybrid, it is the offspring of a male donkey and a female horse. The F1 generation of a hybrid cannot produce its own offspring.

Hybridisation: there are two ways to explain this: cross between closely related species (donkey x horse = mule) and crosses within a species (homozygous dominant pea plants PP x homozygous recessive pea plant pp = heterozygous purple pea plant Pp)

The purpose of hybridisation is to cross breed within a species and understand how genetics are inherited. Genetic make up is passed on e.g. The pea plants that were crossed created different plants. It can also be used to create new variations of species e.g. breeding different types of dogs or horses to get the most pure or best animal. Hybridisation plants and animals is used to produce new commercial plants and animals. It is a good way for characteristics to be chosen and to produce the desired offspring. Many seeds in the American seed market are hybrids. This increases the profit for the business.

Wheat in Australia is another example.
3. Chromosomal structure provides the key to inheritance

- **Outline the roles of Sutton and Boveri in identifying the importance of chromosomes**
  - When Mendel’s journal article on inheritance in pea plants was rediscovered in 1900, it caused other scientists to unravel the mystery of inheritance.
  - The chromosome theory of inheritance was proposed by Walter Sutton in 1902. He observed large chromosomes during meiotic cell division in testes of grasshoppers.
  - Sutton proposed that Mendel’s factors of genes on chromosomes in cells were responsible for phenotypes of offspring.
  - He observed chromosome behaviour during meiosis, cell division to form gametes mirrored Mendel’s law on the sorting of factors when gametes are produced.
  - Sutton gave the first insight into chromosomes as a unit of inheritance, with alleles of genes residing on a chromosome.
  - Morgan Thomas first isolated genes on chromosomes, Sutton recognised that:
    - Mendel’s ‘factors’ were located on chromosomes each from a mother and father.
    - Homologous pairs of chromosomes segregate or move apart, during meiosis and the resulting gametes have one from each pair.
  - Theodor Boveri realised the link between chromosomes, gamete formation and fertilisation.
  - He observed the stage of meiosis where the number of chromosomes is reduced by half, and he decided that each gamete had a half set of chromosomes.
  - When gametes join, in fertilisation, to make a zygote the chromosome number returns to normal (diploid).
  - He also recognised the relationship between Mendel’s factors and chromosomes. The chromosome theory of inheritance is described today as the Sutton-Boveri theory.

- **Describe the chemical nature of chromosomes and genes**
  - DNA is mostly stretched out into long, thin threads. When it is ready to divide, chromosomes replicate, shorten and thicken, which makes them visible under a light microscope.
  - Humans have 46 chromosomes (23 pairs), thus half are the sex chromosomes (one of the 23 pairs):
    - XX = Female
    - XY = Male
  - A gene is a sequence of DNA in a chromosome, they are a code for specific polypeptide and create a protein.
  - A combination of proteins coded by genes that give a person their characteristics that are unique.

DNA and RNA are known as nucleic acids. DNA is a very large macromolecule composed of smaller builder blocks. We can consider the structural features of DNA at different levels of complexity.

1. Nucleotides are the building blocks of DNA.
2. A Strand of DNA is formed by the covalent linkage of nucleotides in a linear manner.
3. Two strands of DNA can hydrogen-bond with each other to form a double helix. In a DNA double helix, two DNA strands are twisted together to form a structure similar to a spiral staircase.
4. In living cells, DNA is associated with any array of different proteins to form chromosomes.
5. A genotype is the complement of an organism’s genetic material.

Nucleotides have three components; a phosphate group, a pentose sugar and a nitrogenous base. Dioxyrbose is found in DNA where as Ribose is found in RNA. The nitrogenous bases can only be paired in a certain way on the double helix. This is because of the opportunities to form hydrogen bonds between the bases.
Identify that DNA is a double-stranded molecule twisted into a helix with each strand comprised of a sugar-phosphate backbone and attached bases – adenine (A), thymine (T), cytosine (C) and guanine (G) – connected to a complementary strand by pairing the bases, A-T and G-C

What does DNA look like?
- Deoxyribonucleic acid (DNA) was separated and isolated from cells in 1869, this process is not hard
- Separating DNA can be done by anyone
- Once separated, DNA appears stringy, white and rather acidic when tasted
- It is rather unremarkable in appearance, students say it looks like spit

Chemical structure of DNA
- In 1920s, Phebus Levene discovered that the deoxyribose sugar molecule in DNA are linked with phosphate groups. He also noted that nitrogenous bases are attached to a deoxyribose sugar and a phosphate group. This provides the first model of a nucleotide.
- A DNA nucleotide consists of:
  - A five carbon deoxyribose sugar
  - A phosphate group
  - One of four nitrogenous bases (adenine, thymine, cytosine, guanine)
- They are considered nitrogenous bases as they contain nitrogen, and, when isolated, are basic to litmus paper
- Each contains differing amounts of nitrogen
- They are classified into two categories
  - Purine - Adenine (A) and Guanine (G)
  - Pyrimidine - Thymine (T) and Cytosine (C)
- 1960 - Erwin Chargaff measured the proportions of nitrogenous bases and found they are not always in equal proportions
  - Adenine always pairs with Thymine
  - Guanine always pairs with Cytosine
- The observation formed the basis for the future discovery of this ‘structure within a species but different between species’. This was done by Watson and Crick, explaining the structure of DNA. The proportions were the same within a species but different between a species.
- Equal portions of A=T and G=C

Explain the relationship between the structure and behaviour of chromosomes during meiosis and the inheritance of genes
Meiosis: Cell division to produce haploid daughter cells
Diploid: usual number of chromosomes for an organism (2 pairs of chromosomes) (46 2N)
Haploid: half of the diploid number. Thus one of each chromosome (23 N)
Homologous chromosome: corresponding pairs of chromosomes that look the same (all except X & Y)
Gametes: sex cells; sperm and eggs (haploid)
Fertilization: combining of gametes to produce diploid
Sister chromatid: each ‘aim’ of a homologous pair held together by a centromere
Crossing over: exchange of a section of chromosomes between adjacent chromatic priors on two different homologous chromosomes producing new linkage groups
Independent assortment: the location of homologous chromosomes along the axis is independent from other homologous chromosomes
Recombination: changing the genetic combination
<table>
<thead>
<tr>
<th>Number of parent cells</th>
<th>One</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent cells are..</td>
<td>Diploid</td>
</tr>
<tr>
<td>Number of daughter cells</td>
<td>Four</td>
</tr>
</tbody>
</table>
| Daughter cells are..   | - Haploid (N)  
|                          | - Different to parent cells  
|                          | - Different to other daughter cells  |
| Number of cell divisions | Two |
| Source of variation    | Crossing over |
| DURING Meiosis         | - Independent assortment  
|                          | - Random segregation  
|                          | - Possible mutations during replication  |
| Source of variation AFTER meiosis | - Random combination of gametes during fertilisation |
| Why we need these variations | - Increase change of survival for particular species as unfavourable characteristics are no likely to be passed on  
|                          | - Increased chances of developing adaptations when environments change (natural selection)  |

The law of segregation: there are factors (genes) in plants that control each characteristic. During reproduction, these two factors segregate, one factor appearing in every gamete. The factors recombine at fertilisation- they do not blend, but match each other.

The law of independent assortment: when the pairs of factors segregate, they do so independently of other pairs of factors. They are distributed into gametes independently of other pairs of factors. We now know that this law applies in all cases except where the genes are situated on the same chromosomes. It is chromosomes and not genes that separate and are distributed independently.

In the parent cell, chromosomes exist as long strands of DNA. Before meiosis begins, the chromosomes in the nucleus thicken and then replicates. The resulting chromatids are joined at the centromere. During the first part of meiosis, homologous pairs find each other and line up on the spindle. It is at this point crossing over can occur between homologous pairs, because chromosomes are easily broken. The further genes are apart on a chromosome, the more crossing over occurs between these genes. If genes are very close together, the crossing over between these genes is unlikely. The chromosomes then pull apart and move to the poles. The cell cytoplasm divides, giving the daughter cells (each containing one half of each homologous pair). During the second division, the chromosomes line up on the spindle and pull apart to each pole. The cytoplasm then divides again, resulting in four haploid daughter cells.

Inheritance of genes follows the behaviour of the chromosomes because genes are located on chromosomes. Crossing over, random assortment of chromosomes during meiosis, and the random coming together of sex cells during fertilisation causes genetic variation.
- Explain the role of gamete formation and sexual reproduction in variability of offspring

Ways to increase variation during sexual reproduction in a population:
- Crossing over during gamete formation (increases range of combination)
- During meiosis, crossing over results in the exchange of alleles between chromosome pairs. This causes the combination of alleles on the chromosomes in the gametes to be more varied than when no crossing over takes place.
- Mutations occurring during DNA replication
- Random separation and independent assortment of homologous chromosomes across equator of cell
- Random combination of gametes during fertilisation
- During meiosis, genes on different chromosomes sort independently. This produces gene combination in gametes from different parents.
- In cross fertilisation, the gametes that combine are likely to be more difficult from those in self-fertilisation. Cross fertilisation results in more variation than self fertilisation.

Why we need this for variation
- Increased survival rate of particular species because unfavourable characteristics are not likely to be duplicated
- Increase change of better adaptations arising through natural selection

- Process information from secondary sources to construct a model that demonstrates meiosis and the processes of crossing over, segregation of chromosomes and the production of haploid gametes

1. Diploid cells with 4 chromosomes. The chromosomes have sorted themselves into homologous pairs they start to shorten and thicken when this process is complete they will be known as chromatids
2. The chromatids replicate themselves and crossing over may occur. Crossing over involves the swapping of genetic material and leads to greater genetic variety
3. The homologous pair line up along the equator of the cells and start to separate
4. The second meiotic division occurs. A second spindle forms at right angles to the first. The pairs of chromatids separate
5. Four nuclei appear, each enclosing the haploid number (2) of chromatid.
6. The cytoplasm divides, the chromatid lengthens and become chromosomes. Results in 4 gametes with half number of chromosomes as the parent.
Describe the inheritance of sex-linked genes, and alleles that exhibit co-dominance and explain why these do not produce simple Mendelian ratios

Sex Linkage in humans:
- Humans have 23 pairs of chromosomes. 22 pairs of autosomes (body chromosomes) and one pair of sex chromosomes
- Male chromosomes = XY and Female chromosomes = XX
- The X chromosome is bigger and contains genes for non-sexual characteristics. If any of these genes are defective, commonly recognised disorders result
- A defect in a gene on an X chromosome is more likely to produce a phenotype effect in males than females, because males only have one copy of the gene.
- A female who has a defective copy of a gene on one X chromosome may have a normal copy on her other chromosomes and this would be dominant, therefore masking any phenotype effect. She will be referred to as the carrier. Only females with two defective copies of the gene - one on each X chromosome - show the phenotype effect
  - If a typical female XX is a carrier, each of her sons will have a 50% chance of showing the trait (getting the X chromosome with the trait).

<table>
<thead>
<tr>
<th>Gene</th>
<th>Disorders resulting from defective allele</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood clotting factor (X)</td>
<td>Haemophilia</td>
<td>- Inability of blood to clot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Ongoing internal bleeding (bruising)</td>
</tr>
<tr>
<td>Colour vision (X)</td>
<td>Red-green colour blindness</td>
<td>- Can't distinguish from red and green</td>
</tr>
<tr>
<td>Muscular strength (X)</td>
<td>Duchenne’s muscular dystrophy</td>
<td>- Muscles become weak, break down and are replaced by fatty deposits</td>
</tr>
<tr>
<td>Hairy human pinnae (Y)</td>
<td>Hair ears</td>
<td>- Hair sprouting form ear rims</td>
</tr>
</tbody>
</table>

Some common sex-linked disorders

Describe the work of Morgan that led to the understanding of sex linkage

Sex linkage means that some gene for non-sexual characteristics are linked to genes for sexual characteristics by being on the same chromosome. The discovery of sex linkage resulted from the work of Morgan. Morgan had been breeding fruit flies or (Drosophila melanogaster). Morgan’s first experiment was to cross pure breeding red eyed females with white eyed males. Resulting offspring was all red eyed, which, assuming red eyes were dominant to white, was consistent with Mednel’s experiments. However when crossing two from the F1 generation he did not get the 3:1 ratio the was expected. The result was that there was no white eyed females in the F2 generation. He decided to investigate this further by breeding this white-eyed male with normal, red-eyed females. All the offspring (F1) had red eyes. He then allowed the F1 generation to breed. The F2 generation contained some white eyed fruit flies. All the white eyed flies where male. Morgan hypothesised that the white-eyed characteristic was ‘sex linked’. He suggested that genes for sex linked characteristics were on the X chromosome. The females in the F2 could only inherit dominant genes from the male red eyed parents because it had no corresponding recessive gene on it’s ‘Y’ chromosome. Therefore the female fruit flies must only carry at least one gene for red eyes and none for white eyes. What Morgan observed was:
**F1 generation**

<table>
<thead>
<tr>
<th>X</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>X'</td>
<td>XX'</td>
</tr>
<tr>
<td>Y</td>
<td>XY</td>
</tr>
</tbody>
</table>

Note the females are carriers but do not express the gene

**F2 generation**

<table>
<thead>
<tr>
<th>X'</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X'X</td>
</tr>
<tr>
<td>Y</td>
<td>X'Y</td>
</tr>
</tbody>
</table>

Note that half the males have and express the gene

This is because if the gene appears on the X chromosome, if the gene is sex linked recessive it will not appear in the phenotype, however if a male gets this gene, it will be expressed because there is no other X chromosome.

It was discovered that in humans, sex linked conditions are usually carried on the X chromosome only, when the condition is recessive it is expressed most often in males. This is because when a male inherits a recessive gene on the X chromosome there can never be a dominant gene on the Y chromosome to mask it's effect.

---

- **Explain the relationship between homozygous and heterozygous genotypes and the resulting phenotypes in examples of co-dominance**

Both incomplete dominance and co-dominance do not follow Mendelian rules and ratios

- **Incomplete Dominance**
  - Unlike 'normal' Mendalian, the heterozygous individuals does not display the dominant trait. Instead it displays a third phenotype, which is a **blend** of the dominant and recessive phenotype
  - Examples include:
    - Snapdragon: the three genotype combination RR, Rr, rr, code for the phenotype red, pink and white respectively
    - Andalusian fouls (chickens): can be either black (BB), blue (Bb) or white (bb)

---

1. In snapdragons where red flower colour (R) is incompletely dominant over white flower colour (r), what will be the flower colour of the offspring and genotypic ratios for each of the following crosses?

   a. Pink flowered plant x red flowered plant

   \[ Rr \times RR \]
   
   = 50% red and 50% pink  
   \[ 1:1 \]

   R  R
   R  RR  Rr
   R  RR  Rr

   b. White x pink

   \[ Rr \times Rr \]
   
   = 50% white and 50% pink  
   \[ 1:1 \]

   R  R
   r  Rr  Rr
   r  Rr  Rr

   c. Red x white

   \[ RR \times rr \]
   
   = 100% pink  
   \[ 1 \]

   R  R
   r  Rr  Rr
   r  Rr  Rr

   d. Pink x pink
Rr x Rr
= 25% red and 25% white and 50% pink

<table>
<thead>
<tr>
<th>R</th>
<th>Rr</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>RR</td>
</tr>
<tr>
<td>r</td>
<td>Rr</td>
</tr>
<tr>
<td>r</td>
<td>rr</td>
</tr>
</tbody>
</table>

**Co-dominance**
- With co-dominance, the heterozygous displays both traits that the dominant and recessive genotype code for.
- Co-dominance is show in a monohybrid cross when both alleles of the homozygous parents are expressed in a heterozygous individual.
- Co-dominance results because both alleles are expressed in the offspring. These codominant alleles can produce three phenotypes - one for each homozygous genotype and one for the heterozygous genotype.
- Examples include:
  - The Roan cow: is the heterozygous individual produced when a red bull (RR) and a white cow (WW). The genotype of the Roan (red and white) and the offspring is RW.

**- Outline ways in which the environment may affect the expression of a gene in an individual**
The characteristics of an individual are determined by both genes and the influence of the environment on the expression of these genes. One of the most obvious examples of this is the comparison of genetically identical plants that have been grown under different conditions. Varying essential requirements, such as nutrients, moisture, sunlight and temperature will result in differences in growth rates, flowering and fruiting, indicating that the environment can have a very strong effect on the phenotype of the organism. Other examples include:

A) The Himalayan Rabbit - alter their coat colour with change in the temperature at low temperatures their fur is black white, at higher temperatures their fur becomes brown.
B) The Siamese cat - have a type of pigmentation that responds to temperature (their extremities are cooler than the rest of their body), which results in their nose, ears, tail and feet are darker in colour.
C) Studies of twins - the major study of identical twins that are raised in different environments has shown that they as of ten no longer appear identical due to nutrition and other lifestyle differences.
D) Hydrangeas - their flowers will grow in different colours depending on the environment and soil in which they grow; and the pH of the soil.

**- Solve problems involving co-dominance and sex linkage**
Recognising different types of genetic crosses

**Monohybrid crosses:**
- Only one type of characteristic is involved in the problem and there is usually only two variations.
- The genotype is written using a capital and a lower case version of the same letter, no X and Y chromosomes are shown.
- The genotype always contains two of the same letters.

**Sex-linked:**
- The sex of the parents and the offspring are always mentioned.
- One sex, usually the male, has only one copy of the gene.
- The X and Y chromosomes are written into the genotype with the carrier marked in superscript.
- The recessive characteristic occurs more commonly in males than females because there is no dominant gene on the Y chromosome to counter its effect.

**Co-dominance:**
- One type of characteristic involves, but there are usually three variations of this.
- The heterozygote exhibits the phenotypes of both homozygote’s- that is both phenotypes are equally dominant and are both expresses.
The genotype is written using two different letters, both capitals
No X or Y chromosomes are shown
The genotype contains two letters. These are both capitals and may be two of the same letters or different letters.

- Identify data sources and perform a first-hand investigation to demonstrate the effect of environment on phenotype

Independent: amount of light available to seeds
Dependent: colour or phenotype of the plant and the height
Controlled: temperature, amount of seeds in each dish, amount of water, type of seed, same measurement intervals, in same medium.

Results:

Plant colour:

<table>
<thead>
<tr>
<th>Environment</th>
<th>Yellow-white</th>
<th>Green</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark</td>
<td>85</td>
<td>15</td>
</tr>
<tr>
<td>Light</td>
<td>5</td>
<td>95</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environment</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
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<tbody>
<tr>
<td>Dark</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Light</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>8</td>
<td>11</td>
</tr>
</tbody>
</table>
Discussion:
The seeds that were exposed to the light grew at a greater height than those in the dark. The seeds that were exposed to the light had a higher percentage of green phenotype, whereas yellow-white was the dominant phenotype for those seeds in the dark.
It is clear that the environment plays a crucial role in determining the phenotype of a plant and on the height of the seeds.
4. The structure of DNA can be changed and such changes may be reflected in the phenotype of the affected organism

- **Describe the process of DNA replication and explain its significance**

  The DNA double helix unwinds itself. The nitrogenous bases that are floating around the nucleus come join next to the bases on the DNA forming an identical strand that is called mRNA (transcription). The DNA then rewinds to form the double helix, and the mRNA moves out of the nucleus and into the ribosome. It is there where each codon of the mRNA strand is joined to a tRNA molecule. The new DNA strand goes out of the cell and off to where it is needed, while the amino acids on top of the tRNA bond together forming a polypeptide chain (translation).

  The critical feature of DNA replication is that the DNA molecule retains the same information and the new molecule is an exact copy. The significance of this process is that genetic information can be passed on from generation to generation. During reproduction the genetic code is copied then half the genetic information passes into each sex cell. When fertilisation occurs the new organism has half the genetic material from each parent.

1. Original double helix strand of DNA
2. Hydrogen bonds between bases break and DNA ‘unzips’
3. Free nucleotides join single strands of DNA following their complementary base pair. The result is two identical double stranded DNA molecules
4. The new DNA molecules recoil into the original double helix shape

The significance of DNA replication:
- The genetic information is passed on from generation to generation. During sexual reproduction, the genetic code is copied and then half of the genetic information passed into each sex cell. When fertilisation occurs the new organism has half the genetic material from each parent.
- The DNA in a cell contains the genetic information to make an entire organism. When a cell divides it takes with it an exact copy of genetic code of that organism.

- **Outline, using a simple model, the process by which DNA controls the production of polypeptides**

  Polypeptide synthesis involves a type of nucleic acid, called RNA (ribonucleic acid). RNA is the intermediary between DNA and polypeptide synthesis. It is a single strand of nucleotide bases. It has ribose sugar and the nitrogen base, thymine, is replaced by uracil which bonds with adenine.

  There are two types of RNA that are involved in polypeptide synthesis, messenger RNA (mRNA) and transfer RNA (tRNA). In the nucleus, the double stranded DNA molecules unzip and the DNA code is transcribed into the single stranded mRNA molecule. The mRNA moves out of the nucleus into the cytoplasm and attaches to a ribosome. In the cytoplasm, the mRNA is translated into amino acids.

  At the ribosome, the messenger RNA lines up forming a template. A group of three bases, called a codon, codes for a specific amino acid. There are codes that start and stop the chain formation. AUG is the starting point for translation.
In DNA code, a ‘word’ is always three letters long (as it is assigned to amino acids to form proteins) and is called a codon. Consider the following DNA segment:

<table>
<thead>
<tr>
<th>DNA</th>
<th>RNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATC</td>
<td>GTC</td>
</tr>
<tr>
<td>GTC</td>
<td>CAA</td>
</tr>
<tr>
<td>CAA</td>
<td>A</td>
</tr>
<tr>
<td>TAG</td>
<td>CAG</td>
</tr>
<tr>
<td>CAG</td>
<td>GTT</td>
</tr>
<tr>
<td>ATG</td>
<td>CAA</td>
</tr>
<tr>
<td>UAG</td>
<td>CAG</td>
</tr>
<tr>
<td>CAG</td>
<td>CUU</td>
</tr>
</tbody>
</table>

ATG is a codon. GTC is a codon and CAA is a codon etc.

In transcription, the DNA code is transcribed (copied) into RNA code, following the similar rules to DNA replication EXCEPT that:

- DNA → RNA
  - A → U
  - T → A
  - C → G
  - G → C

Now =

<table>
<thead>
<tr>
<th>DNA</th>
<th>RNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATC</td>
<td>GTC</td>
</tr>
<tr>
<td>GTC</td>
<td>CAA</td>
</tr>
<tr>
<td>CAA</td>
<td>A</td>
</tr>
<tr>
<td>UAG</td>
<td>CAG</td>
</tr>
<tr>
<td>CAG</td>
<td>CUU</td>
</tr>
</tbody>
</table>

tRNA has an anticodon (a non-amino acid forming codon) on one end and an amino acid on the other. A polypeptide is formed as each amino acid is added from tRNA to a chain following the sequence on the mRNA.

Each mRNA codon corresponds to an amino acid that is transported to the RNA/ribosome complex by another special nucleic acid call tRNA. T Stands for transfer. The ribosome essentially ‘reads’ the RNA code and facilitates the linking of appropriate amino acids to make proteins.

**- Explain the relationship between proteins and polypeptides**

A polypeptide chain folds itself into two possible shapes; an α-helix or a pleated sheet. The α-helix and the pleated sheets become attracted to each other with makes the original polypeptide chain folded up into a particular shape, the polypeptide chain then goes and joins with other polypeptide chains. The chains all fold together to make a protein.

Thus, proteins are made up of polypeptide chains that are made up from a combination of polypeptide chains.

**- Explain how mutations in DNA may lead to the generation of new alleles**

A mutation is a change in the DNA information on a chromosome or a change in a gene. It results in an alteration of the original DNA sequence. When a mutation occurs in a sex cell, the changed genes can be inherited. Some of these inherited mutations are lethal and can lead to the acquisition of certain diseases. Rare instances the altered gene may be beneficial e.g. Giraffes longer necks. This in turn, leads to more variation within a population and so increases the chances of evolution within a species.

- Many proteins are enzymes and have important functional roles in digestive and catabolic breakdown (when large molecules break down into smaller molecules)

**- Cause of mutations**

**Mutagens** are factors that cause mutations. E.g. Radiation in Xray, UV rays and gamma rays

Mutagen can be natural o synthetic

- **Natural mutagens** include radiation from UV rays and Xrays. This occurs because DNA absorbs these wavelengths, which can induce cross-links between the pyrimidines e.g. Skin cancers.
- **Synthetic mutagens** include chemicals such as polycyclic aromatic hydrocarbons, agent orange used in vietnam war and mustard gas.
- Mutagens can affect DNA by deleting nitrogenous base and inserting new nitrogenous bases.
- Sickle cell anaemia - where a substitution of only one nitrogenous base leads to a different amino acid being specified in haemoglobin, resulting in the production of abnormal proteins and mishapen red blood cells that
rupture easily. Mutant form has a thymine in place of adenine. Normal codon = glutamic acid, mutant codon = valine
- Mutants either occur in body cells, somatic cells, and are NOT transmitted to offspring. This altered DNA can only be passed to offspring if it is in the sperm of eggs.

- **Types of mutations:**
  Changes in a chromosome number - in some meiotic divisions chromosome pairs may not separate. This is called ‘non-disjunction’ and results in the gametes having either too many or too few chromosomes. Down syndrome is an example of this, where there is three copies of chromosome 21. When chromosomes fail to separate during mitosis, organisms inherit more than one set of chromosomes. This is known as **polyploidy**. Polyploidy can be useful in commercial plants and is used by plant breeders in the production of hybrid species.

- **Changes in DNA base sequence**
  - **Substitution** - an incorrect base replaces one of the original ones in the DNA strand. The result is that a different amino acid will be incorporated into the chain during polypeptide formation and a different protein will be formed. It can cause problems as it may function differently. E.g. Sickle cell anaemia: the mutated gene varies from the normal haemoglobin gene by only a single amino acid.
    
    | Original DNA | Mutated DNA |
    |--------------|-------------|
    | CAGTAGGTC    | CAGAAGGTC   |

  - **Insertion** - an extra base is added to the DNA sequence, and differs the amino acid sequence and the protein being formed. From this point of the mutation onwards the amino acid sequence will be completely different, causing a ‘frameshift’ mutation and a non-functional protein
    
    | Original DNA | Mutated DNA |
    |--------------|-------------|
    | CACCAGGTC    | CACCTAGGTC  |

  - **Deletion** - a base is deleted from the DNA code. It is similar to that caused by the insertion of a base
    
    | Original DNA | Mutated DNA |
    |--------------|-------------|
    | CAGTCGGTA    | CGTCGGTA    |

  - **Inversion** - a mistake during DNA replication causes a whole triplet to form back to front. Again, this results in a completely new protein with different properties.
    
    | Original DNA | Mutated DNA |
    |--------------|-------------|
    | CAGTTGGTA    | GACTTGGTA   |

- **Discuss evidence for the mutagenic nature of radiation**
  **Mutagens** are factors that cause mutations. This includes radiation, including X rays, ultraviolet light and gamma rays from nuclear reactors. Some chemicals can also act as mutagens; asbestos, certain dyes, nicotine, benzene and some preservatives. In a small number of cases mutations occur spontaneously. These are known as ‘background mutations’

  There is much evidence for the mutagenic nature of radiation. Environmental factors that may increase the rate of mutation include: X rays, radiation from atomic bombs and UV light.

  Radiation was the first mutagenic agent known. Its effects on genes were first noticed in the 1920s. When X rays were first discovered they were thought to be harmless and were used as a novelty. You could even buy an ‘x ray machine’ for your home. Most of the first generation of scientists who worked with radiation died of cancer. Famous examples are Marie Curie and her daughter, who both died of leukemia. So did Rosalind, part of the Watson and Crick team for DNA discovery.

  Hans Muller received a nobel prize in 1927 for showing that genes had the ability to mutate when exposed to X rays. Beatle and Tatum also used X rays to produce mutations in bread mould in the formulation of their ‘one gene - one polypeptide’ hypothesis.
The atomic bomb dropped on Hiroshima and Nagasaki also increased the evidence for mutations caused by radiation. There was tenfold in cancer deaths directly after the bombs were dropped.

**- Explain how an understanding of the source of variation in organisms has provided support for Darwin’s theory of evolution by natural selection**

With research into DNA, scientists have been able to solve two problems Darwin had in developing a universal theory of evolution:

- Darwin knew that characteristics were passed on from one generation to the next. He recognised that this occurred but did not know the mechanism. Mendel showed how characteristics were inherited as ‘genes’. Boveri and Sutton recognised that the behaviours of chromosomes explained how genes could be inherited. Then DNA proved to be the material of which genes are made. DNA is passed from one generation to the next.
- Darwin knew that variation within a population was essential for natural selection to operate but did not know the source of this variation. DNA is the material that codes for characteristics. Thus, changes in the DNA base sequence, mutations, can cause variations to be inherited.

**- Describe the concept of punctuated equilibrium in evolution and how it differs from the gradual process proposed by Darwin**

Darwin’s original theory supports the idea that evolution was and is a gradual process, where one form evolved steadily into another.

In the 1970s Niles Eldridge and Stephan Jay Gould published an alternative explanation for the lack of transitional forms. They proposed that the fossil record was not as imperfect as once thought. In fact, it was an accurate representation of the way evolutionary processes occurred.

Rather than the gradualism proposed by Darwin, it was suggested that there are very long periods where little evolutionary changes occurs, followed by relatively short bursts of change. This may happen due to a crisis, such as volcanic activity or glaciation.

This is known as **punctuated equilibrium**, where no periods of change, or equilibrium, are punctuated by short bursts or periods of rapid change.

There are species found to exist with little change for 5 to 10 million years, but then it disappears and is replaced by a similar species in a relatively rapid succession.

**- Perform a first-hand investigation or process information from secondary sources to develop a simple model for polypeptide synthesis**

**Aim:**
To develop a model of polypeptide synthesis

**Method:**
1. Watch videos and research data about polypeptide synthesis and look at diagrams in which show this process.
2. As a group design a model that shows protein synthesis
3. Make the model
4. Write a report that shows understanding

**Results:**
- Analyse information from secondary sources to outline the evidence that led to Beadle and Tatum’s ‘one gene – one protein’ hypothesis and to explain why this was altered to the ‘one gene – one polypeptide’ hypothesis

* Beadle and Tatum carried out their experiment in 1941
* They used bread, mould and neurospora to carry out their experiment
* Enzymes were needed to convert simple substances into the amino acids and vitamins necessary for growth
* All enzymes code for one gene
* Neurospora could not grow on the minimal medium as one gene was mutated and a mutant would not grow if an enzyme is added as a supplement.
* The mutagen that H. Muller used to cause mutations in the genes was an X ray.
* The Neurospora was unable to make vitamin B6, which is necessary for growth. This is due to Culture #299 which did not grow on a minimal medium with amino acid supplement, only on a medium with vitamin supplements. Because one of the enzymes in B6, the B6 synthesis pathways must be affected.
* Genetic mutations affect metabolic pathways, this is important as mutations create different proteins and enzymes cause abnormalities with the organisms.
* The first conclusion of Beadle and Tatum’s experiment procedure was: ‘One gene is responsible for one enzyme’.
* The hypothesis changed when more research was carried out into proteins. Therefore the hypothesis changed to ‘one gene - one protein’. BUT not all proteins are enzymes (e.g. Some are hormones) therefore the hypothesis changed to ‘one gene - one polypeptide’; as many proteins are made up of more than one polypeptide.
* ‘Beadle and Tatum’s main discovery was that genes act by regulating definite chemical events’

- Process information to construct a flow chart that shows that changes in DNA sequences can result in changes in cell activity

<table>
<thead>
<tr>
<th>Process</th>
<th>Original sequence</th>
<th>Insertion of G-C base pair</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNA Code</td>
<td>TCT AGC TGC AAT TCG</td>
<td>TCT AGC GTG CAA TTC</td>
</tr>
<tr>
<td>mRNA Code</td>
<td>AGA UCG ACG UUA AGC</td>
<td>AGA UGG CAC GUU AAG</td>
</tr>
<tr>
<td>tRNA Code</td>
<td>Arg - Ser - Thr - Leu - Ser</td>
<td>Arg - Ser - His - Val - Lyl</td>
</tr>
<tr>
<td>Polypeptides</td>
<td>Arginine - Serine - Threonine - Lysine- serine</td>
<td>Arginine - Serine - Histidine - Valine - Lysine</td>
</tr>
<tr>
<td>Protein</td>
<td>Functional Protein</td>
<td>Non- Functional protein</td>
</tr>
</tbody>
</table>

- Insertion of just one base pair has caused a change in the sequence and hence a non-functional protein.
- Process and analyse information from secondary sources to explain a modern example of ‘natural’ selection

1. Explain how natural selection affects the European rabbit exposed to the myxoma virus.

Myxomatosis is a disease of European rabbits caused by myxoma virus, which is transmitted from rabbit to rabbit by mosquitoes or fleas or by close contact between an infected rabbit and a susceptible rabbit. The strain of virus originally released in Australia killed 99.8 per cent of infected rabbits. Since that time there has been a substantial evolution of both the virus and the rabbit. Through natural selection, myxoma virus initially became more less effective because the more attenuated viruses were more effectively transmitted. This attempt to kill the rabbits actually allowed some infected rabbits to survive, which in turn led to natural selection for resistance to myxomatosis in the wild rabbit population.

2. Explain how natural selection affects the myxoma virus

Through natural selection, the effectiveness of the myxoma virus has decreased as it no longer causes infertility in European rabbits.

3. Describe how the myxoma virus and the rabbit populations have changed

It was introduced into Australia in 1950 in an attempt to control the rabbit population. It was devastatingly effective, reducing the estimated rabbit population from 600 million to 100 million in two years. However, the rabbits remaining alive were those least affected by the disease. Genetic resistance to myxomatosis was observed soon after the first release and most rabbits acquired partial immunity in the first two decades. Resistance has been increasing slowly since the 1970s, and the disease now only kills about 50% of infected rabbits. In an attempt to increase that number, a second virus (rabbit calicivirus) was introduced into the rabbit population in 1996.

- Process information from secondary sources to describe and analyse the relative importance of the work of:
  - James Watson
  - Francis Crick
  - Rosalind Franklin
  - Maurice Wilkins

in determining the structure of DNA and the impact of the quality of collaboration and communication on their scientific research

In 1962 James Watson (b. 1928), Francis Crick (1916–2004), and Maurice Wilkins (1916–2004) jointly received the Nobel Prize in physiology or medicine for their 1953 determination of the structure of deoxyribonucleic acid (DNA).

Of the four DNA researchers, only Rosalind Franklin had any degrees in chemistry. She was born into a prominent London banking family, where all the children—girls and boys—were encouraged to develop their individual aptitudes. She completed her degree in 1941 in the middle of World War II. There she performed fundamental investigations on the properties of coal and graphite. She was introduced to the technique of X-ray crystallography and rapidly became a respected authority in this field.

Already at work at King’s College was Maurice Wilkins, a New Zealand–born but Cambridge-educated physicist. It was Wilkins’s idea to study DNA by X-ray crystallographic techniques, which he had already begun to implement when Franklin was appointed by Randall. The relationship between Wilkins and Franklin was unfortunately a poor one and probably slowed their progress.

Watson had two degrees in zoology. He became interested in genetics. He had worked under Salvador E. Luria at Indiana on bacteriophages, the viruses that invade bacteria in order to reproduce. Cavendish Laboratory, where several important X-ray crystallographic projects were in progress. Under the leadership of William Lawrence Bragg, Max Perutz was investigating hemoglobin and John Kendrew was studying myoglobin, a protein in muscle tissue that stores oxygen.

Inspired by Pauling’s success in working with molecular models, Watson and Crick rapidly put together several models of DNA and attempted to incorporate all the evidence they could gather. Franklin’s excellent X-ray
photographs, to which they had gained access without her permission, were critical to the correct solution. The four scientists announced the structure of DNA in articles that appeared together in the same issue of *Nature*.

4. **Explain how Watson and Crick were able to form their ideas on the structure of DNA**

A new understanding of heredity and hereditary disease was possible once it was determined that DNA consists of two chains twisted around each other, or double helixes, of alternating phosphate and sugar groups, and that the two chains are held together by hydrogen bonds between pairs of organic bases—adenine (A) with thymine (T), and guanine (G) with cytosine (C).

The background for the work of the four scientists was formed by several scientific breakthroughs: the progress made by X-ray crystallographers in studying organic macromolecules; the growing evidence supplied by geneticists that it was DNA, not protein, in chromosomes that was responsible for heredity; Erwin Chargaff’s experimental finding that there are equal numbers of A and T bases and of G and C bases in DNA; and Linus Pauling’s discovery that the molecules of some proteins have helical shapes—arrived at through the use of atomic models and a keen knowledge of the possible disposition of various atoms.

5. **Describe whether the discovery of the structure of DNA was collaborative or competitive**

This was a discovery that offered a glimpse of the molecular mechanisms that underlie all life, paving the way for a revolution in molecular biology. The insight, innovation, and persistence of James Watson, Rosalind Franklin, Francis Crick, and Maurice Wilkins led to a detailed understanding of the structure of DNA. They weren’t the only scientists thinking about DNA. Several other groups also recognized that the three-dimensional structure of DNA was within reach, so the competition was stiff.

In the mid-1950s Watson decided to write the story of their discovery and circulated the manuscript in draft form among a number of people. the manuscript portrayed the field as fiercely competitive and highly personalized. They learnt that collaboration as well as competition are important factors in a scientific endeavor.

Both competition and collaboration spurred research on DNA’s structure. Knowing that others were investigating the same question, Watson and Crick worked feverishly on the problem in order to solve it first. However, collaboration was also important — many scientists made important contributions to solving the structure. Wilkins and Franklin contributed images that provided key evidence, and Watson and Crick came up with a chemically stable model of DNA. It was agreed that Wilkins, Franklin, and Watson and Crick would publish three separate papers in the same issue of *Nature*, making their findings available for other scientists to evaluate.
5. Current reproductive technologies and genetic engineering have the potential to alter the path of evolution

- Identify how the following current reproductive techniques may alter the genetic composition of a population:
  - Artificial insemination

  **Description:**
  - Injection of male semen into vagina or cervix of a female without sexual intercourse
  - Sperm collected from stud male and can be stored/frozen/sent away
  - Mostly used in sheep, cattle and pigs
  - Desired features = more beef, higher milk production, milk with higher butter fat, sheep with finer wool or pigs with leaner meat.
  - Examples: male Friesian variety with Jersey cow = offspring produced large amounts of creaming milk

  **Advantages:**
  - Means males may provide sperm for many females without leaving paddocks
  - Reduce dangers of injury during transit or mating
  - Increases breeding life of the male frozen sperm can be used after death
  - Can increase the number of changed species

  **Disadvantages:**
  - Relies on 'trial and error' - hoping combinations will work
  - Potential for over exaggerated features such as udders so large the cow can hardly walk
  - Important to keep detailed pedigrees of these animals as less favourable genes are passed on at the same time
  - Important that closely related animals are not interbreeding
  - Overuse of sperm from one particular breeding line can reduce genetic diversity = problems with recessive characteristics or genetic diseases

- Artificial pollination

  **Description:**
  - Involves humans taking pollen from one plant with desired characteristics and placing it on to the stigma of another
  - Mendel used this in his pea plant experiment
  - Used to produce a wide range of fruits, vegetables and cereal crops
  - Desired features = higher yield, larger fruit, disease/drought resistance
  - Examples: Pears grow in Hanyuan country of China have been pollinated by hand since regional bees were wiped out by pesticides in the 1980s.

  **Advantages:**
  - Plants can be bred in climates that they are not usually suited to grow in controlled conditions.
  - Able to assist in production of resistant plants for countries with high incidence of drought etc.

  **Disadvantages:**
  - Overuse can lead to entire areas becoming susceptible to specific pests. E.g. Irish potato famine caused by a fungal disease, plants gradually lose their vigour as there is no genetic variation
  - overcrowding and lack of nutrients

- Cloning

  **Description:**
  - Cloning is the creation of an organism that is an exact genetic copy of another and that every part of DNA is exactly the same
  - Early examples of this would be Dolly the sheep in 1997
  - Two types of cloning artificial embryo twinning and Soomatic cells Nuclear transfer
  - Artificial embryo twinning mimics the natural process of identical twins
  - Somatic cell nuclear transfer is the same process used to procure Dolly the sheep, and thus produces an exact clone or genetic copy
Advantages:
* Gives greater insight into stem cell research
* Helps those needing organ transplants
* Helps infertile couples to have a baby by IVF
* Cloning animals will provide an endless supply of resources
* Further scientific research in the area of cloning

Disadvantages:
* The cloning of an animal is successful though the life span is only half the life span of normal animals which has been cloned.
* By taking embryos from animals, humans take this for research and leaving the animal useless
* Questions religious ethics and is illegal in Australia

Outline the processes used to produce transgenic species and include examples of this process and reasons for its use:

Transgenic species are created by placing a gene from one species into another. This can be done using recombinant DNA technology, or genetic engineering. The reasons for creating a transgenic species may include:
- Increasing crop yields
- Increasing resistance
- Increasing ability to survive harsh conditions
- Producing drugs and vaccines
- Achieving better characteristics
- Developing new products
- Developing species to provide tissues and organs for donation to humans

Three steps in recombinant DNA process:
1. Restriction enzymes cut DNA into smaller species (aka gene shear or scissors)
2. After being cut, ligases strengthen bonds between newly reformed DNA (recombinant DNA).
3. Once recombinant DNA is formed, multiple copies are created using polymerase chain reaction (PCR). The polymerase chain catalyzes DNA replication to make billions of copies very rapidly.

Four main methods:
- **Microinjection** - DNA from one species is inserted into a cell from the other species using a fine glass needle, or micro-pipette. This is the most common method used.
- **Biolistics** - A gene gun fires small metal particles coated with DNA into another nucleus.
- **Electroporation** - Cells are exposed to short electrical impulses so that small pores (holes) form in the membrane. This allows new genes to be inserted.
- **Ti Plasmid** - The bacterium Agrobacterium tumefaciens inserts its DNA into plants, using structure called Ti Plasmid. The infection produces a tumour, called crown gall. Ti plasmid stands for 'tumour inducing plasmid'. The bacterium then inserts a segment of its DNA into the DNA of the plants. This results in a mass of cells known as a callus and cell culture is used to produce plants with the desired gene. Other bacterial such as E. Coli have had the gene for human insulin inserted. This insulin is then collected for people with diabetes.

Biotechnology: is the use of biological processes by industry or agriculture to change organisms, to produce useful products or provide services. For example: baking bread, brewing beer, making cheese and breeding cattle with desirable characteristics.

Genetic engineering: is a technique of modern biotechnology where genetic material is manipulated to alter the characteristics of an organisms.

Annealing process: is when the matching sticky ends of two cut strands of DNA are mixed together, and connect. It is the sealing enzyme DNA ligases, that are added to the annealed DNA to seal and strengthen the bond.

Plasmid: are vector in genetic engineering for bacteria as they do not have a nucleus. Plasma transfers transgenes into bacteria.
Transgenic species: were introduced because it has assisted agriculture productivity, cloned growth factor into sheep so they grow faster, tomatoes have been modified so they do not go soft on ripening. It is also beneficial for the treatment of disease supplying designer proteins for human use e.g human insulin.

- Discuss the potential impact of the use of reproduction technologies on the genetic diversity of species using a named plant and animal example that have been genetically altered

Reproductive technology has been used in agriculture by creating crops with increased yielding and quality. They have also been used to create crops that are resistant to particular insect pests.

E.g extracting the gene from the soil bacterium Bacillus thuringiensis, that produces a toxin which is deadly to the larvae of insect pests.

Genetic diversity is decreasing. This is see by the concern that eventually, if the genetically altered crops is the only variety present in the field, there is will be little diversity. If there is little diversity the crops are susceptible if conditions change.

Biodiversity is the genetic variation found in different life forms on Earth. A concern with biodiversity is due to reproductive technologies. Current efforts on monitoring is seen by, inserting certain human genes into sheep and goats to make them produce milk that has foreign proteins. For example: the sheep milk that had foreign factors VIII and IX, and those with haemophilia B need factor IX. Thus the milk will provide this, and in turn influences the genetic diversity of the human population, as it assists people with haemophilia and their genes stay in the gene pool.

Ethical issues include: environmental concerns on the welfare due to transgenic species. It is the concern that the release of transgenic species into the environment will have adverse effects on other organisms. This is due to the increased ability of survival of these species, and the potential impacts upon the food web.

- Process information from secondary sources to describe a methodology used in cloning

Aim: to describe cloning methodology.

Discussion Questions:
1. Describe the process used to create a clone.

Cloning is a process used to create an exact copy of a mammal by using the complete genetic material of a regular body cell. This process of cloning is seen to be the same one used for Dolly the Sheep:

a. Isolate donor nucleus:
Isolate the nucleus from a somatic (non-reproductive) cell of a adult donor sheep. The nucleus contains the complete genetic material of the organism. This step is repeated many times to gather many cell nuclei. A very small needle and syringe (suction device) is used to poke through the cell membrane to capture the nucleus and remove it from the cell.

b. Get unfertilized eggs
Retrieve unfertilized egg cells (reproductive) from a female sheep. Many eggs are needed since not all of them will survive the various steps of cloning.

c. Remove the egg's nucleus
Remove the egg cell's nucleus, which contains only one-half of the sheep's genetic material. A very small needle and syringe (suction device) is used to poke through the cell membrane to capture the nucleus and remove it from the cell.

d. Insert donor nucleus
Insert the nucleus, with its complete genetic material, isolated from the donor mammal in Step 1 into the egg cell that has no nuclear material. The egg's genetic material now contains all traits from the donor adult. This egg is genetically identical to the donor adult.

e. Place the egg into the womb
Place the egg into a female sheep's womb. Only a small percentage of eggs placed in the womb will start to mature. Those eggs that survive will continue to develop into embryos. The egg matures in the womb. When the offspring is born, it is a clone (genetically identical) of the donor sheep.
2. Explain how humans can be cloned for therapeutic processes
Therapeutic cloning: (a.k.a. Somatic cell nuclear transfer or research cloning): This starts with the same procedure as is used in adult DNA cloning. This involves removing the DNA from an embryo and replacing it with the DNA from a cell removed from an individual. The resultant embryo would be allowed to grow for perhaps 14 days. It's stem cells would then be extracted and encouraged to grow into a piece of human tissue or a complete human organ for transplant. The end result would not be a human being; it would be a replacement organ, or piece of nerve tissue, or quantity of skin. The first successful therapeutic cloning was accomplished in 2001-NOV by Advanced Cell Technology, a biotech company in Worcester, MA.
- The original seed cell is a form of human life; it contains human DNA, whether it comes from a skin scraping or is extracted from the inside of a person's mouth.
- The original ovum is a form of human life; it contains human DNA.
- The pre-embryo that is produced is a form of human life; it contains human DNA.
Theoretically, these stem cells can be used to develop into replacement organs (heart, liver, pancreas, skin, etc). Therapeutic cloning has not yet been accomplished in the laboratory or clinic.

3. Construct a flow chart that outlines this cloning process so a member of the public can understand the reasons for the debate over the last 8 years.

- Analyse information from secondary sources to identify examples of the use of transgenic species and use available evidence to debate the ethical issues arising from the development and use of transgenic species
Aim: to identify the use of transgenic species. To debate ethical issues associated with the use of transgenic species.

Discussion Questions:
1. Define a genetically modified organism
A genetically modified organism (GMO) or genetically engineered organism (GEO) is an organism whose genetic material has been altered using genetic engineering techniques. These techniques, generally known as recombinant DNA technology, use DNA molecules from different sources, which are combined into one molecule to create a new set of genes. This DNA is then transferred into an organism, giving it modified or novel genes. Transgenic organisms, a subset of GMOs, are organisms that have inserted DNA from a different species. GMOs are the constituents of genetically modified foods.
2. Identify products on shelves at the supermarket that contain genetically modified organisms
This is a short list of the genetically modified food crops that are grown in the world today:
Corn, Soy bean, Sugar cane, Tomatoes, Potatoes, Sweet peppers, Bananas, Strawberries, Zucchini, Pineapples, Cocoa beans and Yellow squash.

3. Identify examples of transgenic species and describe their uses
Transgenic cattle were created to produce milk containing particular human proteins, which may help in the treatment of human emphysema.
Genetically engineered salmon, which incorporates the gene that codes for protein bGH (bovine growth hormone), into the genes of the fish. This causes the fish to be larger and faster growing fish which is beneficial for fisherman and also as fish is healthy. Possible farmed source of fish as food. However, the fish are kept in ponds that offer no escape to the wild because there is much concern that they will upset or destroy natural ecosystems.

4. Construct an electronic or paper poster that outlines the main ethical issues arising from the development and uses of these transgenic organisms
Ethical Issues that arise from transgenic organisms:
Bioethics addresses the impact of technology on individuals and societies. Bioethical issues include an individual's right to privacy, equality of access to care, and doctor-patient confidentiality. In the case of transgenic organisms, a major bioethical issue is freedom of choice. Yet broader issues also arise, such as the ethics of interfering with nature, and effects of transgenic organisms on the environment. If mixing DNA in ways that would not occur in nature is deemed wrong, then transgenesis is unethical. A more practical objection to transgenic technology is the risk of altering ecosystems. Those animals with characteristics that are more desirable and can compete better in natural environments will cause disruption to ecosystems. Another ethical dimension to transgenic organisms is that the methods to create genetically modified seeds, and the seeds themselves, lie in the hands of a few multinational corporations. Groups that oppose genetically modified foods sometimes behave unethically. In 1999 environmental activists destroyed an experimental forest of poplars near London. The trees were indeed transgenic, but the experiments were designed to see if the trees would require fewer chemical herbicides, an activity the environmentalists had themselves suggested.

5. Describe the risks to the environment from genetically modifying organisms with new technologies.
Examples of these issues include potential for:
1. Pollen from the GMO may carry to a non-GMO crop, thus introducing the novel gene into a conventional crop; pollen from a herbicide resistant GMO may cross with a compatible weed and introduce resistance in the weed (Rieger et al 1999),
2. Herbicide resistant crop plants may emerge in a following season and be difficult to control,
3. Insects might develop resistance to insecticides made in GMO plants (e.g. Bt cotton),
4. Harm might result to soil biota, thus harming nutrient cycling,
5. The GMO might have a poor nutritional profile or be poorly digested and
6. The GMO might make a toxin, allergen or teratogen.
Discuss the difficulties to defining the terms ‘health’ and ‘disease’

- **Health:** WHO: health is a state of complete physical, mental and social wellbeing
- Health is governed by many different factors e.g.
  - Psychologists look from a mental/social perspective
  - Medical scientists look at biological functions e.g. blood pressure
  - Social scientists look at social aspects e.g. family, finance, adaptability
  - Geneticists look at genetic make up and lack of mutations
  - Epidemiologists looks at trends of disease, measuring in statistics → focusing on a population rather than individual
- Health depends on the interaction between these factors
- **Disease:** Any condition that disturbs or has potential to disturb optimal function of body
- Also governed by multiple factors e.g.
  - Pathogens
  - Exposure to harmful radiation/chemicals
  - Social pressures
  - Psychological stress
  - Metabolic disorders/chemical imbalances
  - Physical injury
  - Genetic errors
  - Nutrition deficiencies → e.g. malnutrition/obesity
  - Malfunctions of immune system → autoimmune diseases e.g. MS, arthritis or hayfever
  - Inadequate sleep or exercise → e.g. DVT
  - Malfunction of body parts e.g. heart

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

- Cells are the unit of life where all metabolic reactions occur
- Homeostasis then provides for optimal metabolism → health
- Ultimately health = the wellbeing of all cells governed by DNA and homeostasis
- Genes
Required to produce enzymes, hormones, structural proteins, antibodies, transport proteins etc

→ mutations in genes would create the wrong protein with the wrong shape → the protein cannot do its job

DNA repair genes produce enzymes to ensure DNA is accurately replicated and enzymes are even able to amend some mistakes

P53 gene on chromosome 17 produces the P53 protein → this protein stops cell division in the G1 (first growth) stage of Mitosis upon the detection of damaged DNA

This allows the enzyme to correct the DNA before cell division recommences

Stops mutated cells being replicated

- **Mitosis**
  - Responsible for growth and repair → without it, growth and repair would not occur
  - Proto-oncogenes stimulate cell division whilst suppressor-oncogenes stop or slow down cell division
    - Their actions complement and supplement each other
    - Health is determined by a balance between the two
    - Imbalance results in diseases such as: cancers or tumours
  - Proto-oncogenes are dominant → only one of the two alleles needs to be mutated in order for the mutation to be expressed
  - Suppressor-oncogenes are recessive → both alleles have to mutate in order for mutation to be expressed

- **Cell Differentiation**
  - Certain genes produce polypeptides, forming proteins which regulate:
    - Development e.g. hormones
    - Metabolism e.g. enzymes etc
  - Each protein is required for tissues and cells to perform their designated functions
  - Without each specified protein, the body cannot function optimally
Analyse the links between gene expression and maintenance and repair of body tissues

Cancer

- Cancer is the disruption of the normal orderly and regulated cycle of cell replication and division
- Caused by genes that do not work properly, through damage or mutation
- Genes involved are those that control cell division, maturation and function
- When normal, these cells divide, mature, function and die in a normal function
- When the genes are mutated or damaged and therefore function abnormally, there can either be excessive cell division or the cells can fail to die on time
- They then accumulate, they can invade normal tissues, and a cancer results

Cystic Fibrosis

- Affects the exocrine glands, which secrete bodily fluids such as sweat, mucus and enzymes
- Glands produce abnormally concentrated secretions
- Caused by a malfunction in the CFTR protein, which plays an active role in transporting the chloride ion found in table salt, across the membrane
- In normal digestion the pancreas produces and releases enzymes needed for the breakdown of food so that the body’s cells can absorb the nutrients and vitamins for normal growth
- In the digestive processes of a CF sufferer, the thick secretions block flows of these enzymes resulting in malabsorption → proper nutrients cannot be absorbed
- Breathing is affected
- Salt loss is higher
Outcome 2 – LEFT-HAND SIDE

Distinguish between infectious and non-infectious disease

Infectious Diseases

- Those caused by a pathogen
- Often communicable, but not always e.g. malaria
- Modes of transmission:
  - Air
    - Air contains droplets of water with pathogens from exhaled breath, sneezing, or coughing of an infected person
    - Contains contaminated dust with fungal spores from clothing and bedding etc. e.g. causes athletes foot, tinia, ringworm
  - Water
    - When sewage contaminates domestic water supplies
    - Or when water is not adequately treated
  - Food
    - Careless handling of food
    - Cross-contamination
    - Poor storage
    - Lack of hygienic practices
    - Abattoir practices must be controlled
    - To maintain this, food establishments have legal requirements e.g. regular health inspections
    - Typhoid mary → people who carry diseases without being sufferers can transmit illnesses
  - Direct Contact
    - STI's e.g. AIDS, herpes etc
    - Glandular fever (kissing disease)
  - Indirect Contact
    - Contact with mutual surfaces rather than the person
    - Fungal diseases e.g. athletes foot, tinia
    - Sharing things e.g. drinks, cosmetics can transmit various infections
    - Contact with air
• Vectors
  o Transmit pathogens between individuals or from one organism to another or between different species **BUT IN ITSELF IS NOT THE PATHOGEN**
  o Female Anopheles mosquito is a vector for malaria
    ▪ Carries plasmodium pathogen → protozoan
  o Lyssa (Virus) → Dog (vector) → rabies in humans (disease)
  o Typhoid Mary was a vector for Typhoid

Non-infectious diseases
• Not caused by pathogens
• Not communicable
• Types:
  o Autoimmune e.g. MS
  o Genetic e.g. Tay Sachs, Down syndrome, Cystic Fibrosis
  o Mental Diseases e.g. schizophrenia
  o Nutritional Diseases e.g. Obesity (anorexia/bulimia is also mental)
  o Deficiency diseases e.g. Scurvy
  o Self-inflicted e.g. smoking, addictions, alcoholism
  o Environmentally caused e.g. radiation diseases or heavy metal poisoning (lead)
  o Degenerative diseases e.g. dementia (cell breakdown is more rapid than cell repair)
  o Metabolic malfunctioning e.g. cancer
• Some disease can be classed in multiple categories e.g. anorexia

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

Water
• Value of clean water has been known since ancient times e.g.
• Hebrews:
  o Carved out cisterns beneath their houses and collected water during winter to use during summer
  o Built a sophisticated drainage system to catch rainwater falling in the streets and transport it to a reservoir
• Chinese:
  o Over 3000 years ago they built roads and canals to move supplies over long distances
  o Later, canals were also built to control the flood-prone Yangtze and yellow river
Then they created irrigation channels

Wealthy people had their own wells

- Romans
  - Pioneers of public sanitation
  - By 312 BCE they had an 18km long sanitation system around 100m underground
  - Some houses were connected to these sewers, others emptied chamber pots into street sewers
  - Public water supply was the established
    - 94 aqueducts transporting water each day
    - Some houses had their own fountains, most relied on street pumps
  - This sewer and water supply greatly reduced incidence of infectious disease

- Today there are still people living in places where there are no provisions for clean water and sewerage e.g. slums, refugee camps, disaster areas
- Many pathogens are water borne
- Water flow allows for easy spread of pathogens, and easy collection of contaminants
- Because of its essential nature, regular exposure can endanger populations

**Personal Hygiene**

- Hebrews
  - Used Egyptian hygiene practices as a basis for their own
  - Pioneers of public health and personal hygiene
  - In the desert between Egypt and Israel certain laws put into place into order to maintain a level of hygiene amongst the people e.g.:
    - Proper disposal of body wastes to ensure basic sanitation
    - Full day of rest after 6 days work
    - Cleanliness of body
    - Protection against spread of contagious diseases e.g. isolation of lepers and disinfection of dwellings after illness
    - Disposal of excreta and refuse
    - Personal hygiene with regards to sex and childbirth
• Some people still spread pathogens, mostly unwittingly, but sometimes knowingly e.g.
  o Coughing
  o Sneezing
  o Spitting out phlegm
  o Not isolating when sick
  o Not washing hands

Food Hygiene
• Hebrews: Kashrut maintained avoidance of certain animals that carried diseases like parasites e.g. round work found in pork
• Food consumption is an easy and vulnerable mode of entry for pathogens
• Food provides nourishing environment for bacteria to live and grow
• Hygienic food practices must be maintained in order to control spread of disease e.g. salmonella spread through the mishandling of poultry

Identify the conditions under which an organism is described as a pathogen
• Pathogen: An organism or infectious agent which causes disease in another organism
• Conditions of classification of a pathogen:
  o Enters body/cells of another living organism
  o Obtains some life requirement from host e.g. food, shelter
  o Must damage cells/body of host in some way e.g. rupturing cells, releasing wastes/toxins
  o May cause nutritional deficiency to host
• May be microscopic or macroscopic
• Microscopic pathogen examples:
  o Prions – rogue protein particles, infectious
    ▪ E.g. BSE (bovine spongiform encephalitis), Scrapie, vCJD (Creutzfeldt Jacob Disease variant form)
  o Viruses – sub-cellular structure with nucleic acid (DNA/RNA) with protecting coat of protein
    ▪ E.g. influenza, HIV causing AIDS
  o Bacterium – prokaryotic, single-celled organisms causing disease
    ▪ E.g. salmonella → typhoid
Protozoans – unicellular animal-like structures causing disease
  - Plasmodium → malaria

Fungi – neither plant nor animal, in a group of their own → mycophyta
  - E.g. Tinia → athletes foot, Candidiasis fungus → thrush

- Macroscopic pathogen examples:
  - Lice
  - Leeches
  - Flatworms
  - Tapeworms
  - Tics

RIGHT-HAND SIDE

First-hand investigation to identify microbes in food or in water
Method
1. Sterilise workbench using methylated spirits
2. Collect 10 sterile petri dishes that contain nutrient agar, each covered by a lid
3. Seal one with tape and label this as the control

Air
4. Expose 2 plates in to separate areas of choice and keep them exposed for 15 minutes
5. Seal both plates with sticky tape, place upside down, and label each with the name of the air environment it was in and the date

Water
6. Pour selected water type into a beaker
7. Open sterile pipette from the handle end
8. Suck 0.5 mL of the water into the pipette
9. Lift lid of agar plate 45 degrees → Squeeze the water into the centre of a sterile agar plate
10. Place agar plate upside down
11. Seal the plate with tape and label it with water type and date
12. Tilt dish slightly in order to make sure water is properly spread along agar, avoid over-exposing the sides of the dish to the water
13. Repeat this with a different water type

Surfaces
14. Open sterile cotton swab at handle end
15. Pour a bit of distilled water onto it
16. Rub the swab along selected surface
17. Lift lid of agar plate 45 degrees and rub swab on agar in a wide ‘S’ motion
18. Seal with sticky tape, turn upside down and label with date and surface
19. Repeat on a different surface

Food
20. Set out heat mat with Bunsen burner
21. Sterilise inoculation loop in fire and turn off Bunsen burner and gas
22. Scrape loop along particular food
23. Open agar lid at 45 degrees and draw 4 lines with wire along agar
24. Close dish, rotate approx. 20 degrees, lift lid 45 degrees and draw another 4 lines along agar
25. Repeat step 23 another 2 times
26. Seal with sticky tape, turn upside down and label with food type and date
27. Repeat with another food type

Milk products
28. Get 3 sterile petri dishes containing milk nutrient agar
29. Seal one with sticky tape, turn it upside down and label it control with the date
30. Select 2 milk products to test, depending on whether they are liquid or food, use appropriate process to test the products on separate agar plates

All agar dishes
31. Incubate all agar dishes together for one week
32. Observe, record and tabulate results

Describe way in which drinking water can be treated and explain how these methods reduce the risk of infection from pathogens
Management: Sydney Catchment Authority → National Health and medical research council, Ku-Ring-Gai council, Department of National Parks and Wildlife, Environment Protection Authority, NSW Department of Agriculture and Fisheries, Private land-holders
  • Multi barrier protection approach
    1. No entry – prohibited area, fines apply, surveillance, animal traps
2. Restricted access areas – some activities are prohibited, no farming → only natural bush land

3. Wilderness area – falls in general catchment area, some restricted farms, for designated use only, prescribed by lawful restrictions e.g. erosion must be controlled, responsible for riparian improvement (i.e. river banks – maintenance), there is sampling of water in these areas

4. Water treatment barrier at water purification plants → these are controlled

5. Quality assurance testing

**Treatment:**

**Multiple processes in treatment:**

- **Removal of larger particles by filtration → Outlet filters of various sizes**
  - Inlet screens → fish, animals etc
  - Sand filters/gravel bed filters
  - Coal filters → particles adhere to coal
  - Synthetic filters → removing particles of different sizes
- Filters selected based on speed and cleanliness required
- **Coagulation:**
  - Chemical and physical technique applied to settle colloids, chemicals, particles etc
  - Usually throughout the addition of electrolyte → neutralizing the charged particles
  - These neutral particles combine to form larger particles and finally settle
- **Flocculation:**
  - Sedimenting out of coagulated materials
  - Use of high-molecular-weight material, to attract or trap the particles and settle them down together
  - Starch and multiple charge ions are often used
- **Sedimentation:** → improves turbidity
  - Allows the water to sit whilst the flocculate, coagulated and dense particles settle out of the water
  - Settling tank is big enough so that water can take a long around (ideally around 4 hours) to move through it in snake-like channels
Inlets and outlets are designed so the water moves slowly in the tank
Settled particles → sludge
Some sludge is returned to aeration tank
Biological sludge: Activated sludge is added to particles
Activated sludge contains microorganisms (aerobic and anaerobic) which digest organic particles
Sludge, is occasionally removed from tanks
This is used in pre-treatment and wastewater treatment
Water is then filtered

- Killing of bacteria through chlorine treatment, could use ozone or UV → removes odours, bacteria etc
- Fluoride is added to harden tooth enamel
- Addition of chlorine can produce bi-product of trihalomethanes → waste product that needs to be removed
- Chlorine can be added with ammonium → possibly more efficient or cost efficient
- Reticulation → chlorine sits in the system of pipes → added until the entrance into taps
- CO2 added if pH is too high, lime added if pH is too low
- Microorganisms treated: coliforms and Cryptosporidium and Giardia
- Chemicals removed: aluminium, magnesium, iron
- Physicality tested/treated/maintained: pH, true colour, turbidity

**Outcome 3 – LEFT-HAND SIDE**

Describe the contribution of Pasteur and Koch to our understanding of infectious diseases

- At the time people thought:
  - Fermentation and decay were caused by a chemical in the air
  - Believed in spontaneous generation for simpler organisms

**Pasteur’s experiment**
- Boiled mutton soup for at least half an hour in two goose-neck flasks
- Dust particles settle in convulsion of goose-neck → not reaching soup
Food decay was brought about by other microorganisms e.g. fungi, bacteria → NOT purely chemical processes (because both were exposed to chemicals in the air but only the one soup was exposed to dust particles and spores)

Demonstrated most infectious diseases are brought about by germs → 'germ theory of diseases'

Demonstrated that living microorganisms are present in the air → generally in the form spores (dust particles) → Established that they are responsible for food spoilage → disproved spontaneous generation

Rest of Pasteur's work

Pasteur demonstrated that fermentation was brought about by yeast microorganisms

Developed pasteurization:
- Sterilizing of milk, beer, wine etc
- Done by flash heating → taken to approx. 70 degrees and then rapidly cooled
- Kill microbes present

Pioneered technique of vaccination
- Developed vaccines for: anthrax, chicken cholera, swine fever

Pioneered vaccination for rabies on a man bitten by a dog

Demonstrated that many microbes do not need oxygen to survive → coined word anaerobic

Demonstrated that disease could be spread via microbes on the clothes of workers → transfer of disease

In essence → laid the foundations for modern microbiology

He did not ever identify which pathogens caused which diseases → Koch did this

Robert Koch

- Rival of Pasteur
- German - 1843-1910
- Also worked on Anthrax → saw how they actually did form spores
- Succeeded in isolating the bacterium that caused anthrax from the blood of dying animals
  - Examined the blood under a microscope and identified active rod-shaped cells and resting spores
  - Established that the blood of animals with the disease always contained these microorganisms, whilst the blood of healthy animals did not
- Established that injecting these spores into other animals → demonstrating that they then became infected → proved Pasteur's germ theory
- Studied TB and identified bacteria responsible
- Developed a test to indicate the presence of this disease
- Developed a range of microbial culture techniques e.g. nutrient soup, agar, potato, inside gel from cow's eyeballs (vitreous humor) etc
- Famous for Koch's Postulates → still used to identify source of diseases today

**Koch's Postulates (procedures)**
1. Specific microorganism must be present in every host with the disease, noting exact symptoms of disease → must be extracted and isolated from host
2. Must be grown in a pure culture
3. Potential host, when inoculated with the microorganisms, must develop the same symptoms as the original host → specific organisms must be able to be isolate from second host and identified as same species originally cultured

- Koch's postulates are difficult to use of viruses because they need a host cell → not a pure culture → need to be grown on some sort of nutrient

Distinguish between: prions, viruses, bacteria, protozoans, fungi, macro-parasites and name on example of a disease caused by each type of pathogen

**PRIONS**
- Produced by mutation of a gene coding for a normal cell protein
- **Structure:** Proteinaceous infectious particles (rogue proteins)
- **Size:** a single protein molecule
Mode of infection: Rogue protein → attaches to a normal protein and twists it out of shape and then those proteins do the same → rapidly debilitating brain and rest of body

Transmission: by transplants from an unwittingly infected person into another person or (speculated) eating affected meat

Disease type: a group of degenerative nervous diseases in mammal

Disease Example: Variant Creutzfeld Jaakov Disease (mad cow disease in humans) → symptoms: rapid dementia, memory loss, seizures, coordination dysfunction
  o In 80% of cases it is fatal within 12 months of being diagnosed

Kuru → Papua New Guinea → only women and children found to contract it, probably due to cannibalism even though men also took place in rituals

Bovine Spongiform encephalitis (cattle) and Scrapie (in sheep)

Treatment: Search for viable treatment still continuing

VIRUSES

Structure: DNA/RNA within protein capsule/covering
  o With DNA as nuclear material → metabolism moves forwards in natural protein formation
  o Retro viruses → RNA nuclear material → metabolism moves backwards i.e. RNA makes DNA instead of DNA making RNA → after DNA is created they moves forwards again

Size: Only seen under electron microscope → many times smaller than bacteria

Mode of infection: invades cell → abandons capsule and makes cell its coating (concealed from immune system) → Reproduces within cells → Cell ruptures releasing viruses → Process repeats
  o Some replicate within bacteria → bacteriophages

Transmission: Easily transmitted by contact or droplets because if its crystalline stage

Disease types: measles, influenza, and STDs

Treatment: Viruses not affected by antibiotics → because they have no metabolism
  o Must be controlled by preventative measures e.g. vaccination
  o Use anti-viral drugs → inhibit cell division (stop division)
Culturing not pure b/c needs living host cell in order to survive → Can be cultured in human embryonic lung fibroblasts or monkey embryonic kidney

PROTZOANS
• **Size and Structure:** Single celled parasites
• **Mode of infection:** Invade and multiply inside human red blood cells
• **Transmission:** Usually through a vector e.g. anopheles mosquito
• **Treatment:** Some are able to be treated but some have become resistant to these drugs
  o Also controlled through use of pesticide in breeding grounds
• **Disease example:** malaria → anaemia and regular bouts of fever → plasmodium → anopheles gambia
• Giardia → Giardiasis → resistant cyst stage surviving in food or water → once ingested produce 2 by mobile forms reproducing by binary fission → millions form in small intestine → diarrhea and dehydration

BACTERIA
• **Structure:** Prokaryotic single cell → chromosomes not contained within nuclear membrane
• **Size:** Microscopic
• **Classification:** according to shape:
  o Rod shaped → bacilli
  o Spiral → spirochaetes
  o Spherical → Cocci
• Can be identified by characteristics such as the way they stain → gram stain identifies as either gram positive or gram negative
• **Mode of infection:** Reproduces rapidly by Binary fission within host or producing toxins poisonous to host
• Some are good → assist digestion in intestines
• **Disease example:** tetanus → Clostridium tetani → bacilli bacteria entering body through wounds
• E.g. tuberculosis → mycobacterium tuberculosis → oxygen uptake becomes less efficient, ingested through the air, characterized by cell wall high in lipids
• **Treatment:** Antibiotics
MACRO-PARASITES

- **Structure:** Flat worms and rounds worms
- **Examples:** Flat worms → Echinococcus granulosus → hydatid tape worm → major surgery needed to remove → dogs are major carrier and then pass on to other animals by contact or through faecal contamination
- **Round worms** → 1/3 people affected by it
- **Diagnosis:** Easily diagnosed → samples of blood, urine or saliva taken → pathogen can be identified and affect can be noted

Fungi

- **Structure:** Rigid cell walls like plants
  - Non-motile and have no chlorophyll
  - Most made up of long tissues called hyphae and fruiting bodies which contain microscopic spores
- **Classification:** Saprophytes (living on dead matter) or parasites (living on live tissue)
- **Reproduction:** Fungi reproduce via spores
- **Transmission:** Spread via contact with spores
- **Disease examples:** Tinea → cased by trichophyton → symptoms can be odourous, blistering
- **Thrush** → candida albicans
- Many are beneficial in production of food and medicines e.g. mushrooms or penicillin
- **Treatment:** Penicillium → fungus which, Flemming found, inhabits bacterial growth and is there for used in the antibiotic penicillin

Identify the role of antibiotics in the management of infectious diseases

- **Antibiotic:** organic chemo-therapeutic substances that are antagonistic to the growth of others, produced by fungi and some other organisms to defend themselves against bacteria or sometimes other fungi
  - → extracted and purified and then processed for medicinal use

History

- 1928: Alexander Flemming first discovered penicillin
- During WW2: first commercial of penicillin by Australian Howard Florey and UK college Ernest Chain
Antibiotics

- Always have **selective toxicity** → harmful to the pathogen but not the host
- Spectrum of activity:
  - **Broad spectrum**: attack a wide range of bacterial pathogens
  - Administered if a patient is very ill and particular bacteria cannot be identified
  - Disadvantage: if released into environment, it becomes a selection factor amongst a large range of bacteria leading to resistance by multiple strains of bacteria over time rather than specific types
  - **Narrow spectrum**: target a specific or restricted range of bacterial pathogens
- **Bactericidal Antibiotics**:
  - Kill bacteria → Generally by destroying cell wall
- **Bacteriostatic Antibiotics**:
  - Inhibits reproductive process of bacteria
  - Could disrupt membrane function
  - Could inhibit protein synthesis → cannot grow and cannot produce enzymes with which to control its metabolism
  - Cannot be used on viruses → no metabolism with which to disrupt
- **Penicillin** brings about a rupture in the cell wall
- **Streptomycin**: one of the last broad spectrum defenses we had and now it is virtually useless
- **Vancomycin**: only antibiotic that is somewhat effective against golden staph
- **Tetracycline**: common antibiotic, not used on small children though because it can turn teeth black
- Some modern antibiotics are artificially synthesized
- Antibiotics can cause problems by killing all bacteria, good and bad, leading to candidiasis

**Role in society**:
- Fewer people suffer and die from bacterial infections
- Speedy recovery allows less work time to be lost → assisting the economy
- Creates a smaller natural reservoir of the pathogen → less people carrying it
RIGHT-HAND SIDE

Model Pasteur’s experiment to identify the role of microbes in decay

1. Pour 400mL of soup into 2 round-bottom conical flasks
2. Place a rubber bung, with glass entrance into the top of each flask
3. Place both flasks on top of a Bunsen burner for half an hour
4. Set up 2 retort stands with clamps and boss heads, both at around the same height
5. To one conical flask glass tubing, attach a length of rubber tubing
6. Thread this rubber tubing through the two boss heads so it falls into a snake like formation
7. Leave the other conical flask as is
8. Leave them both to rest for a few weeks and observe bacterial built up in each over the time

Historical development of our understanding of the cause and prevention of malaria

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approx. 120 CE</td>
<td>Romans believed swamps bred ‘certain animacula which cannot be seen’, we breath them and they cause malaria Prevention: many swamps were drained → malaria incidents declined Association between mosquitos and malaria was recognised → often mosquito-ridden areas had prohibited visitation by humans</td>
</tr>
<tr>
<td>Approx. 162 CE</td>
<td>Ancient Greeks: Cause: recognized fevers were associated with summer Treatment: suggested that vomiting accompanying malaria → body's attempt to expel poisons and bleeding → rid body of ‘corrupt humours’ victims were subject to purgation and blood-letting → killing survivors in a short time</td>
</tr>
<tr>
<td>1696</td>
<td>Morton presented first detailed description of clinical picture of malaria and its treatment with Cinchona</td>
</tr>
<tr>
<td>1716-1717</td>
<td>Italian physician, Giovanni Maria Lancisi identified malaria as being due to bugs or worms → then by mosquitos</td>
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<tr>
<td>Early 1800's</td>
<td>Antimalarial properties of the bark of the Cinchona</td>
</tr>
<tr>
<td>Time</td>
<td>Event</td>
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<tr>
<td>1820</td>
<td>Pelletier and Caventou isolated pale yellow gum from bark that could not be induced to crystallize → highly effective against malaria, identical properties to ‘China base’ → named as ‘quinine’</td>
</tr>
<tr>
<td>1844</td>
<td>Sporadic resistance to quinine reported</td>
</tr>
<tr>
<td>1880</td>
<td>Malaria parasite was first seen in the blood by French scientist – Charles Laveran → awarded Nobel Prize for this in 1907</td>
</tr>
<tr>
<td>1882</td>
<td>American, Albert Freeman Africanus King, noted the mosquito as being the vector for the parasite</td>
</tr>
<tr>
<td>1884</td>
<td>Marchiafava and Celli called these same forms of parasite ‘Plasmodium’</td>
</tr>
<tr>
<td>1885</td>
<td>Camillo Golgi, Italian neurophysiologist → first to note they were caused by two distinct parasites</td>
</tr>
<tr>
<td>Late 1800's</td>
<td>British physician, Ronald Ross, extensive studies in the transmission of malaria, intentionally transferring it between victims and healthy people via mosquito bite and later found malaria parasite in red blood cells</td>
</tr>
<tr>
<td>1898</td>
<td>Ross was able to describe the complete life cycle of the malaria parasite → awarded with Nobel Prize 1907</td>
</tr>
<tr>
<td>1910</td>
<td>Sporadic resistance to quinine reported</td>
</tr>
<tr>
<td>1934</td>
<td>Hans Andersag synthesized Rosechin (chloroquine) and sontoquine → compounds belonged to a new class of antimalarias known as 4 amino quinolines</td>
</tr>
<tr>
<td>1930s-40's</td>
<td>Water supplies regulated and controlled to prevent mosquito attraction to stop spread of Malaria, mosquito breeding areas were destroyed by use of DDT as well → Brazil and Egypt became clear of malaria because of this</td>
</tr>
<tr>
<td>1943</td>
<td>Hamilton Fairly, in Australia, found prophylactic agent useful in protecting troops in malarious areas → no longer used due to undesirable side effects</td>
</tr>
<tr>
<td>1944</td>
<td>British investigators at ICI → curd, Davey and Rose synthesized antifolate drugs progunail/Paludrine</td>
</tr>
<tr>
<td>1950</td>
<td>Elderfield discovered Primaquine</td>
</tr>
<tr>
<td>1953</td>
<td>Resistance to progunail emerged in Tanzania → previously in Malaya (1947)</td>
</tr>
</tbody>
</table>
| 1971  | Chinese scientists found an ethyl ether extract of Qing-Hao to be as effective as chloroquine and }
<table>
<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td></td>
<td>quinine at clearing malaria parasite</td>
</tr>
<tr>
<td>1998</td>
<td>Malarone, drug combination of proguanil and atovaquone, became available → effective antimalarial treatment</td>
</tr>
<tr>
<td>1990-2000's</td>
<td>Malarial vaccination research progressing</td>
</tr>
<tr>
<td>2000's</td>
<td>Artemisinin → chinese herbal extract used to treat malaria → overuse has led to a level resistance</td>
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</tbody>
</table>

Describe one named infectious disease in terms of its: cause, transmission, host response, major symptoms, treatment, prevention and control

**Cause and transmission**
- Malaria is caused by the parasites called Plasmodia. There are five identified species of this parasite causing human malaria
- Transmitted by the female anopheles mosquito
- Human is also a vector because it gives the plasmodium back to the mosquito
  - Although the mosquito is not made ill, it still takes nutrition and shelter from the mosquito → still a pathogen in the mosquito

**Life cycle of Plasmodium**

![Life cycle of Plasmodium](image-url)
Female anopheles expels saliva as an anticoagulant $\rightarrow$ Sporozoite in saliva infects human's blood

From blood plasmodium travels to liver cells $\rightarrow$ (gains protein and divide into merozoites)

Merozoites $\rightarrow$ produced by asexual reproduction by sporozoites

Each merozoite invades a red blood cell and multiplies asexually until the red blood cell bursts and releases many more merozoites $\rightarrow$ repeated

Some merozoites develop into male and female Gametocytes $\rightarrow$ one merozoite enters a red blood cell and remains there (not multiplying) $\rightarrow$ dormant in the human

If mosquito feeds on gametocytes they are transferred into the mosquito gut $\rightarrow$ the males and female gametes fertilise each other to form zygotes (sexual reproduction)

Zygote burrows outwards and forms a cyst on the outside of the mosquitoes stomach

Sporozoites develop asexually inside the cyst which then ruptures releasing sporozoites into blood which then takes them to the mosquitoes salivary glands

Restarting the cycle

**Symptoms and host response**

- Fever and Chills
  - Usually every 8 hours as the plasmodium completes a cycle through the body
- Body ache, back ache and joint pains
  - Fairly common in malaria
  - Can occur during the prodromal period and at that stage these are generally ignored and diagnosis of malaria is impossible owing to lack of peripheral parasitemia. They are also
  - Common accompaniments of the malaria paroxysm
  - Malaria may present only with these symptoms, particularly in cases of recurrent malaria.
- Altered behaviour, acute psychosis
  - Patients may present with altered behaviour, mood changes, hallucinosis or even acute psychosis, with or without fever.
  - Malaria may be detected accidentally in such cases and they improve completely with anti malarial therapy.
- Altered behaviour may also be due to high grade fever or drugs.

- Convulsions, coma
  - Patients with cerebral malaria present with generalised seizures and deep unarousable coma.
  - Sometimes one single fit can precipitate deep, unarousable coma.

- Cough

- Weakness
  - Sometimes patients may present with history of weakness, malaise and prostration.
  - May have significant pallor, hypotension, dehydration etc. Algid malaria may present like this and the patient may not have fever at all.

- Vomiting and diarrhoea
  - Malaria can present as a case of acute gastroenteritis with profuse vomiting and watery diarrhoea (Choleraic form).
  - Vomiting is very common in malaria and is due to high-grade fever, the disease itself or even drugs.
  - May pose problems in administering antimalarial treatment.

- Jaundice due to kidney failure

- Treatment
  - Malaria can be cured entirely if treated in the first 48 hours
  - Treatment is often unsuccessful because it remains untreated until disease is far advanced
  - Treatment drugs → quinine
  - Subsequent to that → Mefloquine, malarone and artemisine → best used in conjunction with each other or resistance builds up as shown presently
  - Not much treatment because → mostly needed in poorer countries so expensive treatment would be virtually useless → given the costly nature of developing treatment and vaccines it has proven very difficult to manage
- **Prevention**
  - Use of repellent such as DEET in endemic areas
  - Chemoprophylaxis, primary/terminal prophylaxis → Anti-malarial drugs administered before entering endemic areas
  - Prevention is usually only applicable to short term ventures into endemic areas → Most effective when consistent and regimented
  - Development of vaccines → still in progress
- **Control**
  - Use of insecticides on vector populations → overuse is avoided so to not build up resistance
  - Swamp draining
  - Genetic engineering of mosquitoes → made to resist the parasite
  - Use of protective clothing in endemic areas
  - Destruction of vector breeding grounds
  - Maintenance of water standards to avoid accidental contamination by malaria
  - Control is usually used in permanent residencies → most effective through concerted efforts of community and government

**Problems relating to antibiotic resistance**
- Not finishing course of antibiotics leads to resistance building up on antibiotics
  - Those few left untreated are left with higher resistance to that particular antibiotic and they will reproduce creating a bacterial strain in need of a much stronger antibiotic to attack it
- As resistance increases within a strain it may, like the golden staph, become entirely resistant
  - Leaves human totally vulnerable to the bacteria
  - Allowing it free reign to cause diseases and endemics
- Bacteria do not only reproduce asexually, they can also exchange genetic material → conjunction between bacterial strains
  - This allows for greater spread of antibiotic resistance from a resistant strain to an entirely vulnerable strain
- Thousands of antibiotics are tested every year, but on average, only 3 are discovered to be successful every 10 years
- Science is not able to keep up with the rate of resistance building up in bacterial strains
- Through this process of resistance humans could become vulnerable to resistant pathogens present in everyday life → human healthcare would be backtracked 90-100 years
- More money needs to be invested into the production of vaccines to prevent infection by these highly resistant pathogens

**Outcome 4 – LEFT-HAND SIDE**

Identify defence barriers to prevent entry of pathogens in humans: skin, mucous membranes, cilia, chemical barriers, other body secretions

- First line of defence is made of non-specific physical and chemical barriers protecting body at possible points of entry

**Physical barriers**

- **Skin**
  - Continuous all over body and multi-layered (epidermis and dermis)
  - Water proof outer layer
  - Dead outer layer (epidermis) → pathogens cannot damage something that is already dead
  - Sebaceous oil glands, preventing skin from cracking and breaking, keeping skin supple and healthy
  - Skin bacteria lives off this oil → Those bacteria then produce acid (keeping pH down) → other pathogens cannot live in the acidic environment

- **Mucous membranes**
  - Lines urogenital tract, respiratory tract and digestive system tracts with slimy mucous
  - Allows the exchange of substances when needed and protects against invasion
  - Have gland cells which produce mucus
  - Mucus produce Ig A’s → type of immunoglobulin/antibody
    - Reacts with potential pathogens, preventing them from invading the surface
• Cilia
  - Fine hairs which project out from respiratory surface/lining of nose, trachea and bronchi
  - Hairs trap particles like a filters
  - They beat in synchrony/waves, moving mucus along (like crowd surfing), backwards from nose, upwards from the lungs
    - Particles trapped in mucous are transported either to nose or pharynx where they are either coughed out or swallowed → coming into stomach where acid will kill it

Chemical barriers
• Tears
  - Contain an enzyme which can break down bacterial cell walls
  - Contains bacteriostatic substances
• Ear Wax
  - Contain bacteriostatic substances
• Hydrochloric acid in stomach
  - Kill pathogens
• Saliva
  - Mildly antiseptic
• Urine acid
  - Flushes out ureter
• Vagina contains harmless microorganisms
  - Create acidic environment
  - Leads to competitive inhibition of other bacteria and fungi

Identify antigens as molecules that trigger the immune response
• Antigen: A foreign molecule which is able to trigger the immune response, or the 3rd line of defense → including the production of antibodies
  - Usually a carbohydrate or a protein molecule with a distinct 3 dimensional shape corresponding to a T and B lymphocyte
  - Can be a chemical e.g. venom in snake bite
  - Particular pathogen may have 2 or more antigens on it’s surface and so it would activate 2 or more sets of T and B lymphocytes
In very rare cases different pathogens may have similar antigens e.g. cowpox and smallpox → cowpox was used as a vaccination for smallpox → immunity to one will automatically confer to immunity to another.

**Explain why organ transplants should trigger an immune response**
- All cells in the body have surface proteins called markers to identify these cells and ‘self’ → MHC class 1 markers
- Class 1 markers distinguish self cells from all others because those without self markers are regarded as being ‘non-self’ or being ‘foreign’
- When ‘foreign’ markers are found in a body they are an antigen therefore triggering an immune response
- Everyone has different class 1 markers → organ transplants, with different or foreign markers, the organ acts as an antigen triggering the immune response

**Identify defence adaptations, including: inflammatory response, phagocytosis, lymph system, and cell death to seal off pathogen**
5 mechanisms of the second line of defence
- **Phagocytosis**
  - Non-specific response by phagocyte cells
  - Engulf and destroy the microorganism
  - 2 types of cells:
    - Neutrophils:
      - First phagocytes
      - Immediate response
      - Self-destruct after a few days
    - Macrophages:
      - Heavy duty phagocytes
      - Employed when chronic infection is present
      - Can engulf the used neutrophils
      - They can survive and then form pus with the other remaining matter at the site of a wound
      - Work by changing their shape, surrounding and engulf pathogen → Taking it into a vacuole called a phagosome
      - Phagosome fuses with a lysosome containing a digestive enzyme
      - This enzyme breaks down microbe within phagosome
Phagocytosis allows short term infections to be controlled because it takes some time for the antibody production of the 3rd line of defense.

Stages:
- 1. Detection
- 2. Ingestion
- 3. Formation of phagosome
- 4. Fusion with lysosome
- 5. Digestion
- 6. Discharge (of puss) if necessary

**Inflammation**
- Local response to injury \(\rightarrow\) characterised by redness, swelling and heat
- Cut, graze, burn or damaged tissue releases chemical signals \(\rightarrow\) histamine
- Histamine signals cause blood vessels in an area to dilate and the walls become more permeable \(\rightarrow\) allows plasma and white blood cells (phagocytes) to seep out
- This causes swelling and allows phagocytosis to begin immediately
- Redness is due to increased blood flow and heat due to increased activity
- Tissue repair then takes place from nutrient brought by increased blood flow
- Benefit of swelling is that it traps any pathogens or microbes present

**Fever**
- Elevated body temperature
- Triggered by a macrophage \(\rightarrow\) It ingests and destroys the pathogen and then releases a chemical called interleukin-1 (a chemical messenger)
- Interleukin goes into the blood stream into the hypothalamus
- Hypothalamus is the thermoregulatory centre of the body
- Here is resets the thermostat higher \(\rightarrow\) for a short while the norm is elevated
- Increased temperature inactivates pathogen enzymes and/or toxins, it increases rate of metabolism \(\rightarrow\) increases rate of repair, increases blood flow \(\rightarrow\) promoting delivery of white blood cells (phagocytes), promotes increased T-cell production
• **Lymphatic system**
  - Lymph capillaries and lymph vessels drain tissue fluid back to the circulatory system
  - Once inside the lymph vessels, tissue fluid is called lymph
  - Lymph is passed through lymphnodes/glands on the way → these filter pathogens
  - In lymphnodes, phagocytes are present which will engulf the pathogens
  - Lymphnodes are also important because they produce lymphocytes (mature into antibodies) and monocytes (mature into macrophages)

• **Sealing off of the pathogen (isolation)**
  - Literally seals off pathogen
  - In an area where there is infected tissue:
    - Macrophages will surround infected tissue (only in diseased or infected tissue rather than a normal pathogen in the blood)
    - A layer of lymphocytes are pulled in around macrophage
    - Other cells come in to produce a tough outer, fibrous barrier around outside of lymphocyte layer – fibroblasts
  - Cells inside this formation die
  - The structure that is formed is called a granuloma, common in TB and leprosy patients
  - This granuloma can be identified in x-rays allowing diagnosis of diseases like TB and leprosy
  - Another example: may also form around tiny cysts of worm parasites in muscular tissue
Outcome 4 - RIGHT-HAND SIDE

How a named disease results from an imbalance of microflora in humans

- **Candidiasis fungus** (thrush) → caused by the *Candida albicans* (microorganism)
- Normally inhabits mucus membrane of mouth, urine-genital tract, and intestine
- Normal bacteria keep them under control by competitive inhibition
- Each produce certain toxins to keep the other under control
- Comprises of the normal gut flora, aids digestion
- Helps to detect and destroy other pathogenic bacteria that may enter the body
- Assists in decomposing of a dead body

**Causes of the imbalance**

- Use of external detergents and douches in the vagina, which reduce the amount of microflora as well as bacteria
- When antibiotics kill off ‘good’ bacteria responsible for maintaining the healthy levels of microflora in the body
- Lowering of the healthy function of the immune system by factors such as, HIV/AIDS, stress, cancer treatments → lowering the bodies ability to control the amount of candida in the body
- Certain immune-suppressant drugs e.g. topical cortisone, oral contraceptive pill, pregnancy, diets high in sugars, yeasts or fermented foods, steroid hormones

**Transmission**

- Can be spread from one human to another by direct contact. The yeasts can spread via sexual intercourse, as well as saliva exchange

**Treatment**

- Simple mouth washes can sometimes kill off oral thrush
- Sometimes antibiotics are needed to control
- Most commonly treated using anti-mycotics → antifungal drugs
- Although these anti-mycotics are effective there is growing resistance towards them

**Prevention:** Whenever taking antibiotics one should take probiotic bacteria

**Symptoms include:**

- Itching
- Burning
- Mucuous discharge of infected area
- Irritability
Outcome 5 – LEFT-HAND SIDE

MacFarlane Burnet → 1899-1985
- Won a Nobel Prize for his work on the ‘Clonal selection theory’
- Theory explains how the body distinguishes self-cells from non-self cells AND how the body responds to non-self antigens
- Theory suggests:
  - Ability to recognize self-substances cannot be inherited but gradually developed in the course of foetal development
  - Because of constant contact with cells in the body at an early age, the developing immunity-producing tissue learns to recognize and remember its own pattern
    - Any T and B cells which do not ignore self marked cells in childhood development are screened out and destroyed immediately
  - The antigen in the body will select the right type of B and T lymphocytes → which will then clone themselves thousands of times
  - Therefore antigen selects the agent of its own destruction

Identify the components of the immune response: antibodies, T cells and B cells

Diagram of the immune system components: blood cells, white blood cells (WBC), red blood cells (RBC), platelets, lymphocytes, monocytes, neutrophils, basophils, eosinophils.

Cell function of blood
- Agranular Types (made in bone marrow and lymph tissue)
  - Spherical nucleous
- Granular Type (they have granules; they are made in the bone marrow, their nucleus is lobed)
- Neutrophil (day to day, normal phagocyte)
- Basophil
- Eosinophil

Identify the components of the immune response: antibodies, T cells and B cells
BACKGROUND

Immune response components

- **T lymphocyte cells**
  - Produced in bone marrow and mature (gain class 2 markers) in the Thymus gland (only found up to toddler age) located near the heart in the mid line
    - All T cells ever needed in human life will develop and mature in childhood
  - **T CELLS CANNOT BE RE-USED AND RECYCLED →** only memory cells used to combat a re-infection
  - 2 Types of T lymphocyte cells: Cytotoxic and Helper
    - **Cytotoxic**: controls the cell-mediated response
      - Produces proteins, retained within the cell, which react directly with cells bearing antigen markers
      - I.e. kills target cells on contact which attracts macrophages
    - **Helpers**: activate/stimulate other corresponding lymphocytes (B&T)
      - Release interleukin chemicals → assisting B cells make antibodies
      - Assist formation of active T cytotoxic cells
      - Trigger inflammation and macrophage phagocytosis
  - Both remain inactive in the blood and lymph until they come into contact with an antigen
  - Helper T cells and Cytotoxic T cells can be activated by binding to an antigen, or by a presenter macrophage, presenting an
  - Cytotoxic T cells clone into multiple forms:
    - **Cytotoxic/killer cells**
    - **Hypersensitivity cells**: set level of immune response → can cause hypersensitivities like asthma and hay fever
    - **Amplifier cells**: Stimulates and promotes other T and B cells
    - **Suppressor cells**: Turns off immune response after infection is controlled
    - **Interferons**: protect cells around an infected cell from viral invasion
• **B lymphocyte cells**
  - Are produced and mature in the bone marrow
  - Activated by T-helper cells, antigens or presenting macrophages
  - Control humoral (blood) response (primarily against toxins and pathogens) →
    - Occurs in the lymph nodes
    - B cells in the blood and lymph are activated by the presence of antigens
    - Activated B cells then clone themselves forming either active plasma or memory cells
    - Each plasma cell then manufactures its specific antibody which circulates in blood/tissue fluid
    - Antibodies bind to their specific antigen

• **Antibodies:**
  - Immunoglobulin protein molecules produced in response to only one antigen → because they have a particular shape, specific to an antigen
  - B lymphocytes → exposed to antigen → Lymphocytes reproduce and mature into plasma cells → produces antibodies
  - Will only combine and inactivate an antigen with a corresponding shape
  - Circulate in blood and tissue fluid
  - 4 mechanisms of inactivating antigens:
    - **Neutralisation**
      - Antibodies bind to viral binding sites of pathogen and coat the bacterial toxins → enhancing phagocytosis by disallowing pathogen to infect cells
    - **Sticking together particulate antigens**
      - Solid antigens such as bacteria are stuck together in clumps → enhancing phagocytosis, by allowing macrophage to engulf multiple pathogens as well as disallowing pathogens to spread
    - **Precipitation of soluble antigens**
      - Soluble antigens, like snake venom, are stuck together to form precipitates → enhancing phagocytosis by disallowing spread of pathogens
    - **Activation of complement**
      - Antibody tags foreign cells for destruction by phagocytosis and complement protein → enhances
phagocytosis, inflammation and leads to rupture of cell (bacterial cell lysis)

- **Cytokines**
  - Proteins secreted by T cells and macrophages
  - Signal other cells to initiate the immune response e.g. for a B cell to transform into a plasma cell
  - Regulates T and B cells in recognizing antigen fragments on the outer membrane of a macrophage
  - Cytokines and Interleukin-1 allow the interaction between B and T lymphocytes

Describe and explain the immune response in the human body → Noting interactions in black
Outline the way in which vaccinations prevent infection

- **Vaccine**: preparation containing a killed or attenuated but live pathogen or toxoid → administered to artificially induce the immune response to provide immunity for that particular pathogen/antigen
- Aim to trigger an immune response to antigen without presenting symptoms
- Some provide life-long immunity e.g. measles vaccine
- Some provide shorter spurts of immunity e.g. tetanus lasts for 10 years
  - In this case, booster injections are given at various intervals to maintain immunity
- A person has resistance to a disease because they have evoked the immune response via previous exposure
- **Primary immune response**: the first immediate production of antibodies/ immune response
- **Secondary immune response**: a more complex one which occurs on second exposure to the antigen → quicker and more intense than the primary because the memory cells are already present
- Following secondary response, the decline in antibodies is much slower
Natural Immunity

- **Passive**: Transmission of antibodies from mother to baby through the mother's breast milk
  - Babies come from a sterile environment in the womb so need the added antibodies as their immune systems are not prepared to tackle the antigens in their surroundings

- **Active**: gained after one contracts the disease

Artificial Immunity

- **Passive**: injecting ready prepared antibodies e.g. immunization serum against snake bites → serum of antibodies produced by a horse or rabbit against the snake bite
  - Only very short term

- **Active**: injecting ready prepared antigens or pathogens (either attenuated or inactivated) causing an immune response but not causing any symptoms in the host

Outline the reasons for the suppression of the immune response in organ transplant patients

- Introduced organs contain antigens that are recognized as foreign to the recipient → because everyone has different self-markers
- This will trigger an immune response and stimulates the production of antibodies that attack and possibly destroy the new tissue
- For this reason rejection of tissues has posed a major problem
- Tissue typing and stem cell therapies have been used to try and combat this
- Suppression of immune response is necessary to prevent rejection
- Blood drains from transplanted organs into the recipients circulation, the body then recognizes these foreign tissue cells and produces antibodies in response
- Cytotoxic T cells, macrophages and B cells, can all be involved and cause serious reaction that destroy the tissue
- Rejection is reduced by: matching transplanted tissue proteins as closely as possible to that of the patient, and by giving antilymphocyte globulin drugs which suppress the immune response
- There are many risks in this though so the use of suppressive drugs must be bane against the risk of life-threatening infection
Outcome 5 – RIGHT HAND SIDE

Evaluate the effectiveness of vaccination programs in preventing the spread and occurrence of once common disease, including smallpox, diphtheria and polio

Smallpox

- 2 forms → Variola major (life-threatening) and Variola minor (rarely causes death)
- Symptoms include: delirium, diarrhea, excessive bleeding, raised pink rash, body aches, malaise, fever, vomiting
- First smallpox endemic in 1500s
- Moved to north and south American and the West Indies by the Spanish explorers, troops, missionaries, colonists etc
- Aboriginals and Mauris ravaged by smallpox upon arrival of James Cook (1789)
- Mid-1600's killed entire towns and canals were choked with caucuses – north america
- Late 16th century, Europeans went to Siberia and took smallpox with them
- Edward Jenner, English physician, noticed that milkmaids who developed cowpox (far less harmful), didn’t develop smallpox
- 1796 → Jenner took fluid from a cowpox pustule on a dairymaid’s hand and inoculated an 8-year-old boy → when he exposed the boy, 6 weeks later, to smallpox, he didn’t develop any of the symptoms
- First criticized, but then rapidly accepted and adopted
- 19th century → vaccinations were more common, but informal
- 1967 → the WHO initiated their campaign for absolute eradication and immunisation:
  - Global immunization
  - Global monitoring
  - Immediate quarantine of any sufferers
- As vaccination increased, herd immunity was established → natural reservoirs are removed
- Goal was accomplished in 10 years due to massive vaccination efforts
- Last endemic of smallpox occurred in Somalia in 1977 → eradication succeeded that in this year
- 1980 → World Health Assembly declared the world free of smallpox
• Still have stock of virus in research labs

**Diphtheria**

• 1735 → first diphtheria epidemic in New England
  - Said to have killed 80% of children under the age of 10
  - 40% of those infected, died

• 1923 → Gaston Ramon, French veterinarian, and Alexander Thomas Glenny, English physician, developed diphtheria toxoid by treating diphtheria toxin with heat and a solution of formaldehyde called formalin → inactivated the toxin molecule so that it could no longer attach to cells and cause toxicity
  - Once injected into humans, it was able to induce antibodies that blocked natural toxin from attaching to cells

• 1925-1935 → 7000 kids died of diphtheria in Australia
• 1974 → WHO advocates the use of the DTP vaccination → worldwide immunization → at this time only 5% of kids were immunized
• Today over 80% of kids are immunised
• 1975 – 1985 → fewer than 50 kids died of diphtheria is Australia
• 1980 → 100 000 cases reported globally
• 2003 → less than 10 000 cases reported globally

**Polio**

• Poliomyelitis → caused by a polio virus
• Affects the digestive system, and in some cases, the nervous system
• Can be contracted from food, water or hands that have been contaminated by the faeces of an infected person

• 1894 → The first major polio outbreak in the USA, Vermont → 18 deaths and 132 cases of permanent paralysis were reported

• 1941 → Albert Sabin and Robert Ward, proved that the virus entered the body through the mouth, passed into the digestive system, and was then distributed by the blood to the nervous system
  - Lead to development of vaccine that would produce antibodies to fight the virus in the bloodstream before it reached the nervous system

• 1988 → WHO passed a resolution to eradicate polio by 2000 → only cases found in Nigeria and India

• 2003 → Rumour that these vaccines were a plot of the USA to make children infertile and reduce HIV as apart of the USA drive against Islam
During the 9 month suspension of the vaccine, the disease moved to 10 other African nations

- **2004** → Nigerian state of Kano resumed polio vaccinations
- With the Islamic pilgrimage to Mecca, the virus was taken to Mecca from Nigeria
- **2005-2007** → around 12 countries infected
- Australia was clear of polio from 1986 until a student traveller arrived in Australia, infected with the disease in 2007
- **2012** → Rates still relatively high in poorer countries

**Whooping cough**
- Peak in England 1980’s due to rumour saying that the vaccination caused children to get autism
- Vaccination rates lowered to around 30%

**Evaluation**
- The purposes vaccinations seek to fulfill are to: **reduce the incidence and human suffering from disease**, along with **reducing the natural human reservoir available for pathogens**
- They do this effectively, with benefits outweighing negatives such as side-effects

**Outcome 6 – LEFT HAND SIDE**

Identify and describe the main features of epidemiology using lung cancer as an example
- Study of patterns in the incidence of diseases
- Includes factors which determine: frequency and distribution of said diseases
- **Purpose** →
  - To discover any trend which could establish a link of cause and effect
  - To develop programs to prevent and control the incidence and spread of the disease
- **Value** →
  - Can used by clinical research organisations or government health departments to determine the most effective use of public funds
  - Allows the planning of effective preventative programs
  - Use them to evaluate existing health programs → modify or continue
  - Identify individuals at high risk of the disease
  - Invest in improving the health of a population
• **Looks at 3 main questions:**
  - Who gets ill?
  - Why do they get ill?
  - How should they be treated?

**3 types of epidemiological studies**

• **Descriptive epidemiological study**
  - Describes the incidence of the disease and any factors that could have caused or influenced it
  - Essentially retrospective in time → going back in time to ascertain where the disease occurred, and the lives of the people it affected

• **Analytical epidemiological study**
  - Formulates a hypothesis as to what caused the disease, relating to the data at hand
  - Works prospectively to support or reject the data found

• **Intervention epidemiological study**
  - Measures the effectiveness of some sort of intervention program e.g. education programs, vaccination programs, treatment/drug trials etc

• **Two main aspects of diseases are recorded:**
  - Morbidity: the number of people who are made ill by the disease → has to be carefully defined because it is dependent on how the measurements are made
  - Mortality: The number of deaths resulting from the disease

• **Provides an explanation of disease by taking both social and biological factors into account**

• **Limitations:**
  - Must be a strict definition of the disease and symptoms
  - A choice has to be made about which social and biological factors to focus one → this will affect the eventual results of the study
  - Because of the needs to simplify the situation in question, an epidemiological study may fail to take account of multifactorial causes or the interaction between factors
  - Association being identified between two factors does not necessarily mean the one causes the other
Several factors which epidemiology has shown to be closely associated with health or disease of an individual:

- Age
- Gender
- Marital status
- Ethnic background
- Place of residence
- Social class
- Occupation

**Lung cancer** is a disease caused by the abnormal growth of cells in the lung into either:

- Primary tumor in the lung
- Secondary deposits → having travelled to other organs in the body

Can be difficult to detect in early stages, **symptoms include:**

- Cough
- Hoarseness
- Shortness of breath
- Recurring lung infections
- Weight loss

**Treatment includes:**

- Surgery
- Chemotherapy
- Radiotherapy
- Laser treatment

Collection and analysis of epidemiological data on lung cancer has increased our knowledge of the disease

Australian Cancer Council and State Cancer Councils all collect and report on the incidence, mortality, prevalence and survival of lung cancer

**Main cause is smoking**

**Other causes include:** Exposure to a wide range of industrial substances e.g. asbestos and polycyclic aromatic hydrocarbons

**Lung cancer is the fifth most common cancer in Australia**

Over 8000 Australians are diagnosed with it every year

Approximately 1 in 33 Australians will develop lung cancer by age 75

Trends in lung cancer incidence reflects changes in smoking habits
Incidence of lung cancer in males has fallen in the past 10 years but risen in females
Comparisons with data from other countries help give us a global picture of the disease

Identify causes of non-infectious disease using an example from each of the following categories:

Inherited diseases
- Genetically transmitted diseases, including both gene and chromosome abnormalities

Cystic fibrosis
Cause: Inherited from two carrier parents
Occurrence: Varies between populations but estimated at 1/3300 in most Caucasian populations → most frequent childhood genetic disease

Symptoms:
- Disease of secretory glands
- Mucus becomes thick and sticky → builds up in lungs and blocks airways
- Buildup of mucus makes it easy for bacteria to grow → repeated, serious lung infections causing damage to lungs
- Can block tubes or ducts in pancreas → enzymes produced to help food breakdown, by pancreas cannot reach small intestine
  - Intestines cannot fully absorb fats and proteins from foods
  - Can cause vitamin deficiencies and malnutrition
  - Can cause bulky stools, intestinal gas, and swollen belly from severe constipation
- Can cause very salty sweat
  - Leading to excessive loss of salts
  - Can upset balance of minerals in blood and cause many health problems e.g. dehydration, increased heart rate, fatigue, weakness, decreased blood pressure, heat stroke, and rarely death
- CF patients are at greater risk of diabetes or osteoporosis (bone-thinning condition)
Treatment/management:
- Nutritional and respiratory therapies, medicines, exercise etc
- Pulmonary rehabilitation → broad program that helps improve the well-being of people who have chronic breathing problems
- Treatments of mild acute pulmonary exacerbations include:
  - Frequent clearance of airways
  - Inhaled bronchodilator
  - Chest physical therapy and postural drainage
  - Administration of Pulmozyme (mucolytic agent)
  - Use of oral antibiotics
- Medications include:
  - Pancreatic enzyme supplements
  - Multivitamins
  - Mucolytics
  - Nebulized, inhaled, oral or intravenous antibiotics
  - Bronchodilators
  - Anti-inflammatory agents
  - Agents to treat associates disease e.g. insulin
- Use of hypertonic saline to improve lung function
- Gene therapy
  - Still in the developmental and experimental stages
- Physical activity
  - Contributes to overall health

Nutritional deficiencies
- Can be caused by the lack of a vital component
- Can be starvations
- Anorexia Nervosa or Bulimia → caused my psychiatric disorders

Scurvy
Cause: insufficient intake of vitamin C due to; famine, anorexia, restrictive diets, oral ingestion difficulties etc
Occurrence: Generally associated with sailors in the 16<sup>th</sup>-18<sup>th</sup> centuries → modern cases of scurvy are very rare
Symptoms:
- Appetite loss
- Poor weight gain
- Diarrhea
- Rapid breathing
- Fever
- Swelling over long bones
- Bleeding (hemorrhaging)
- Feelings of paralysis
- LATER → bleeding gums
- Loosened teeth
- Bleeding in eye
- Costochondral beading (beading of the cartilage between joints)
- Hyperkeratosis (skin disorder)
- Corkscrew hair
- Sicca syndrome (autoimmune disease affecting connective tissue)

Treatment/management:
- Administering vitamin C either orally or via injections
- Daily intake of orange juice
- Specific vitamin supplements

Environmental Diseases
- Mechanical trauma e.g. motor vehicle, workplace accidents, sports injuries etc
- Temperature extremes e.g. burns, hypothermia, frostbite, heat stroke
- Irradiation e.g. sunburn, skin cancers, radiation sickness
- Chemicals (e.g. alcohol, heavy metals, mercury, water pollution etc.) e.g. alcoholism, heavy metal poisoning, nervous disorders, cancers
- Excessive noise e.g. hearing loss, sleeplessness, hypertension
- Bites and stings e.g. cardiopulmonary failure, respiratory failure, blood poisoning, tetanus, sores, lesions, ulcers

Lead poisoning
Cause: Prolonged exposure to lead sources e.g.
- Painted toys, old house paint (white paint particularly), lead bullet shrapnel etc.
- Garden soil, dust
- Unregulated industrial emissions and car emissions through leaded petrol or petrol sniffing
  - Although petrol no longer contains lead, the emissions will remain in the air for years to come
- Domestic industries e.g. metal polishing, jewelry making etc
- Make-up still contains lead e.g. kohl eye pencils
- Lead solder used in water pipes and rain water tanks → In aus water is heavily monitored but lead solder products are not necessarily clearly marked
**Occurrence:** Year 2000 → Australia 7.3%, developing countries, around 50% give or take 10%

**Symptoms:**
Insidious or ‘silent’ epidemic → at lower levels are can be no or few observable symptoms
Most harmful in children, especially unborn, can lead to:
- Behaviour or attention problems
- Hearing problems
- Kidney damage
- Reduced IQ
- Slowed body growth

**Symptoms include:**
- Abdominal pain and cramping
- Anemia
- Difficult sleeping
- Headaches
- Irritability
- Constipation
- Low appetite and energy
- Reduced sensations

**Management:**
Exposure can be reduced by:
- Keeping house dust free
- Let tap run for a minute before cooking or drinking it
- Avoid canned goods from foreign countries
- Get rid of lead house paint
- Screening of children’s blood at regular intervals

**Treatment:**
- Lead sources kept out of exposure
- Chelation therapy → removes high levels of lead that have built up in the body
- Following ingestion of lead:
  - Bowel irrigation with polyethylene glycol solution
  - Gastric lavage

**Controls:**
- Legislation limiting lead usage in products
- Enforcement of OH&S standards
- Surveillance of potentially exposed groups, especially vulnerable ones e.g. children, pregnant women, workers
Outcome 7 – Left-Hand Side

Discuss the role of quarantine in preventing the spread of disease and plants and animals into Australia or across regions of Australia.

- **Quarantine aims to protect Australia’s natural and economic assets while minimising disruption to the international movement of people and goods.**
- **Quarantine:** isolation of potentially infected sources (not already ill)
- **Isolation:** physical containments of an already ill host
- Australia has a unique natural environment, free from many pests and disease found in other parts of the world.
- The entry of just one new disease could devastate our ecosystem and agricultural industries → worth billions to the Australian economy.
- Reduces the risk of disease to plants, animals and humans.
- **Balance:** Quarantine cannot be totally effective because of international trade and travel → we need a balance between allowing and disallowing items into the country.
- Protect international reputation for pest free agricultural products.
- Important investment to protect the value of our food exports making up under 10% of GDP = excess of $70 000 mill VS $450 mill cost to run AQIS.
- Protecting our priceless flora and fauna.
- **Circle of viewpoints:** Farmers, ecologists, epidemiologists, Police, shipping agents, AQIS, government and state boundaries.

**AQIS**

- **AQIS** → Australian Quarantine and Inspection Service
- **Role** → to keep Australia free from pathogens or pests or diseases that could cause harm to Australia.
- **AQIS** checks items entering the country at all major mail handling centres, container terminals and airports.
- **Use:** detector dog teams and Rapicasan X-ray equipment to screen mail entering the country → very reliable methods.
- Administer the quarantine law of the Commonwealth.
- Between 500 000 and 750 000 confiscation annually.
  - Effective as a deterrent as well as capturing classified or restricted goods.
• Very few notable failures e.g. bird flu, equine flu in 2007-08
• Empowered to inspect persons and goods, they may confiscate and destroy goods → can also impose fines
• They can put plants, people and animals into quarantine
• Monitor the movement of people and their positions
• Monitor drugs, plants and animal positions, foods, soil – contains pathogens that could kill off our farming industry, ballast water

• **Movement of shipping:**
  - Ships come with goods → If the ship is too light, it will be unstable, therefore they add ballast water so that they boat is heavy
  - → If this water comes from overseas, it could potentially harm our water (if it contains contaminants such as oil) → this water must be changed in the middle of the ocean so that they water is the same

• They act and initiate contact with respect to international trade – imported goods such as agricultural goods
• Have an education role, such as signage at the airport → Adverts in newspapers and magazines

• **Categorises goods:**
  - Fully prohibited e.g. meat or milk products, bird products, plant and animal material
  - Good requiring inspection prior to entry e.g. all foods, timber products, feather products
  - Goods that pose little risk e.g. clothing
  - Pets or organisms requiring quarantine e.g. racehorses, ornamental plants etc

**Pest animals**

*Giant African Snail*

• Originated in east Africa and was deliberately introduced into new areas as a food source
• In areas with few predators, they can attack up to 500 different plants including legume crops, ornamental plants, vegetables and the bark of large trees such as Citrus and pawpaw
• They could enter Australia as eggs or snails
• Could enter in containers, bags, soil, under packing cases, pallets or on shipping containers, machinery, motor vehicles, bicycles etc
• Often intercepted at ports by careful inspection of all imports, steam treatment of vehicles and, if necessary, fumigation of equipment
• So far these quarantine processes have been successful in keeping the Giant African Snail out of Australia

**Khapra Beetles**
• Would have serious consequences on Australia grain storage industry and jeopardise export grains market
• IT can destroy beans, lentils, dried fruits, desiccated coconut, spaghetti, noodles, rice, barley, wheat, bran etc and a range of spices
• Unless stringent pre-shipment condition are met, all containers with exposed infestable agricultural produce imported into Australia from areas hosting khapra beetles, must be unpacked for inspection or the produce

**Foot and Mouth Disease**
• Wasting disease of cloven-hoofed animals caused by airborne virus
• Can spread through a herd of cattle in 48 hours
• Caused by contaminants such as animal manure, blood, soil and feather could introduce serious animal diseases to Australian cattle
• Can survive in frozen, chilled or freeze-dried foods, any cattle products e.g. wool, or in meats or livestock
• Australia has been free of foot and mouth disease for over 100 years
• Korea and Japan had their last outbreak in 2000
• England had their last outbreak in 2002

**Pest plants**
**Patterson’s curse**
• Dominant pasture weed
• Infects grasslands, heathlands and woodlands
• Causes reduced livestock weight or even death, if ingested by crops
• Disperses by movement of seeds on fur of animals, water and hay or grain

**Fireweed**
• Eliminates all other plant species in its surroundings
• Is toxic and can kill animals if ingested
• Detrimental to beef, dairy and horse industries
• Expenses in herbicides to eradicate fireweed are high
Alligator weed
- Blocks waterways and readily covers an extensive surface area of lakes and other water bodies
- Creates a breeding ground for mosquitoes
- Accumulates heavy metals which can be toxic to humans
- Easily spread by boats and soil movement

Prickly pear – opuntia
- Imported into Australia in the 19th century for use as a natural agricultural fence and in an attempt to establish a cochineal dye industry
- Quickly became a widespread invasive species, rendering 40,000 km² of farming land unproductive

Evaluation:
- Does AQUIS effectively protect the Australian population against pathogens, our biodiversity, our crops, our economy, international trade reputation?
- Advantages
  - As an island continent is relatively free from pests and AQUIS protects this status
  - Natural biodiversity is protected against the competition of exotic species that may endanger our biodiversity
  - Also protecting the ecosystems that are unique to our country
  - Protecting our food security against the inadvertent important of pathogens on foods such as fungus spores
  - We are protecting our economy and our international reputation as an exporter of quality agricultural products
  - Exercises the moral duty we have to protect our lands for future generations as custodians of the land
  - Interstate border control to protect the movement of pathogens between states
  - Protects our exports
- Disadvantages
  - Cuts off the Australian consumer from cheaper international products
  - Restricts the availability of fresh or dried biological materials for either research or agricultural purposes
  - Could restrict or stifle an individuals industry or entrepreneurial-ship
It is not an infallible service → has seen the infestation of diseases such as swine flu
Costs about $450 million annually to run
Restricts our imports

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

- **Public Health programs aim**: prevent disease by education about the nature of the disease and the pathogen, how it is transmitted, prevention measures (e.g. change in behaviour, hygiene etc) AND immunization
- Improves overall the quality of peoples lives by preventing rather than curing disease
- Saves money by prevention rather than treatment
- Direct strategies at 3 main targets: the pathogen, the host (people) and the environment
- **Types of Public Health Programs targeting environment:**
  - To modify behaviour e.g.
    - Slip, slop, slap and wrap – sun safety
    - Smoking adverts → every cigarette does you harm
    - Healthy eating
    - Stop revive and survive – safe driving
    - Don’t turn a night out into a nightmare
    - Swap it don’t swap → healthy eating
    - Most disseminated in the media and advertisement
    - Given to supervisors at work to ensure OHS
    - Government control and inspection with fines applied
    - Laws in place requiring government authorities to be notified of the occurrence of certain diseases such as leprosy and AIDS
  - Increase immunity of population by inoculation and immunization
    - Primarily immunize youth, travellers and the elderly
    - Immunized in local municipal council chambers under state government health departments OR GPs
    - Mothers informed in maternity ward of vaccination programs
- Isolation of those infected
  - Usually 40 days quarantine
- Limit transfer of pathogens through correct food handling
  - Restaurants/cafés etc
  - Shops e.g. grocery shops/distribution networks
  - Education by supervisors on site
  - Health inspectors allocated by the council
  - Inspectors look at food handling, cleanliness of utensils and premises, protective clothing, handwashing, food storage, cross-contamination, use-by dates or best-before dates
- Water purification and sewage disposal
  - Council and state governments
  - Subject to national water standards
- Medical facilities
  - E.g. hospitals, dental surgeries, clinics
  - Education and practices focused on hand washing, instrument sterilization, protective clothing
  - Aware of ID lanyards and ties because of the germs they carry
  - Treatment of sharps are disposed of in sealed containers that are appropriately dealt with properly
  - Disposal of any contaminated tissues → burned or incinerated
  - Disposal of bandages etc also incinerated

Discuss the changing methods of dealing with plant and animal diseases, including the shift on emphasis from treatment and control to management or prevention of disease
- Disease will always be present
- Hendra virus in 2011 moved from bats to horse and then to humans and dogs → already killed 3 vets
- Resistance to antibiotics in increasing so prevention becomes more imperative
- Agriculture → genetically resistant crops are grown so that the plants do not have to be sprayed for diseases later in life
- Animal and plant diseases have been managed by quarantine restrictions in Australia
• Diseases, such as foot and mouth, rabies and plum pox, are managed by not allowing infected organisms to enter the country
• Worldwide immunisation has caused diseases such as small pox to be eradicated.
• Management strategies have changed and will continue to do so
• We initially treated patients, then we understood the importance of hygiene to prevent disease
• Prevention:
  o Hygiene
  o Immunisation → continuing today with the search for AIDS vaccine
  o New treatments for previously untreatable disease e.g. chemotherapy for cancer
  o Gene therapy as a new front against disease e.g. for cystic fibrosis
  o Genetic engineering → creates human insulin for diabetics
  o Stem cell therapy → used for muscle and skin grafts derived from the patients itself
  o Less invasive surgery → key-hole/microsurgery, sometimes through natural orifices
  o Miniature cameras used
  o Computers used to talk or move for the incapable or paralysed e.g. development of the new Honda android
  o Hormone replacement therapy e.g. aldosterone for Addisons disease
  o Gene identification → the knowledge of the location and actions of genes → leading to the movement away from industrialised medicine to personalized medicine
  o Transgenic plants → Monsanto has a monopoly over this → mad to resist pathogens e.g. Bt cotton and golden rice
• Considerable advances in medical prevention
• One must use antibiotics and insecticides with great caution
• Continued education and public health programs
• Clean water must continue to be provided
• Safe surgical practices must be maintained in the first and third world
Part 1:
You are to gather and process information to trace the historical development of our understanding of the cause and prevention of malaria

Your findings are to be presented as a written report which looks at:
- The historical developments in our understanding of the disease
- Symptoms, treatment and prevention
- The nature of micro organism involved and its life cycle
- Social and economic factors involved in the effects of the disease and its treatment

Malaria is a protozoal disease which is transmitted by the Anopheles mosquito that infect human and insect hosts. It is believed that prehistoric man suffered from malaria and thus Malaria is known to be an old disease. Malaria is thought to have originated in Africa and fossils have proven that malaria mosquitoes have existed for around 30 million years, before known history. Malaria, or a disease similar to this, has been noted in history more than 4000 years. This disease has probably influenced to a great extent, the human population of many countries in the history.

- The historical developments in our understanding of the disease
In Ancient History, 2700 BCE to 340 CE, Malaria was thought to have been recorded. Symptoms of Malaria were recorded in ancient Chinese medical writings. In 2700 BC, symptoms that were described were matching to those that were discovered later to be named malaria. By the 4th century BCE Greece had had its share of malaria, to the extend that is was responsible for the decline of many city-state populations. The symptoms were noted by Hippocrates, a Greek Physician in 400BC. Later in the Susruta, a Sanskrit medical treaties recorded that the symptoms of malaria were due to bites of certain insects. Some Roman writers attributed the malaria disease was due to swamps. In the 2nd century BCE, in China that Qinghao plant was referred to the Medical Treatise and then in the United State this plant was known as the annual or sweet wormwood. This plant was important in 1971 as it had an ingredient called artemisinins, which today is an antimalarial drug. The early 17th century, Quinine was an effective means of treating malaria. This came about by the ‘New World’, with medical advances. The Spanish Jesuit missionaries taught of a medicinal bark used for treating fevers. Today this bark is known as the antimalarial quinine.

Charles Louis Alphonse Laveran is responsible for the discovery of malaria, in 1879 he began his research at the military hospital of Bône in Algeria. There he aimed to identify and discover the black pigment particles that were unidentified in the blood of people suffering from malaria. At this time malaria was a serious problem amongst the Army, and given that Laveran was involved in the medical field of the war he was able to provide an understanding of malaria. After 1850, the particles were known as melanins, and measures were set to discover whether the particles would be found in patients suffering from malaria or if they were present in other diseases also. Laveran is an important contributor to the diagnosis of malaria through his research and findings. In his research Laveran found the unknown particles, though, in 1880, also discovered a completely unidentified body that had characteristics which led him to believe that parasites were involved. Theories earlier in history suggested, by the Italians, that it was caused by ‘bar air’ from marshlands. Louis Pasteur’s work during this period gave an intriguing angle to the origins of Malaria. Pasteur posed that most infectious diseases are caused by microbial germs, and so
originated the ‘germ theory’. In relation to Malaria, the hypothesis that this disease was caused by bacteria became more believable.

As Laveran had expertise in anatomical pathology, he used those observations to help him in his research for the causal agent of malaria. Further research of infected or damaged areas in organs and blood of those with severe attacks and chronic malaria, it was evident that the black particles previously found in his research was consistently reappearing. Also, his discoveries show that the amount of these particles differed with the severity of the case. Laveran’s conclusion was that the black pigment particles were only specific to the Malaria disease, originating in the blood of an infected host. Laveran displayed immense patience whilst researching and examining freshly collected blood specimens as he used primitive methods of examinations without using chemical reactions or any staining processes.

The hospital in Bône was where Laveran noticed spherical bodies, either free or attached to red blood cells. They were either glassy and difficult to see while others had dark black pigment granules that had ameboid movements. This discovery led Laveran to his greatest findings at the military hospital in Constantine. On the 6th of November 1880, after monitoring and investigating the blood a patient who had been showing symptoms of malaria for 15 days, he saw “…on the edges of a pigmented spherical body, filiform elements which move with great vivacity, displacing the neighboring red blood cells.” Due to his patience whilst researching blood specimens, Laveran was able to link his patient to his research as he had seen the exflagellation of male gametocyte, which is a phase in the lifecycle of malaria parasites, that occurs in the stomach of the Anopheles mosquito. Evidently he was able to conclude that the agent causing malaria was a protozoan parasite.

This illustration, drawn by Laveran displays the various stages of malaria parasites in fresh blood. The dark pigment granules are evidently in majority of the stages. The last row demonstrates the exflagellating male gametocyte which ‘move with great vivacity.’

In 1882, Laveran decided to move to the marshy regions of Italy to continue his discoveries and investigations as this was the scene of Malaria break outs. Here he was successful in his research as there was the same bodies in people infected with marsh fever, that Laveran discovered earlier in his research. His aim of discovering malarial parasites became a certainty. He looked for parasites in the air, water and soil of the marshlands. Sadly his efforts were unrewarded as he was unable to be successful in his findings. Though there was a negative outcome, history still recognises the large contribution and merit of his work on the malaria disease.

http://www.cdc.gov/malaria/about/history/laveran.html

1 http://www.cdc.gov/malaria/about/history/laveran.html
Camillo Golgi, discovered that there was two species of the malaria disease. Firstly one with fevers every other day (tertian periodicity) and one with a fever every third day (quartan periodicity). His further observations are that there were differing numbers of merozoites which are new parasite. They differed when they matured and the fever occurred simultaneously with the release of these merozoites.

The mosquito vector was discovered by Ronald Ross in 1897 who was an Army surgeon in the Indian Medical Service. Ross undertook experiments and tests with reference to the mosquito-theory that was proposed by LaVeran and the investigator, Patrick Manson. His interest in malaria came about in 1892, as he originally doubted the existence of the parasites, though soon converted after Patrick Mason explained their existence in the blood stream. Patrick Masons also was an important contributor to the history of malaria. He was named the ‘Father of Tropical Medicine’. In 1878, he was the first person to show that a parasite the caused disease in humans could infect a mosquito, it was the filarial worm that caused elephantiasis.

In 1895 Ross returned to Indian with the aim to prove Alphonse LaVeran and Mason’s hypothesis that mosquitoes were responsible for spread of malaria. With constant reference to Manon’s findings he began his work. His work was almost compromised as the Indian medical Service ordered Ross to a malaria free-environment, though with Mason as his representative he was allowed special duty for a year to investigate malaria and Kala Azar (visceral leishmaniasis). The 20th of August 1897, Ross made an important discovery in Secunderabad in relation to the transmission of Malaria through mosquitoes. During a dissection of the stomach tissue of an anopheline mosquito that had previously fed, four days prior, on a malarious patient, he made this discovery. He found that the malaria parasite showed that Anopheles mosquitoes are able to transmit malaria parasites in human.

Continued research in India by Ross aims to prove his theory further. This time he used a different experimental body, malaria in birds. It was by July in 1898 that Ross was able to show that mosquitoes could carry bird malaria. This was after Ross fed mosquitos in infected birds, that he discovered malaria parasites could grow in mosquito’s salivary glands, and thus infect birds during their feeding process. This discovery was greatly helpful in history as it began to create an awareness for how easily malaria can be contracted through mosquitoes. Through his research, in the late 1800s there was a decline of malaria break outs in the United states and Europe, this mainly was due to the draining of swamps and eradicating mil ponds.

The complete sporogonic cycle of Plasmodium falciparum, P. vivax, and P. malariae was demonstrated in 1898 to 1899 by a team of Italian investigators. This was led by Giovanni Batista Grassi, also with Amico Bignami and Giuseppe Bastanelli. They collected mosquitos and allowed them to feed on malarial patients. In 1899, those infected mosquitos were sent from Rome to London, where they fed two volunteers that both developed malaria. This was the discovery of the transmission of Malaria parasites Plasmodium.

In the early 1900s the construction of the Panama Canal heavily depending on whether malaria could be controlled in the area. Through Ronald Ross’s discoveries of the transmission of malaria via mosquitos helped the Isthmian Canal Commission discover preventative measures of the disease. At Panama, the antimalarial work was mostly that in rural areas, with a population of 80,000 living within half a mile of the railroad, and 30 villages around the area. A program of preventative measures of mosquitos was implemented, with seven basic step that were enforced. Throughout history, by experiments and investigations, the knowledge of the 21st century has enable most countries to live free from the threat of malaria.
• Symptoms, treatment and prevention
As early as Ancient history it has been noted that the Malarial fever has been linked to the bites of certain insects that have left marks swollen and red. Further symptoms in history is seen in the seventeenth century when the Spanish Jesuit missionaries taught of a medicinal bark used for treating fevers. Fevers were/are a common symptom of malaria. Camillo Golgi, discovered two types of malaria, both of which caused fevers with different severities. Firstly, ‘tertian periodicity’ meaning one with fevers every other day, and the other ‘quartan periodicity’ which means one with a fever every third day.

When a person is infected with the parasites that cause malaria, *Plasmodium*, they begin to multiply. Symptoms can being to show within 10 to 30 days of being infected, this is called the malaria incubation period. This period can differ from as short as a week to even several years. The severity of the symptoms will differ person to person, from mild to severe. Malaria can be cured with the correct medical treatment. Early uncomplicated symptoms of malaria include: fevers, sweating, shaking chills, headaches, tiredness, muscle aches, diarrhea and, nausea and vomiting.

On the rare occasion, the symptoms of malaria may last six to ten hours, then appear to be going away, then a couple of days later may return. This will depend on the type of malaria parasite. The table below explains this. The P.falciparum shows that fevers have a quick onset and then gradually seem as though they are ceasing, though on the third day come back and plateau between the third and fourth day. Similar is the P. vivax & ovale, a quick onset on the first day and then by the end of the first day fevers decrease dramatically and plateau to almost normal bodily functions, though on the third day come back as bad as the first day and follow a similar pattern. Lastly is P. malariae, which starts on the first day then decreases until the middle of the fourth day. This diagram shows that the fevers of malaria follow a cyclical pattern.

If the severity of malaria is high then there are different symptoms, this also depends on the type of malaria parasite that a person is infected with. Severe malaria is seen by *Plasmodium falciparum*, which is responsible for organ failures and blood metabolisms problems. If left untreated then symptoms include: kidney failure, seizures, mental confusion, coma, severe anemia, fluid in the lungs, Acute Respiratory Distress Syndrome, bleeding due to blood clotting and even death.

http://en.wikipedia.org/wiki/File:Malaria_fever.svg
People can become immune to malaria, though it is common that if one is not, severe malaria is likely to occur. People at risk of this are those living in areas with a low transmission of malaria, young children and pregnant women. Further and severe symptoms include: yellowing of the skin, anemia, trouble with movement, deafness, blindness or speech difficulties. Pregnant women are at risk of a low birth weight baby, premature delivery, delayed growth or a miscarriage. Malaria is a serious medical health emergency and if symptoms of the disease appear, seeking doctors advice is imperative, even though it may not be malaria.

In ancient times, beneficial treatment for malaria was to allow limbs to bleed, emesis, amputation and skull operations. In England, opium was used that was grown locally as well as opium-laced beer as treatment for the fever. Treatment also went as far as astrology, it was thought that the periodicity of malaria was connected with the astronomical phenomena. Through history, treating malaria has been brutal and violent. In 162 AD, who were very poor and could not afford medical professionals used this method of expelling the ‘poisons’. In fact these methods were making the suffers worse as repeated bleed made the anemia of malaria much worse. Some turned to witchcraft though this neither cured malaria patients. In the 2nd century BCE, in China that Qinghao plant was referred to the Medical Treatise and then in the United State this plant was known as the annual or sweet wormwood. This plant was important in 1971 as it had an ingredient called artemisinins, which today is an antimalarial drug.

The Cinchona bark has been useful for over 350 years. It’s origins is unknown, though what is known is that it was greatly used, as native plant remedy more effective than techniques of European physicians of the time. It is unknown also how it came into Europe though it was concluded that it was entirely by accident. Though despite this it proved to be successful in treating malaria infected people. It wasn’t until the early 17th century that an effective cure for malaria was discovered, due to this malaria suffers continued to die. The early 17th century, Quinine was an effective means of treating malaria. This came about by the ‘New World’, with medical advances. The Spanish Jesuit missionaries taught of a medicinal bark used for treating fevers. Today this bark is known as the antimalarial quinine.

Next is the chloroquine drug along with Primaquine, Proguanil, amodiaquine and Sulfadoxine which was used to protect the troops from malaria during World War II. With conflict during the war, supplies were cut off and overtaken. As a result, it only took ten to twelve years before a resistance of chloroquine was seen in *P. Falciparum*. This resistance was spread from Colombia to Cambodia-Thailand border, then throughout South America and southern Asia. By the late 1970s this resistance of Chloroquine had reached the African continent which was detrimental as malaria was common there.

Allied chemists formulated Atabrine which soon was produced in large scale as it was effective in treating malaria without the unwanted side affects. Acceptance of this spread worldwide as an excellent therapeutic agent as well as a Prophylactic agent as it protected troops from the disease. Furthermore, the discover of chloroquine and the effectiveness Camoquin, Primaquine, Daraprim or malocide was discovered. Though within a few years there was resistance to Proguanil in Thailand, South East Asia and recently in Africa. Mefloquine was then introduced to combat malaria after World World II, by the U.S. Army Medical Research and Development Command, the World Health Organisation and Hoffman-La Roche Inc. It was effective in the US Army in Southeast Asia and South America, though when it became available to the public, resistance to the drug appear in Asia. In 1998 came a new drug called Malarone, that was released in Australia is the most effective as it is plant derived. Throughout history is it evident that plant derived drugs have outlived many of the synthetic drugs that have built resistance.

http://www.malariasite.com/malaria/history_treatment.htm
Prevention for malaria has been a long and tough battle, with many failed attempts with also some effective measures. With the aim of constructing the Panama Canal, there was measures that had to be taken in order for it to be successful and free of the risk of malaria. With this came the first sign of prevention of the disease, and with this came the building blocks for prevention for the future. The Malaria control plan was seen in the early 1900s. Firstly drainage, subsoil drainage was changed to concrete ditches, then bush and grass cutting. All bush and grass was cut to less than a foot high near villages, this was with the knowledge that mosquitoes would not cross open areas over 100 yards. Next was oiling, this was done when drainage was not possible on edged of ponds, it killed mosquito larvae. Larviciding, when oil was not effective larviciding was performed, it was a mixture of carbolic acid, resin and caustic soda which killed mosquito larvae. Next was Prophylactic quinine: quinine was given out to all workers along the construction line as well in hotels and mess tables. Screening, all governmental buildings were screened against mosquitos. Lastly was killing adult mosquitos, it was known that adult mosquitos remained in houses or tents after feeding during the daytime, thus killing them seemed the be effective. All the seven measures that the Isthmian Canal Commission put forth in history has been built on for today. It was an important step in history, by the malaria program being implement, there was an eradication of yellow fever and a dramatic decrease of malaria moralities. Though it was not fully controlled, it was to the extent that the Panama Canal construction could be completed.

Further prevention and control of malaria is seen with the discovery of insecticide DDT in 1942 by Paul Müller and first used in 1944 in italy. This gave hope for the global eradication of malaria. Following this discovery control measures were that of spraying with DDT, coating marshes with paraffin (which killed Mosquito larvae), draining stagnant water and the growingly popular installment of mosquito nets. Cheap effective drugs, Chloroquine were also implemented. All preventative measures were effective having positive results. Though there was initial success, there was a failure to address some considerations in some countries in an attempt to eradicate malaria. There was a drug resistance to the parasite drug which was one failure, the other is that it was overseen that some countries had poor social and political factors which prevented efficient application of control measures.

In 1955 the World Health Organisation (WHO) proposed and implemented at the World Health Assembly an eradication of malaria worldwide. Procedures included: spraying houses with residual insecticides, antimalarial drug treatment and surveillance. Prevention did have setbacks up until 1969, when eliminating malaria on a global scale was abandoned it was evident that many European countries were able to control endemic malaria. The countries in: Hungary, Bulgaria, Romania, Yugoslavia, Spain, Poland, Italy, Netherlands and Portugal.

Further measures of prevention include: travelers should avoid areas where outbreaks of malaria have occurred, to be aware of peak exposure times and locations of when the mosquitoes are likely to feed, usually this peak can be during dusk and at night in moist or humid conditions with little light. Also, when traveling, to wear appropriate clothing that minimises the areas of exposure, long sleeved shirts, long pants, boots and hats will help with this. Repellants are an effective prevention measure it can be applied to skin or clothing. Bed nets can be used in accommodation or in houses that are not screened off around windows and doors, usually they contain a insecticide called permethrin. More insecticides include aerosol insecticides, vaporizing mats and mosquito coils. All preventions should be an effective measure in minimising the bite of a mosquito. It is cost effective to look towards a preventative rather than a cure.

3 [http://www.cdc.gov/malaria/about/history/panama_canal.html](http://www.cdc.gov/malaria/about/history/panama_canal.html)
There are numerous factors that will determine which form of treatment for malaria a person will take. Factors include: type of infecting parasite species of *Plasmodium*, situation of the patient (whether they are adult, child or pregnant female), and the drug susceptibility of the parasite depending on the location upon infection. Different locations in the world show that some malarial parasites are resistant to forms of treatments and medications. The severity of malaria also plays a role on which medication a person will take. For mild malaria an oral medication can be taken, severe malaria will require hospitalisation, a intravenous drug treatment as well as fluids. Chloroquine phosphate is a drug for all malarial parasite except for resistant parasites, Chloroquine resistant *plasmodium* strains. Drug resistance for the treatments is due to failures due to patients not follow drug-treatment protocol. Though there is a resistance to Chloroquine phosphate, there are alternate drugs, for example: quinine sulfate plus doxycycline, or tetracycline, clindamycin or atovaquone-proguanil. The type of treatments are based on the majority of *Plasmodium* species diagnosed and the drug-resistant patterns of the area, country or region where the person is infected. Studies for new drug treatments are continual as *Plasmodium* will continue to create drug resistance that usually spreads to other regions.
The nature of micro organism involved and its life cycle

The above diagram portrays the lifecycle of the malaria parasite involving two hosts. In order for the malaria disease to be successful, the malaria parasites must infect two hosts, the female *Anopheles* mosquito and humans. The female *Anopheles* mosquito are only able to carry the disease, pass it on human to human, acting as a vector. However, the mosquito vector is not affected by the malaria parasites.

1. **The process starts in the Human Liver Stage**, the female mosquito takes a blood meal and transfers sporozoites into the human host.
2. Upon inoculation, ten to a few hundred sporozoites are introduced to the skin and the sporozoites travel through the body to the liver and infect the cells. Some sporozoites are destroyed by the local macrophages though some are able to enter the lymphatics and others to blood vessels. Within a few hours the sporozoites that have reached the blood vessels will travel to the liver.
3. Once the liver cells are infected they then mature into schizonts
4. The matured schizonts rupture and release merozoites. Previously to this stage it is known to be the pre-erythrocytic stage as the human host is unaware of what is happening inside their body as there is little to no symptoms of malaria.

http://www.cdc.gov/malaria/about/biology/
The next stage is referred to the Human Blood Stage where the P. vivax & ovale can infect the liver and remain dormant which can lead to a relapse weeks or years later through the bloodstream.

5. After replication, the parasites begin asexual reproduction and multiply in the erythrocytes (red blood cells). The reproductions occur periodically and at the end of each cycle, there are hundreds of new daughter parasites that are released and infect more cells.

6. Trophozoites is the ring stage where they mature into schizonts, which release merozoites after rupturing. Then an onset of fevers occur as is characteristic of malaria. Once merozoites that are released from the liver attach and enter the red blood cells within as little as 60 seconds. Due to the quick disappearance, there is little time for the body to verify the antigen, thus they are protected from the immune response. This means that it is able to continue the cycle.

7. Some malarial parasites develop into sexual erythrocytic stage, (gametocytes). The blood stage parasites attribute a clinical manifestation of the disease.

8. Sexual erythrocytic stage causes both Gametocytes, male (microgametocytes) and female (macrogametocytes), both of which are transmitted to an Anopheles mosquito during their feed on humans. Gametocytes are incapable of producing gametes within the human host so they must do so in the female mosquito after feeding on a human host with malaria.

The next stage is referred to as the Sporogonic Cycle where the parasites' multiply in the mosquito.

9. Zygotes are formed in the mosquito’s stomach as the microgametes penetrate macrogametes.

10. The Zygotes that are formed then develop into a motile and elongated shape

11. The Zygotes travel to invade the midgut wall (small intestines) of the mosquito. There oocysts are developed.

12. The Oocysts follow a similar process, they grow, rupture and release sporozoites which end up in the salivary gland of the mosquito. This is the site where the mosquito then infects a human host up feeding, and the malaria cycle starts again.

- Social and economic factors involved in the effects of the disease and its treatment

The effects of malaria in an economical and social view, directly impacts the individual and the government. Today, the impact for an individual with malaria include, the cost of drug treatment, expenses for traveling to and from clinics that have the treatments, lost days at work and school due to sickness of malaria all add up to be expensive. The cost of treatment for malaria is not cheap. When traveling to any country overseas with risk of malaria one must take antimalarial tablets around one to two weeks beforehand as well as four weeks after leaving the area. Doxycycline is a common drug used for short-term travelers. It costs $50 for 6 weeks. Side effects include: thrush, stomach & bowel upsets and sunlight sensitivity. Not only does this cost money is also takes a toll on the health of the individual.

On a government level, their aims for their country is to provide a safe environment that is supportive of good health for all citizens, and that will put into place measures that will keep this. In keeping with that is best for the citizens of the country, the government on an economic basis must look at what is cost effective in treating and maintaining a country free from malaria. Whilst finding a cure for and disease, including malaria, is always a positive outcome, finding and implementing a preventative is must more cost effective for the government. Governments have the responsibility to allocate money towards health, if malaria can be prevented from becoming a major health issue in the first place then, in the long run, it will be more effective for the economy. The expenses for
the Australian government to consider include: purchasing drugs and supplies for treating malaria and maintaining health services with the current load hospitals have on them. For people who are infected with malaria and are unable to work a loss of income will result for people and families. Also if malaria is a major problem within a country the government will suffer due to a decrease in tourism, which is a major source of economic value to any country. It is fair to say that a preventative rather than a cure approach for malaria is more effective economically as the expenses for the individual and government for a cure exceed those of preventatives.

In the late 1800s there was a decline of malaria break outs in the United states and Europe, this mainly was due to the draining of swamps and eradicating mill ponds. By draining the swamps good agriculture land was what was left, this meant an increase in livestocks and also allowing people afford better houses and thus isolate the sick. Improved health and nutrition was a positive outcome from draining the swamps and mill ponds. Improved housing, an isolation of the sick in mosquito-proof areas, access to healthcare and medication, improve nutrition, sanitation and hygiene of the late 1800s also may have reduced mortality rates.

During this period of time, controlling the spread of malaria was a difficult process and one of hot debate. An Italian parasitologist Battista Grassi, suggest that tighter netting would help eliminate chances of being infect. German microbiologist Robert Koch though it would be possible to eradicate malaria by giving quinine as a medicine. Ronald Ross disagreed with the ideas put forth in history and emphasised vector control which was supported by Malcolm Watson and LW Hackett of England and the Americans Fred Soper and Paul Russell. SP James had a suggestion that was based on factors that had not been explored previously. James factored in the social and economical situations of areas. The believed that malaria will only disappear with an improvement in the environment one lives in, their housing and separating humans from mosquitos. Thus malaria is thought to be a social disease and the solution was to improve the economic life of the populations under threat from infection of the disease. Good housing, good nutrition, good health and education services in conjunction with modern agricultural practices are step that will ensure control of malaria. As years went on, there was an improvement in economic standards and an advance as well due to the disappearances of cases of malaria in Northern Europe and England. Statistics show there more than 10,000 cases had been admitted to London's St. Thomas's Hospital alone between 1860 and 1870, a rapid decline to four or five cases each year by 1925 positively followed⁴. At one point of history it was of strong belief socially as to not allow anyone to develop immunity to malaria, even at the cost of a few young lives.

It is evident that malaria has a negative impact overall on society in a political and economical way. Though it is through the technology, prevention and treatment of the disease that it can be controlled and eradicated from various countries. If countries focus on preventatives rather than cures for malaria it will be beneficial and more economically sustainable in the long run.

⁴ [http://www.malariasite.com/malaria/history_control.htm](http://www.malariasite.com/malaria/history_control.htm)
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Part 2: You are to gather, process and analyse information from secondary sources to:

- **Describe, at a molecular level, the cause of cataracts**

  A Cataract is a common eye dysfunction and forms in the eye’s natural lens which causes a person’s vision to become blurred or clouded. It causes a reduced image quality and sharpness, and also a sensitivity to light and glare. It is present between the iris and the pupil and can occur in either one eye or both, though they cannot spread from eye to eye.

  There are three types of cataract. Firstly, **Secondary cataract** which can form after surgery associated with other eye problems, glaucoma. It can also form in people with health problems, e.g. Diabetes. **Traumatic cataract** is caused due to injuries of the eye that can come out years later. **Congenital cataract** is when babies are born with cataracts or eventually will develop it in childhood, commonly in both eyes. The cataracts may be small enough not to affect the visions. If so they may need the lens to be removed. **Radiation cataract**, is caused by exposure to certain types of radiation. Age-related, senile, cataracts are by far the most common form of eye dysfunction as more than one in five among people over 65, one in three among people over 75 and two thirds of people over 85 years of age suffer.⁵

  The lens of the eye uses surrounding light to focus on objects or images, this happens on the retina due to arrangement of specific properties of its constituent cells. Like most cells in the body, cellular exchanges occur as it is an essential source of nutrition and also removes waste products. In the eye this cellular exchange must adapt to the specific properties of the lens, the proteins in the membrane of the lens include an assembly of aquaporins and connexons. The aquaporins are water channels and the connexons are channels for metabolites and ions. Both proteins combine to ensure the essential cell adhesion in the eye.

  At the Institut Curie, Simon Scheuring’s team used an Atomic force microscopy (AFM), to determine the protein assembly function. This microscope contains an automatically sharp tip which scans over the sample surface and is tracked by a laser. By Scheuring’s team studying the aquaporins and connexons they have been able to identify the biological changes that cause cataracts. Senile Cataracts that occurs with old age is due to a lack of connexons, which results in the formation of the channels that allow metabolites and ions to circulate which prevents cell to cell communication. This alteration in molecules within the eye are responsible for the lack of connection between cells and so waste accumulates in cells and the transport of water, ions and metabolites in the lens are compromised. Thus the result is a cataract.

  The lens cells contain specific properties that allow the eye lens to function correctly. The cells in the lens have no nucleus nor organelles, such as mitochondria. This means that the lens is unable to perform specific biochemical actions and functions that aids in nutrition. Due to this it is the role of the aquaporins and connexons, which are the transmembrane channels, to provide water, ions and metabolites as well as waste removal in cells. The cells contain lens proteins (crystallins), which provide lens transparency. If this process if compromised the essential nutrients is not received in the eye as well as the waste products not being remove, will inevitably result in a cataract. As the eye’s lens focuses and uses light to form a sharp image, it aims to avoid the loss of the light. In avoidance the network of cells are compacted so that the gap between the cells is

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less that a wavelengths of visible light. A cataracts is due to the lens becomes opacified and hardening.

- **Discuss and describe what macroscopic changes the condition causes in the organism**

Over time, depending on the degree of cloudiness, the cataract will eventually grow and impair vision. The rate of which this occur will differ person to person. It is not a tumour or growth, nor is it a film covering the eye that can be peeled away. This may not cause a vision problem though it may cause difficulty to read and perform normal activities. Severe cases of cataracts are easily detectable as there is an evident covering of the pupil. This cover appears to be a cloudy grey-white film that ranges from partial cloudiness to a full cover of the entire pupil.

Symptoms of cataracts in the early stages of it’s development is very small and unnoticeable. One may experience visions that is a little blurry, like looking through a cloudy or fogged piece of glass and as it ‘grows’ the blurriness or a dulling will intensifies. Another way cataracts can effect an organism is that the clear lens slowly colours with age and vision may turn to a brownish colour. Initially it will affect the organism minutely, though tinting may increase which makes it difficult to read and perform routine activities. Though vision does tint, it does not however, affect the sharpness of the image that is transmitted to the retina. Further changes include: a change in colour vision, colours may seem to blur into one and some purples and blues may mix. Poor night vision can result from a cataracts which affects a person as driving may be their form of transport, especially headlights from other oncoming cars can become dangerous on the road. Also lights can appear to have halos or a glare around them and double visions can occur with objects in a distance. Signs of a cataracts worsening is when prescription glasses need to be replaced.

The two pictures above show what a person suffering from cataracts can usually see. The symptoms of blurriness or the image appears as though you are looking through a cloudy or fogged piece of glass is evident. The picture on the left is normal visions and on the right is one what you can except from the visual impairment cataract sufferers experience. All symptoms that are displayed from a cataracts will be directly influenced by age, injury, certain diseases and lifestyle. If one has a poor lifestyle then they are at risk of a cataracts.

- **Describe and evaluate the technology that is available to address this health problem**

Through the progression of technology, it has enabled treatment and detection of various diseases happen so that the health problem can be addressed. Technology for a cataract has undergone a revolution over the last two decades, operations that once required a stay in hospital and a long visual rehabilitation, to a quick one hour procedure with immediate results. Surgery today, has been able to provide an early intervention of cataracts which means that patients do not have to
suffer long periods of visual impairment. Cataract surgery has a high success rate with between 85% - 92% and 95% of patients satisfied with the outcome.

A cataracts can be detected through an eye exam at your local Doctor. Firstly visual acuity test which is an eye chart test that measures how well you see at various distances. A Dilated eye exam is when drops are placed on your eye to widen or dilate the pupils. Eye professions will examine the retina and optic nerve with magnifying lenses to examine damage of problems of the eye. Tonometry procedure is a measurement of the pressure in the eye, measured by an instrument. It is evident that as technology has advanced the detection of cataracts has become easier. Manuel Datiles, medical officer and senior clinical investigator at the National Eye Institute, believes that if a cataracts can be detected early then is is possible to slow or stop the build up of damaged proteins.

The choice of whether of not to have surgery for a cataract is completely up to the person. Pre-surgical management of a cataract is to understand the cause of visual disability. Usually prescription glasses are assigned to improve quality of the vision and reduced blurriness. As the cataracts progresses strong bifocals, occasional magnification and visual aids will help to satisfy vision. These methods of improving vision may be temporary for someone as they may wish to decide upon surgical intervention. Prescription glasses and contacts are an effectiveness means of helping periodically improve vision amongst many. For those that cannot afford surgery, money and time wise, this is an effective way to address the health problem of a cataracts. Though if the cataracts continues to grow and the possibility of blindness is a threat then perhaps it not as effective as some forms of eye surgery could have been.

The decision of whether to elect to have cataract surgical intervention is placed upon the person after must consideration. The aim of the cataract surgery is to reduce and ultimately eliminate the impaired vision cause by the cataracts. The surgery will reduce the cataracts to the level to which interferes with the daily activities of the person. The most common cataract surgery today is by the process of phacoemulsification. A surgeon will used a microscope in order to make a minor incision in the surface of the eye in or near the cornea. A thin ultrasound probe is inserted into the eye, which sends ultrasonic vibrations which will dissolve the clouded lens. Once it has been dissolved the left over tiny pieces will be suctioned out by the probe and the cataracts has been removed. Once removed an artifical lens is then inserted. This is done by the lens being inserted back into the eye to the place of the thin capsular bag where the cataract has previously been.

Another treatment of cataracts is Extracapsular cataract surgery which is reserved for very severed or advanced cataracts. Usually the lens is to dense to be dissolved by the ultrasound probe. Thus larger incisions are made in Extracapsular surgery so that the cataract is removed without being broken up, in one piece. The same technique used in the phacoemulsification surgery, an artificial lens is inserted into the capsular bag. Recovery is longer than that of the phacoemulsification surgery as this surgery requires a larger incision made in the eye. Lastly is the Intracapsular cataract surgery which requires a larger incision to be made than the extracapsular surgery. A surgeon will remove the entire lens and surrounding capsule. The intraocular lens will need to be placed in a different location, which is in front of the iris. This technique is only used in the most significant cases where severe trauma has taken place, this surgery is rarely used today.

http://www.technologyreview.com/biomedicine/21961/
Evidence shows that the surgery procedures of phacoemulsification, Extracapsular and Intracapsular can improve visual acuity. Ophthalmologists strive for every patient to once again have “20/20” visions. It is important to note that the improvement in sight can also have an impact on the patient’s health and day to day life. Recent studies have shown that poor visions has a great negative impact on sufferers than previously thought. Other studies show a connection between cataract and increased mortality, though there is no causal link found. With poor vision it becomes hard to participate in physical exercise which has lead to physical disabilities and in females hip fractures. With poor visuals people believe that their quality of life has diminished and their routine activities slowly decrease. The cataract extradition, in the past, was associated with high complication rates, long rehabilitation and poorer outcomes. One had to delay their treatment until a cataract had matured, though by the time it had, normal and routine activities would have been compromised. With the revolution of technology it is now possible for sufferers to be assessed and have cataract surgery earlier and before the general functioning is disrupted. It is fair to say that surgery definitely has a positive outcome for those who seek to remain competent and enjoy their normal functioning of life.

With any surgery there are high expectations that a patient will be cured, though there is always the risk that an outcome may not be to the standards a person may want. It is important to know of these risks. Studies show that with increased age the outcome seems to worsen with cataract surgery. This may be due to a combination of ocular diseases or that the surgery was performed too late to improve their visual ability. Other complications include, bleeding, which is unusual as an incision is made where there is no blood vessels, though possible. Bruising or a black eye can occur if an injection around the eye was necessary, it is uncommon happens occasionally. Also Retinal detachment, which can happen if one is nearsighted, symptoms include floaters, flashing lights, a shadow or bubble/curve in your vision, and a possible loss of your vision.

A cataracts can sometimes be preventable, this can be done through wearing sunglasses and a hat whilst in the UV rays, this may help to delay cataracts. It is proven that by smoking it increases your risk of developing cataracts, by not smoking an individual has decreased their chance. Also maintaining a healthy diet, and eating the recommended green vegetables, fruit and other food with antioxidants can also help minimise the risk. This demonstrates that preventative measures can be more effective than the cure itself. Surgery is effective and has great results, though this uses time and money for individuals. An advantage to the surgery is that if a cataract is genetic then surgery is an effective way of curing that person as it is non-modifiable. Also it is positive as all surgeries have high success rate of restoring vision for people. A disadvantage is that in developing countries, opportunities of having the surgery are virtually non-existent, also people do not have the money to fund the procedure. This is a clear indication of the gap between countries of first world and second world countries.

Though there are factors that suggest cataract surgery have negative complications, it is safe to say that the positives outweigh the negatives. People that have impaired vision suffer from emotional, cognitive, physical and mental stress and anxiety due to their compromised daily activities. With surgery, people have the chance to gain their quality of life back which is why it is safe to say that surgery is an effective technology to address this health problem.

- Assess the implications of this technology for society. You are asked to consider the work of the Fred Hollow’s Foundation and the implications in contemporary society

Technology has provided the world with the opportunity to better their health in many ways, from screenings, drugs, medication and surgery. In relation to eye sight, simple procedures can allow people to see again or to repair vision to those who have experienced a cataracts. However, thought there are cures for many of those who can afford to pay for surgery, there are those in the

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8 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2684074/
world that cannot. Cataracts blinds millions of children and adults in Africa, though in countries like Australia and North America, they’re are simply and easily removed with surgery. This just highlights the evidence inequities in health around the world. Technology can only better those who have the knowledge, money and accessibility. It is important to highlight that technology can be both positive and negative. It does help those who have the ability to access it, though it just further widens the gap between countries of wealth and that are poor. Simple interventions, can alter peoples lives for the better. Inexpensive mediation and even surgery can help people in the simplest ways such as restoring peoples’s sight can give them the opportunity to live productive lives that benefits the individual, families and the community.

The impact and improvement to the individual is large as surgery for a cataract means that their quality of life has now returned to what it once was or even better. The blurriness, sensitivity to lights, poor night visions and glare can all be eradicated. This then allows a person to resume or partake in normal activities that were once experienced. Visual impairment affects many elderly people as cataracts develop over time, associated with this is falls amongst older people. With impairment their depth perception, contrast sensitivity and visual field can affect them greatly. Surgery would eliminate the massive impact a fall could have on their well-being. From a fall a deterioration in health, hospitalisation, decrease in confidence and even mortality can occur. Technology definitely has impacted society in a positive way in regards to eye sight. It is evident that visual impairment amongst elderly people has proved that normal activities have greater difficulty than those without a cataract. Kenya, a cataract sufferer said that “Before the operation I felt as if I was put into a jail that I couldn’t escape. Many times I would take tea and burn myself as I couldn’t see the handle. It was horrible.” Elderly people who do suffer from cataracts feel their independence fading away, as well as many other sufferers of all age. Some feel that they are less able to do earn a living and contribute to the household, with the technology of surgery this feeling can be turned around. This proves that technology definitely has impacted elderly people in a positive way in regards to eye surgery.

With a cataract, there is a physical change in the eye and how one is able to see the world, though there are psychological restrictions that result due to visual impairment. To many when their visions is impaired by a cataract, they feel as though they are less able to engage themselves in sociable events. Conversing and socialising with family and friends becomes harder and participation in activities, work and leisure becomes difficult. Without regular socialising people can soon feel isolated and can feel as though they have a lack of social support and as a result may develop depression. With vision impairment comes a reduced opportunity to participate in physical exercise and if this happens other health problems can develop. Another impact is that with visual impairment, to a family member, others around them feel saddened by their restrictions. For many grandparents, being a part of their grandchildren’s life and taking care of them is important, though with a cataracts these moments are difficult to have. Though with surgery, the experiences are able to be lived. Technology has helped those who have difficulties in seeing, to live their life to the fullest.

The Fred Hollows Foundations aims to address the inequities around the world in relation to eye sight. Their vision is end avoidable blindness. This foundations was set up in Sydney 1992, by an Australian, Fred Hollows (1929-1993), who was a passionate and dedicated ophthalmologist. Hollows aimed to improve the vision of those in the developing world. So became the foundation’s primary focus, is to improve the prevalence for loss of vision in the developing world, which in most cases can be preventable. In Australia he aimed to improve indigenous health care as well. This foundation has been successful enough to spread throughout the world from Australia to Africa, South Asia, South East Asia and the Pacific. By the year of 2020 they seek to “strengthen national eye health systems”. In their attempts they will seek to use their funds to train surgeons, support current staff, and community health workers, improve and construct new facilities, provide

http://www.cehjournal.org/0953-6833/21/cejh_21_66_024.htm
equipment, and subsidise screenings and procedures for those that cannot afford it, this includes the cataract surgeries. The Hollows foundations also funds research and advocacy. It is this foundation that aims to use technology and apply this to helping those less fortunate, to give them a better life. With their efforts, a gap can be closed and access to better health is provided to those in the developing world.

The Fred Hollows Foundation states that 75% of blindness is unnecessary or could have been avoided. The aims of the foundation is to decrease this figure and moving towards improving eyesight through such a simple procedure. Fred was suffering from cancer and lost his battle in 1993, though since his death, the Fred Hollow Foundation has been able to restore sight to over a million people in the developing world. This has been done by reducing the cost of the surgery to $25 in some developing countries. In the last years of Hollow’s life he worked tirelessly to open an Intraocular lens (IOL) factory in Eritrea and Nepal, which would help to reduce the price of IOLs internationally. This would mean that the surgery would become more accessible for very poor people. At this time it was extremely expensive to replace a cataract, with costs up to US$100. The Multinational IOL manufacturer disagreed with Fred in reducing the price of the IOL. It was decided that the Foundation would create their own. Their thoughts were that "By significantly increasing the supply of affordable high quality IOLs to developing countries, we will reduce one of the barriers to disadvantaged people having their sight restored," said Fred. It was The facilities were opened one year after Hollow’s death in 1994. [http://www.hollows.org.au/Fred-Hollows/the-foundation](http://www.hollows.org.au/Fred-Hollows/the-foundation)

An example of the work of Fred Hollow’s foundation is seen in Burundi in Eastern Africa. It is the smallest and poorest country in Africa. With a population of 8.5 million people, 87,000 of them are blind, 50% of this is due to cataracts. Burundi is in need or urgent eye care as governments are tight with money and there are only 10 ophthalmologists in the country. Though there is ten only 2 have performed eye surgery and the other 8 are based in their capital city of Bujumbura, who work with normal eye services. The Hollow’s Foundation started work in Burundi in 2009. They performed pilot surgical campaign that was a great effort and was effective as it helped restore sight to 183 people. In 2011 they intended to attend to the overall situation of eye care in Burundi. In 2010 the Foundation also funded 3 nurses to be trained in Ophthalmic nursing, provided hospitals with sterilised medical equipment and will implement more measures in helping the eye sight of the overall population. With the contribution of the Hollows foundation, Burundi now has a bright future ahead of them, and a step closer to closing the gap between countries. This is only possible due to the technology that is present in the world in the 21st century.

Technology and facilities of the 21st century has helped minimise avoidable eyesight loss amongst many in developing countries and has given them a second life. Technology has also benefitted society through the internet. The Fred Hollows Foundation is accessed through the internet at [https://www.hollows.org.au](https://www.hollows.org.au). On this page there are links for people to donate money towards equipment, procedures, fundraising, programs and ultimately to help those less fortunate than us. It is through the help of the Fred Hollows Foundation that sight can be given to children, adults and elderly people in developing countries. Their aim of correcting and helping those who are unnecessarily blind is still going strong since 1993 when the Foundation was set up before Fred passed away. With their contribution to society, in conjunction with the available technology of today, the foundation has given other people another chance at sight, which is priceless.

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The Fred Hollows Foundation, 2010, Sydney Australia, 28/01/12  

The Fred Hollows Foundation, 2010, Sydney Australia, 28/01/12  
1. What is a healthy organism?

Discuss the difficulties of defining the terms ‘health’ and ‘disease’

**Health:** A state of complete physical, mental and social health, and not merely the absence of disease

- Very broad - if taken literally it would be very difficult to achieve a healthy status
- Health is very subjective and is a relative term - different perceptions of healthy
- E.g. A person with a chronic disease may consider themselves as healthy, as they have learnt to cope with it

**Disease:** any condition that adversely affects the normal functioning of any part of the body

- Quite broad and imprecise - conditions not normally classed as diseases could be under this def.
- E.g. pregnancy could be classed as disease because they affect ‘normal functioning’
- “normal functioning” is relative and has different levels to different people – absent-mindedness is a normal facet of aging for the elderly, but it could be a manifestation in the young

Also, terms used in general convo have different meanings to sci definition

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

**Cell differentiation** is when cells mature and take on different structures, becoming structurally suited to perform a specific function. **Cell specialization** is when specific genes are ‘switched on’ to perform a particular function. These enable cells to work together to carry out complex functions, in order to maintain and repair body tissues = health.

E.g. Nerve cells - have a particular structure and specific genes ‘switched on’ to transfer electrochemical messages

**Genes** are hereditary units that control the production of proteins. These proteins ensure normal cell functioning, growth and repair. They tightly regulate cell growth and mitosis. E.g.
DNA repair genes - stop cell cycle while damaged DNA is being replaced, preventing damaged DNA from replicating and causing disease

Proto-oncogenes – stimulate cell growth and mitosis

Mitosis is a process of cell division by which identical body cells are produced. This maintains health by allowing for growth, repair and reproduction of cells, maintaining body tissues.

Use available evidence to analyze the links between gene expression and maintenance and repair of body tissues

A gene is expressed when specialisation occurs and it is ‘switched on’ to perform a specific function. This allows the production of proteins that ensure normal cell functioning, growth and repair. They tightly regulate cell growth and mitosis. When normal gene expression is interrupted, proteins that normally maintain and repair body tissues cannot be produced. This can lead to disease.

E.g. one type of breast cancer is fostered by a mutation to BRCA1 gene which codes for proteins that repair the tumour suppresser gene PTEN. Mutation to the BRCA1 gene means that the PTEN gene cannot be repaired if needed and therefore not expressed. This results in a lack of control of the cell cycle and may cause the formation of tumours.

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 diseases are diseases caused by a pathogen. E.g. Measles, chickenpox, influenza

Non-infectious diseases are diseases not caused by a pathogen. There are a number of causes including, environmental, nutritional and inherited. E.g. Cystic fibrosis, scurvy, lung cancer

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

These help to prevent the growth and transmission of pathogens and therefore help control disease.

Personal hygiene practises involve keeping our bodies and any openings clean to reduce the risk of pathogens entering our bodies, or transmission of these pathogens to others.

Regular washing of the body and hair also inhibits the build-up of micro-organisms on our bodies. E.g. gingivitis resulting from a build-up of bacteria in the mouth.

Cleanliness in food reduces the risk of pathogen-contaminated food. E.g. Salmonellosis is a bacterial disease transmitted in undercooked food. Certain guidelines must be followed by food handlers. Food should be fresh and properly stored to prevent microbe growth. All utensils to be properly washed to avoid
Cleanliness in water reduces the risk of pathogen-contaminated water. Domestic water quality must comply with strict standards and is tested daily.

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

Any organism or infective agent that lives in or on another living organism, and causes a disease.

Gather, process and analyze information from secondary sources to 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

Screening- often with large metal grates; removes larger objects that would otherwise rot and keep adding microbes to water

Flocculation- a chemical is added to the water, which binds small organic particles (including microbes) together for easy removal as larger particles.

Filtering- Water is passed through a filter media, such as beds of stones and sand, to remove coagulated organic matter and associated bacteria

The following are disinfection treatments:

Chlorination- chlorine is added to disinfect the water, which kills most remaining microbes. Leaves a residual that protects treated water from recontamination

Ozone treatment- very effective in killing microbes and removing metal ions

UV treatment- Water is passed under large UV lamps. The energy from light can kill microbes. Positive- rapid, does not add toxicity to water. Negative- no lasting residual, allowing possible regrowth

3. During the second half of the 19th 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

Pasteur

• He studied fermentation of beet juice, found it was due to microbes called yeasts

• Also found that microbes called bacteria caused wine, beer and vinegar spoilage. He created a solution, pasteurisation – heat these solutions to kill contaminating bacteria

• Refuted the theory of spontaneous generation, proposing the germ theory of disease- that microbes cause disease, and all microbes come from pre-existing microbes.

• He supported this theory in his famous ‘swan-necked flask’ experiment (see experiment)
Demonstrated that microbes were responsible for causing various diseases, and developed vaccines for many of these, including rabies Koch.

Developed the agar plate technique for growing microbes.

Supported Germ theory of disease by demonstrating that the bacteria anthrax bacillus causes anthrax disease. How: he extracted bacteria in the blood of sheep that had died from anthrax, and cultured it. Then injected it into healthy sheep, that subsequently developed anthrax.

Determined that each disease is caused by a specific micro-organism—discovered the bacterium that causes TB, which was different to the one that caused cholera.

Used principles called Koch’s postulates to identify whether specific micro-organism (MO) cause a particular disease—still used today:

1. Same MO present in every diseased host
2. MO must be isolated and cultured
3. When pure culture is injected into healthy host, host must develop same symptoms as original host
4. MO must be isolated from 2nd host and cultured, and identified as same as original species.

Distinguish between prions, viruses, bacteria, protozoans, fungi, macro-organism and name one example of a disease caused by each type of pathogen:

<table>
<thead>
<tr>
<th>Type of pathogen</th>
<th>Description</th>
<th>Example of disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prions</td>
<td>A mutated form of a protein needed within the organism</td>
<td>Creutzfeldt-Jakob disease (CJD)</td>
</tr>
<tr>
<td></td>
<td>Do not contain genetic material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smallest pathogen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Capable of multiplying by infecting normal prions</td>
<td></td>
</tr>
<tr>
<td>Viruses</td>
<td>A small particle containing genetic material enclosed in a protein coat</td>
<td>Influenza</td>
</tr>
<tr>
<td></td>
<td>Both living and non-living characteristics—contain genetic material (living), but non-cellular (non-living)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smaller than bacteria, but larger than prions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can replicate only inside host cells by taking over the cells reproductive mechanisms</td>
<td></td>
</tr>
<tr>
<td>Bacteria</td>
<td>Unicellular prokaryotic organism—cell wall, no membrane-bound organelles</td>
<td>Humans—Meningococcal Plasmas—Crown gall</td>
</tr>
<tr>
<td></td>
<td>A single chromosome of genetic material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Larger than viruses, smaller than protozoans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reproduce asexually</td>
<td></td>
</tr>
<tr>
<td>Protozoans</td>
<td>Unicellular eukaryotic organism—membrane-bound organelles, no cell wall</td>
<td>Malaria</td>
</tr>
<tr>
<td></td>
<td>Range in size</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reproduce asexually</td>
<td></td>
</tr>
<tr>
<td>Fungi</td>
<td>Eukaryotic organisms—cell wall, no chlorophyll, non-photosynthetic</td>
<td>Humans—tinea (athletes foot) Plants—rust</td>
</tr>
<tr>
<td></td>
<td>Can be unicellular or Multicellular</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vary in size</td>
<td></td>
</tr>
</tbody>
</table>
Macro-parasites

- Reproduce sexually and asexually
- Multicellular eukaryotic parasites, visible to the human eye
- Vary in size
- Some cause disease directly, others act as vectors
- Some live inside host’s body, others outside

Gather and process information to trace the historical development of our understanding of the cause and prevention of malaria

**Cause**
- *Roman times*- recognised symptoms. Greeks believed the disease was caused by bad air, particularly near swamps
- 1880- Laveran discovered the pathogen that causes malaria; a protozoan called *Plasmodium*
- 1897- Ross found that malaria parasite was transmitted by *Anopheles* mosquito
- 1898- Grassi discovered that human malaria is transmitted in the same way as bird malaria

**Prevention**
- 1600s- first drug to treat malaria, quinine, extracted from bark of Peruvian *Cinchona* tree
- 1898- procedures were followed to reduce the chance of being bitten by a mosquito- protective clothing, bodies of water sprayed with oil to prevent mosquitoes breeding
- 1930s- anti-malarial drug Atebrin used to prevent infection in WW2- unpleasant side effects
- 1940s- Chloroquine was developed, which was effective in curing malaria. However, evolution saw parasite resistance to drug
- 1950s- WHO created a program to eradicate malaria. Widespread spraying of DDT insecticide to destroy mosquitoes. Introduced new species of fish into swamps to eat mosquito larvae. Malarial infections dropped dramatically
- 1970s-onwards- a number of new anti-malarial drugs used, yet each becomes ineffective as evolution sees parasite resistance. Measures to prevent being bitten such as mosquito netting remain the most effective measures of prevention

Identify data sources, gather process and analyze information from secondary sources to describe one names infectious disease in terms of its cause, transmission, host response, major symptoms, treatment, prevention and control.

**Disease:** Diphtheria

**Cause:** Bacterium called Corynebacterium diptheriae

**Transmission:** by touch between people, from people to objects then to people, sprayed into the air by coughs and sneezes and then inhaled
**Host Response:** acquired immunity can be developed to the pathogen. However, normal body processes tend to be overwhelmed by the pathogen, and can be fatal if left untreated.

**Symptoms:** initially- sore throat, runny nose, swollen neck glands. A membrane may form at the back of the throat, blocking the windpipe causing suffocation. The bacteria also produce a toxin that can damage heart and nerves.

**Treatment:** antibiotics to kill bacteria, antidote for toxin

**Prevention:** because this disease is very contagious, people with the disease and those who care for them are isolated. Health authorities must be notified of an infection.

**Control:** immunisation – three inoculations are given in the first year of life, then again at 18 months, 5 yrs and at 10 year intervals to maintain immunity.

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**Identify the role of antibiotics in the management of infectious disease**

Antibiotics are chemicals capable of destroying or inhibiting the growth of bacteria that cause disease. Different antibiotics destroy bacteria in different ways and are effective against particular types of bacteria. E.g. pencillin disrupts cell wall structure so bacteria cannot replicate. Erythromycin prevents protein-synthesis. Broad-spectrum antibiotics (sulphonamides) also exist to act on a wide range of bacteria when bacterium is unknown.

**Process information from secondary sources to discuss problems relating to antibiotic resistance**

Infectious bacteria once easily cured (e.g. TB) have developed resistance to cheaper ‘first-line’ antibiotics. As a result, the effects of these diseases are now more severe and the infectious period is longer, meaning there is a greater chance of passing on resistant bacteria. When ‘second-line’ and ‘third-line’ antibiotics have to be used, they are more expensive and toxic. In countries where this is too expensive, the disease is untreatable and therefore spread.

We are now faced with the emergence of ‘superbugs’ – bacteria resistant to all antibiotics (golden staph). The current trend indicates that in the near future, some diseases will have no treatment.

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: skin, mucous membranes, cilia, chemical barriers and other body secretions.**

The first line of defence is a non-specific defence that attempts to prevent the entry of pathogens.

- **Skin** forms a tough outer barrier. It is dry to prevent the growth of pathogens. Oil and sweat glands produce antibacterial and antifungal substances that inhibit the growth of pathogens.
- **Mucous membranes** line the respiratory, digestive, urinary and reproductive
tracts to trap entering pathogens, until they are removed

- **Cilia** are tiny hairs that line the trachea and bronchial tubes. They beat upwards to move mucous containing pathogens towards the throat, where they are removed by coughing and sneezing
- **Chemical barriers**- different types of chemicals secreted in different parts of the bodies act as barriers. E.g. acids in the stomach, urinary system and on skin destroy or inhibit pathogen growth
- **Other body secretions**- tears and saliva contain lysozymes that destroy cells walls of bacteria.

**Gather, process and present information from secondary sources to show how a named disease results from an imbalance of microflora in humans**

Microflora- all the microbes in the body
Candidiasis (thrush) occurs when the natural balance of microflora is upset, causing an increase in the number of the fungus Candida albicans present.
One way this can occur is by taking antibiotics, which reduce the number of natural bacteria. This allows Candida albicans to multiply uncontrollably.

**Identify antigens as molecules that trigger the immune response**

An antigen is any molecule the body recognises as foreign and that triggers an immune response.
E.g. pathogens, foreign cells, toxins may have antigens on their surface

**Explain why organ transplants should trigger an immune response**

‘Marker’ molecules (antigens) on the surface of cells in transplanted organs are foreign to the body and therefore should trigger an immune response.

**Identify defence adaptations, including: inflammation response, phagocytosis, lymph system, cell death to seal off pathogens**

When pathogens enter the body, non-specific responses of the second line of defence are activated.

- **Inflammation response**- when cells detect a pathogen, they release chemical alarm signals that cause blood vessels to dilate, increasing blood flow to the site of infection. The chemicals allow phagocytes to move from the blood into the tissue to attack invading pathogens. The area becomes red, hot and swollen.
- **Phagocytosis (pacman)**- specialised WBC called phagocytes engulf foreign particles, where they are destroyed by enzymes. Two main phagocytes: Neutrophils are short-acting, fighting acute infections. Macrophages fight chronic infections.
- **Lymph System**- Lymph vessels collect intercellular fluid from around the body and carry it to a point near the heart where cleaned lymph fluid is drained back into the blood. As lymph passes through a lymph node, foreign particles are destroyed by macrophages.
• Cell death to seal off pathogens- cells die to seal off an area of infected tissue, preventing it from spreading

5. MacFarlane Burnet’s work in the middle of the 20th century contributed to a better understanding of the immune response and the effectiveness of immunisation programs

Identify the components of the immune response: antibodies, T cells, B cells

The third line of defense is called the immune response and it is a specific response.

<table>
<thead>
<tr>
<th>T Cells</th>
<th>B Cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Lymphocytes produced in bone marrow, mature in thymus gland</td>
<td>• Lymphocytes produced and mature in bone marrow</td>
</tr>
<tr>
<td>• Each T cell has a unique surface receptor protein to identify a specific antigen</td>
<td>• Each B cell has a unique antibody on its surface to identify a specific antigen</td>
</tr>
<tr>
<td>• When activated, cytotoxic T cells are cloned, move to site of infection and release chemicals to destroy infected cells</td>
<td>• When activated, produces plasma cells which secrete antibodies that combine with antigen (antigen-antibody complex) to deactivate it</td>
</tr>
<tr>
<td>• Control cell-mediated immunity</td>
<td>• Control antibody-mediated (humoral) immunity</td>
</tr>
<tr>
<td>• Defend against bacteria &amp; viruses inside cell, protozoans, fungi, flatworms, roundworms, cancer cells, transplanted organs</td>
<td>• Defined against bacteria &amp; viruses outside cells</td>
</tr>
</tbody>
</table>

Antibodies- proteins called immunoglobulins. When B cell is activated by antigen, it produces plasma cells which secrete antibodies that combine with antigen (antigen-antibody complex) to deactivate it.
Can destroy antigen by: immobilising it or blocking its active site.

Describe and explain the immune response in the human body in terms of: interaction between T and B lymphocytes, the mechanisms that allow interaction between B and T lymphocytes and the range of T lymphocytes types and the difference in their roles

Two major pathways of immune response:
• Cell-mediated immunity- t cells
• Antibody-mediated immunity- B cells
Each of these responses is specific to the type of antigen present.

**4 types of T lymphocytes and the difference in their roles:**

1. **Helper T cells** - releases a cytokine chemical (interleukin-2) that activates cytotoxic T cells and B cells to destroy it and stimulates macrophage activity.
2. **Cytotoxic T cells** - move to site of infection and release chemicals that destroy infected cells.
3. **Memory T cells** - remain in body to respond to future infections by the same antigen.
4. **Suppressor T cells** - stop the immune response once infection has been defeated.

**Interaction between B and T lymphocytes:**

- Helper T cells can be activated by B cells.
- B cells encounter antigen, bind it with their antibody and present this to helper T cell.
- Helper T cell then secretes cytokine chemical (interleukin-2) which activate the production of clones of B cells and cytotoxic T cells to destroy infection.
- When infection is defeated, suppressor T cells stop activity of B cells and cytotoxic T cells.

**Mechanism that allows the interaction of B & T cells**

- On the surface of B & T cells are glycoprotein molecules called MHC molecules. These allow the cells to identify each other as cells of the body, preventing them from attacking each other.

**Macrophage:** when it encounters a foreign particle with an antigen on its surface, it engulfs it, where it is destroyed by enzymes. The antigen moves to the surface of the macrophage, which presents it to the helper T cells, activating it.

**Outline reasons for the suppression of the immune response in organ transplant patients**

‘Marker’ molecules (antigens) on the surface of cells in transplanted organs are foreign to the body and therefore will trigger an immune response. Cytotoxic T cells are activated, which attack the cells of the transplanted organ.

**Ways to suppress immune response:**

- ‘tissue typing’ - closely matching tissue of donor and recipient
- Anti-rejection drugs such as cyclosporine

**Outline the way in which vaccinations prevent infection**

When the body experiences a particular disease, memory cells are produced which remain in body to respond to future infections by the same antigen, achieving active acquired immunity.

Immunity to a particular disease can be artificially acquired through vaccinations. They contain cultures of micro-organisms which may be either weakened (rabies),
dead (whooping cough) or contain modified toxins (diphtheria). These contain antigens that trigger the immune response and produce memory cells for that antigen. If the body is exposed to that antigen in the future, the memory cells will destroy it, preventing infection.

Process, analyze and present information from secondary sources to evaluate the effectiveness of vaccination programs in preventing the spread and occurrence of once common diseases, including smallpox, diphtheria and polio.

Smallpox- was a highly infectious viral disease that caused thousands of deaths each year. In 1967, WHO committed itself to a worldwide immunization program. In 1969, WHO declared it had eliminated the virus from the world population.

Diphtheria- highly infectious bacterial infection. In 1974, only 5% of children were immunized. WHO launched the Expanded Program of Immunization, which saw the % of children immunize increase to 80% by 1990, greatly decreasing mortality rates.

Polio- highly infectious and deadly viral disease. In 1988, the World Health Assembly launched a global goal to eradicate polio- widespread vaccination of children under 5. This saw a 99% reduction in polio cases.

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 distribution and frequency of diseases to identify causes and patterns of occurrence of disease in human populations. The relationship between smoking and lung cancer has been established through epidemiological studies.

Three major types of epidemiological studies:

1. Descriptive Studies: large quantities of data are collected over a long period of time to show patterns in the way diseases are distributed. In studies to determine the causes of lung cancer, data collected included the age, sex, smoking habits, diet, occupation and drinking habits of both smokers and non-smokers.

2. Analytical Studies: data is statistically analyzed to identify trends and possible causes. 2 types:
   a. Case-control studies: compare people with the disease to people without the disease and look for differences in exposure to the possible causes of the disease. Doll’s 1947 case-control study in London compared patients with lung cancer to patients with other conditions. It revealed that most of the individuals with lung cancer were smokers.
   b. Cohort studies: two or more similar groups of people who are free of the disease, but have different exposures to the potential cause of the disease, are studied. Over a long period of time, the resulting incidence of the disease is compared. In a 1951 cohort study by Englishman A.B.Hill, more than 40,000 doctors were studied over a 10-year period. One group were smokers and the
other were non-smokers. The results showed that there was a higher incidence of lung cancer in the group of smokers.

3. **Intervention studies**: test the effectiveness of a new treatment or a public health campaign. E.g. the effectiveness of the ‘Quit’ campaign to decrease the number of smokers.

**Gather, process and analyze information to identify the cause and effect relationship of smoking and lung cancer**

- A 1966 case-control study in America showed that smokers have a 10 times greater chance of dying from lung cancer than non-smokers
- In the 1970s, data from about one million American men was collected, including their smoking habits and the diseases they developed. This revealed that the more cigarettes smoked per day, the greater incidence of lung cancer.
- Patterns of smoking changed throughout 20th century, which was correlated by the incidence of lung cancer. In 1900, the majority of lung cancer deaths were men as few women smoked. By the 1990s, the proportion of male smokers declined and so had the incidence of lung cancer. Smoking in women continues to increase and so is the incidence of female lung cancer.

**Identify causes of non-infectious disease using an example from each of the following categories: inherited diseases, nutritional diseases and environmental diseases**

**Inherited diseases**: genetically transmitted and are caused by errors in genetic information

- *E.g.* Cystic fibrosis is caused by a mutation to the CFTR gene on chromosome 7, which codes for the protein that regulates normal movement of sodium chloride. It causes mucus-secreting organs to produce abnormally thick mucus.

**Nutritional diseases**: caused by diets lacking the proper balance of nutrients. They can also be caused by psychological conditions that lead to inappropriate diets.

- *E.g.* Scurvy is a nutritional deficiency that results from a lack of vitamin C in the daily diet, which weakens blood capillary walls, leading to bleeding and bruising

**Environmental diseases**: Various types, including:

- Lifestyle diseases. *E.g.* diseases caused by substance abuse, (lung cancer caused by smoking)
- Diseases caused by physical factors. *E.g.* skin cancer caused by excessive exposure to UV
- Diseases caused by exposure to chemicals in the environment. *E.g.* lead poisoning caused by exposure to high levels of lead in the atmosphere

**Gather information from secondary sources to analyze and present information about the occurrence, symptoms, cause, treatment/management of a named non-infectious disease**

**Inherited disease**: Cystic Fibrosis

**Cause**: caused by a mutation to the recessive CFTR gene on chromosome 7, which codes for the protein that regulates normal movement of sodium chloride. It is recessive, so person must have two mutated copies of it.

**Occurrence**: varies with ethnic groups. 1 in 3300 Caucasians, 1 in 9500 Hispanics

**Symptoms**: mucus secreted is abnormally thick and blocks passageways, affecting breathing, digestion and absorption. May progress to lung disease. Severe chest infections. Malabsorption of nutrients.
Treatment: relieving symptoms, as there is currently no treatment. Supplements to counter the effect of insufficient absorption of nutrients. Daily breathing exercises to prevent excessive build-up of mucus. Lung transplant.

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, or isolation, is a strategy used to control the spread of disease.

The AQIS has many strategies in place to prevent exotic pests and diseases from entering Australia:

- **Border control**- involves the checking of passengers and cargo at the entry points into Australia. Techniques such as X-ray machines, detector dogs and inspection are used.
- **Animal quarantine**- involves all animals coming into Australia spending time at quarantine stations to ensure they are free of disease before they are released
- **Plant quarantine**- all plants and plant products are examined upon entry into Australia. Most are refused entry however, some may be allowed if treated by quarantine officers
- **Human quarantine**- the captains of aircrafts or ships are required to notify AQIS if any passengers or crew display symptoms of prohibited diseases, such as malaria.

Within Australia, there are also restrictions on the movement of fruit, vegetables and livestock to prevent the spread of disease from one region to another. E.g. sugar cane is a restricted import and only inspected cane may be moved across the NSW and Queensland border, to prevent sugar cane diseases such as leaf scald from spreading.

Process and analyze information from secondary sources to evaluate the effectiveness of quarantine in preventing the spread of plant and animal disease into Australia

AQIS is very effective and has kept Australia relatively disease-free. It places restrictions on substances that may be brought into the country (e.g. apples are forbidden) and has many strategies in place to prevent the spread of disease into Australia. E.g. border control involves the checking of passengers and cargo at the entry points into Australia, through the use of X-ray machines, detector dogs and inspection. Living plants and animals must be isolated in quarantine stations to ensure they are free of disease.

When there is an outbreak of a particular disease in another country, further quarantine procedures specific to the prevention of that disease are implemented. E.g. following an outbreak of foot-and-mouth disease in Britain in 2001, which affects cloven-hoofed animals, Australia banned the import of any cloven-hoofed animal products from infected regions. Passengers and mail entering Australia from these regions were thoroughly inspected

Explain how one of the following strategies has controlled and/or prevented disease: public health programs, pesticides or genetic engineering to produce disease-resistant plants and animals

Pesticides are chemicals used to kill the pests of plants and animals, pathogens and vectors that transmit pathogens. They are used widely to spray items brought into Australia. The
effectiveness of pesticides is limited however, as insect vectors and pathogens may build up resistance to it by natural selection.

DDT is an insecticide used to kill insect vectors. It has been widely used to kill the Anopheles mosquito, which carries the malaria-causing pathogen, preventing transmission of this pathogen. The effectiveness of DDT was reduced when mosquitoes built of a resistance to it by natural selection.

Gather and process information and use available evidence to discuss the changing methods of dealing with plant and animal diseases, including the shift in emphasis from treatments and control to management or prevention of disease

As little as 150 years ago, when there was little understanding of the causes of disease, people responded to disease through treatment. With our increased understanding of the functioning of the immune system and genetics, the emphasis is shifting towards prevention of disease.

There are a number of ways diseases are treated and controlled. Antibiotics are used to kill bacterial infections. However, some diseases such as AIDS cannot be cured. This would not be a concern if the disease had been prevented in the first place.

Preventative strategies reduce the occurrence of the disease. For example

• Quarantine restrictions. E.g. Australia banned the import of any cloven-hoofed animal products from infected regions following an outbreak of foot-and-mouth disease in Britain in 2001
• Disease risk planning. E.g. in 2002, Australia set in place a detailed emergency plan in case of an outbreak of foot-and-mouth disease
• Vaccination prevent the individual from contracting disease
9.3 The Search for Better Health

Contextual Outline

When physiological processes malfunction, the body tries to repair the damage. The process is similar in all living things and it is only when the process fails to contain the damage that disease can be recognised.

Humans have long recognised the symptoms of disease both in themselves and the animals and plants around them. Since the beginnings of recorded history, they have noted the signs that reveal that the body is malfunction. Increasing understanding of the causes of disease together with accompanying advances in technology have changed approaches to treatment and management of disease.

The search for measures to treat and manage disease of humans and other organisms continues and this search is paralleled by continued refinements in technology.

This module increases students understanding of the history, nature and practise of biology, the applications and uses of biology, and the implications of biology for society and the environment.
9.4 – The 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 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.
  - **Health** is difficult to define as it has many components, such as physical, mental, and social, some of which are very subjective. What is healthy for one, may not be regarded as healthy for another. Different individuals have different ideas about what is considered appropriate.
    - For example a person who is physically fit and has no sickness can be considered healthy, however he may have mental problems such as depression. On the other hand a person who has a disability such as chronic disease, may describe themselves as healthy, as they have learnt to adapt and appreciate their disability.
  - **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. Also it can used in the wrong context, and the definition is taken too literally.
    - For example the normal absent-mindedness in the elderly which is a normal aging process, however in teenagers is considered a problem as it isn't considered accepted in the 'norms' of teenage society.
    - Also, in the wrong context, a broken arm or pregnancy would be classed as a disease because it adversely affects normal body functioning.
- Outline how the function of genes, mitosis, cell differentiation and specialisation assist in the maintenance of health:
  - **Genes**:
    - Gene are hereditary units that control the production of polypeptides make up proteins needed in the body for growth, repair, normal cell functioning.
    - A malfunction in a particular gene may result in the inability to cells to function properly, and lead to disease. Such as cystic fibrosis is a genetic disease that is caused by the mutation of CFTR gene.
    - Through production of proteins (especially enzymes), genes ensure the correct cell processes occur, maintaining metabolism and homeostasis.
  - **Mitosis**:
    - Mitosis is the process of cell division by which identical body cells are produced, that:
      - allows genetic material to be copied exactly, ensuring the genes are correct and able to maintain health in their own way
      - allows organisms to grow, the more cells the larger the organism.
      - maintain and repair body cells, maintaining health.
Cell Differentiation and Specialisation:

- Cell differentiation and specialisation: is a process in which different genes are activated in different cells, creating the specific proteins that give a particular cell type its character, usually in un-specialised cells (ie stem cells) which develops into a specific type of cell in response to specific triggers from the body or the cell itself. It then develops to a certain shape and produces only certain proteins so that it does a certain job.
  - This is the process which allows a single celled zygote (fertilised egg) to develop into a multicellular adult organism which can contain hundreds of different types of cells.
- 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:

- Gene expression: is the use of information in a gene to produce a observable characteristics in a organism,
  - It DOES NOT mean phenotype, genes are not only for body characteristics, some genes are used inside the body for hormones etc.
  - Each gene in a cell can be ‘switched on’ or ‘switched off’ by a number of conditions both within the cell and outside the cell. A gene is expressed when it is ‘switched on’ and the DNA encoded within this gene is converted into polypeptides.
  - 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.
  - Extra:
  - 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 hence 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:**
  - A **disease** is an abnormal medical condition of an organism that impairs bodily functions, associated with specific symptoms and signs.
  - **Infectious Disease:**
    - It is a disease caused by an organism or infective agent (known as pathogen).
    - The disease can be transferred from one organism to another.
    - Eg:
      - viruses (influenza), bacteria (tonsillitis), protozoans (malaria), prions (CJD), fungi (tinea).
  - **Non-infectious Disease:**
    - It is diseases that are not caused by pathogens.
    - There is no transfer of the disease from one organism to another, with the exception of inherited non-infectious diseases. These can passed down through generations.
    - Eg:
      - Inherited (genetic) disease: down’s syndrome, haemophilia
      - Nutritional disease: scurvy, beriberi, kwashiorkor
      - Environmental disease: skin cancer, asbestosis

- **Identify the conditions under which an organism is described as a pathogen:**
  - **Pathogens** (commonly known as germs) are defined as any infective agent that causes disease.
  - Pathogens can be microscopic organisms (abbreviated microbes) or macroscopic organisms (macrobes).
  - Pathogens include: prions, viruses, bacteria, protozoans, fungi and macro-parasites.
  - **Conditions in which an organism is a pathogen:**
    - Must be **virulent**, that is be able to cause an infection, thus disease.
    - They must be able to **survive transmission** from one host to another.
      - For example chlorea bacteria can survive on food, then can be ingested.
    - Must enter the host through a certain part of the body without being destroyed by the body’s natural defenses then reproduce.
      - For example smallpox enters the digestive system, where its too virulent for the body defence system.
  - **These conditions are known as “Koch Postulates” developed by Robert Koch (his work discussed later).**
  - **Note:**
    - Not all pathogens are micro-organisms (microbes), some are macro-organisms (macrobes, they can be seen with the naked eye, like tape worms).
    - NOT all microbes are pathogens, most are actually very beneficial, such as the ones that participate in the recycling carbon in the air.
Identify data sources, plan and choose equipment or resources to perform a first-hand investigation to identify microbes in food or in water:

- **Aim:** To model and identify the role of microbes in decay.
- **Equipment:**
  - 1 petri dish
  - Moistened bread
- **Safety:**
  - The petri dish is very fragile, hence glass should be worn, and gloves worn in case of accidental damage.
  - Hands should be washed when touching the moistened bread as it may contain pathogens.
- **Method:**
  - In one petri dish, place a piece of bread that has been moistened.
  - Seal the petri dish with a tape and place in a warm place.
- **Result:**
  - Without the aid of magnification, individual microbes are too small to see, though many microbes will cluster together and can be seen with the naked eye, these are known as colonies.
  - After about a week, furry colonies of *Aspergillus* and shiny yeast colonies (both examples of fungi) were observed growing on the bread.

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

- This dotpoint relates to infectious diseases, caused by pathogens.
- Micro-organisms are everywhere around us and can easily enter our bodies through any body openings. Not all are disease-causing, some even beneficial, but in order to decrease the spread and growth of pathogenic micro-organisms, and hence control the incidence and spread of disease, it is important that hygienic (set of rules a promoting cleansing/sanitary practices) are followed, including:
  - **Cleanliness in Food:**
    - Contaminated food is a source of pathogens (such as salmonella), and can very readily spread diseases, as it provides a quick entrance method for the pathogen.
    - 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 (i.e. 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
  - **Cleanliness in Water:**
    - Water will always contain microbes, as this is needed by nearly every organisms, hence reducing the numbers through treatment controls the spread of disease.
- 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, and seep into water through sewage systems.

  - **Personal Hygiene:**
  - If a body is kept unclean, the build of microbes increases, and this increases the chances of there entrance into the body, hence disease.
  - Examples:
    - **Washing hands and covering mouth when sneezing:** reduces the spread of pathogens from person to person.
    - **Sterilization:** complete removal of all traces of microbes. This is required in situations where pathogens are particularly dangerous, eg surgical rooms.
    - **Disinfecting:** reducing microbes to a safe level, such as washing clothes or dishes with disinfectant.

- **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:**
  - To ensure that pathogens do not pose a health risk to the community, water supplies are treated in various ways before distribution to the community.
  - The treatment of water usually has 3 stages:
  - **Primary Treatment:**
    - **Screening:** out large debris using bars and screens.
    - **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.
  - **Secondary Treatment:**
    - **Filtration:** this removes nearly all the remaining microbes and other particles by passing the water through sand beds or charcoal, removes any suspending bacteria.
  - **Tertiary Treatment:**
    - **Chlorination:** adding chlorine forms highly oxidising hypochlorite ions, which kills of the remaining harmful microbes.
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, this included infectious disease causing organisms.
  
  - For example, the Ancient Greeks thought that rats came from garbage.

- **Louis Pasteur:**
  
  - Pasteur discovered that infectious diseases are caused by micro-organisms, and he this is known as his ‘*germ theory of disease*’.
  
  - Hence he dissaproved theory of spontaneous generation, and further proved diseases where caused by microbes.
  
  - **Pasteur’s Swan-flask experiment:**
    
    - 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.
    
    - The flask with the broth open to the air developed cloudy bacterial growths, while the flask with the swan-neck stayed clear.

- **Extra:**
  
  - Pasteur’s work with Anthrax and Vaccination:
    
    - Pasteur demonstrated that anthrax was caused by a rod-shaped bacterium.
    
    - Anthrax is a disease caused by the bacteria (*Bacillus anthracis*) that affects both sheep and humans.
    
    - 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.
    
    - This was because when the ‘weakened’ strain is introduced into a host, they could cause the body to be ready to recognise the real infection. This was known as a *vaccine*, and further put forward the theory of ‘*principle immunity*’ that is used today through vaccines.

- **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 (hence the unwanted sour taste).
  
  - 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:**
  - Koch provided further proof of microbes and their cause of diseases, this was through the studies of the anthrax disease.
  - Koch’s work with anthrax:
    - He obtained infected matter from a sheep suffering from anthrax
    - He placed it on a slide, observed it under a microscope and saw active rod-shaped cells and inactive, dormant spores.
    - He established that the blood of animals with the disease always contained these micro-organisms, while the blood of healthy animals did not.
    - He found that 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; they developed the disease. This proved that it was the bacteria, and not any other blood component that caused disease.
  
- **Perform an investigation to model Pasteur’s experiment to identify the role of microbes in decay:**
  - This is very similar to the experiment before, essentially you can use this as Pasteur experiment in the before task.
  - **Aim:** To model Pasteur’s experiment to identify the role of microbes in decay.
  - **Equipment:**
    - Beef broth made using beef stock cubes, filtered to remove any cloudiness
    - 2 conical flasks, each with a single-hole stopper to fit
    - Glass tubing bent into a S-shape fitted into one of the stoppers
    - Straight glass tubing fitted into the other stopper
    - Bunsen burner
  - **Safety:**
    - The broth that is left open, should not be smelt, or ingested it contains bacteria that can be infectious.
The bunsen burner can reach temperature of over 600 degrees, gloves should be worn and glasses.

- **Method:**
  - Add a filtered beef broth to each of the flasks until they are approximately one-third full.
  - Fit the stoppers, one with straight tubing and the other with the S-shaped tubing to the flasks.
  - Heat each flask so that it boils gently for 15 minutes. Ensure that after boiling there is a small amount of water trapped in the S bend.
  - Leave both flasks in a warm position out of direct sunlight for several weeks.
  - Every 2 or 3 days, observe the contents of each flask.

- **Result:**
  - The s-shaped glass tube, after several weeks, was still relatively clear as cold beef broth, the microbes cannot enter through the water sealed S-shaped tube.
  - The straight glass tube however due to microbes, had converted to a mouldy green and gave a strenous smell when approached.

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

  and name one example of a disease caused by each type of pathogen:

- **Recall:**
  - **Non-cellular life:** is life that exists without a cell structure.
  - **Cellular life:** life that exists with cell structure.
  - **Eukaryote:** a cell with contains a nucleus, and membrane bound organelles.
  - **Prokaryote:** a cell that lacks a nucleus and lacks any membrane-encased organelles.

- Pathogens can be broadly classified as the following:
Prions (ALL cause spongiform diseases):
- Non-cellular, proteins agents that cause disease in mammals.
  - They are altered protein shape from the normal and contain no DNA or RNA.
  - They are coded by genes, but the ‘normal prion protein’ is harmless, but mutated genes codes for a different then ‘normal’ protein, that are infectious. These form long chains that are toxic to nerve cells in the brain, which kill them.
  - They can also convert normal proteins to abnormal proteins.
  - Can be passed from one organism to another (such as when canibilism occurs in Papua New Guinea of the dead).
  
  - Eg:
    - Kuru (this is the canibilism disease)
    - Creutzfeld Jacobs disease.

Viruses:
- Non-cellular, protein coat around genetic material (DNA or RNA).
- Are found in eukaryotic and procaryotic cells; however viruses are neither prokaryotic nor eukaryotic.
- Can only reproduce inside other cells (host cells), killing them.
- There is no cure for viral diseases.
• Eg:
  ➢ AIDS
  ➢ Smallpox
  ➢ Influenza

– Bacteria:
  • Unicellular (single celled), procaryotic cells. Cell wall surrounding cell.
  • No membrane bound organelles, but have a plasma membrane.
  • Some are pathogenic (all parasites) and cause disease; many are useful.
  • They are classified depending on the basis of their shape
  • Eg:
    ➢ Tetanus
    ➢ Pneumonia
    ➢ Anthrax

– Protozoans:
  • Unicellular, eucaryotic (have cell membrane that bounds nucleus and organelles), BUT no cell wall.
  • Free-living, or parasitic.
  • Eg:
    ➢ Sleeping sickness
    ➢ Giardiasis

– Fungi:
  • Unicellular OR multicellular, eucaryotic; have a cell wall made of chitin (not cellulose).
  • Some are unicellular (eg yeast), most are multicellular (eg mushrooms), they reproduce asexually or sexually.
  • They play an important role in decomposition of organic molecules, together with bacteria.
  • Eg:
    ➢ Ringworm
    ➢ Athletes foot (tinea)
    ➢ Candidiasis (thrush)

– Macro parasites:
  • Multicellular, eucaryotic.
  • Large disease causing organisms that can be seen with the naked eye.
  • External parasites are called ectoparasites, internal are called endoparasites.
  • Eg:
    ➢ Endoparasite disease: elephantiasis (by filarial worm)
    ➢ Ectoparasite disease: 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, they target the bacteria without destroying the host.
  
  ▪ Note: Other diseases are treated by anti-virals (for viruses), anti-malarial (for malaria) etc. Antibiotic is only for bacteria.
  
  – Broad-spectrum antibiotics (such as sulphonamides) affect a wide range of bacteria this is done when the bacteria cannot be identified others, known as narrow-spectrum (such as penicillin) act on only one or two.
  
  – 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.

• **Process information from secondary sources to discuss problems relating to antibiotic resistance:**
  
  – **Extra:** the way in which bacteria develop antibiotic resistance:
    
    ▪ In a particular environment, the organisms that have the variation that is best suited to that environment survive and reproduce. This produces a population in which most organisms are adapted to survival in that particular environment. When antibiotics are administered to treat a bacterial infection, some of the bacteria present may possess a natural resistance to that particular antibiotic, and so they survive. They then reproduce and can quickly build up a population that is resistant to the antibiotic. They also can pass this resistance on to other bacteria, which further increases the population of resistant bacteria.
  
  – **Problems relating to antibiotic resistance:**
    
    ▪ Micro-organisms that cause diseases once easily cured, such as tuberculosis, have developed resistant strains that are not responding to the cheaper ‘first-line’. As a result, the effects of these diseases are now more severe, and because they take much longer to cure, the infectious period is longer, thus greater chance of passing this resistant strain of micro-organisms to other members of community.
    
    ▪ When ‘second’ or ‘third’ line antibiotics have to be used they are usually much more expensive and more toxic. The drugs needed to treat multi-resistant tuberculosis are 100 times more expensive than those used to treat the non-resistant forms, and in countries where this is too expensive to use, the disease is untreatable and thus spreads.
    
    ▪ Also there are now a number of infectious bacteria that are so resistant to almost all antibiotics. Even the antibiotic vancomycin, which is used when all other treatments have failed, is having its effectiveness greatly reduced by VRSA (vancomycin-resistant: **Streptococcus Pneumonia** and **Staphylococcus Aureus**) commonly known as ‘golden saph’. These so called superbugs resist near all treatment. They can only be treated using experiment drugs.
      
        ➢ They cause meningitis and pneumonia
        
        ➢ One strain of S. Aureus has added a new gene, enabling it to spread through skin contact and even infect healthy people.
        
        ➢ 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.
• Identify data sources, gather process and analyse information from secondary sources to 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:

  Infectious Disease: Malaria

- Cause:
They are caused by 4 species of the protozoan, more scientifically, sporozoans (type of protozoan or single celled animal) which are called the Plasmodium. There are essentially 4 types which cause harm to humans, the two most common are the Plasmodium Falciparum and Plasmodium Vivax, which cause the subtertian malaria (found mostly in central American) and Benign tertian malaria (Europe, North America) respectively. The less common Plasmodium Malariae, are Plasmodium Ovale quartan and Ovale tertian.

Transmission:
- The Anopheles mosquitoes are the hosts that transmit the disease to humans during the blood-sucking process. When an Anopheles mosquito bites an infected person, a small amount of blood infected with microscopic malaria parasites is taken as it sucks the gametocytes (the sexual forms of the parasite), along with blood. The parasite grows and matures in the mosquito's gut for a week or more. The gametocytes continue the sexual phase of the cycle, which produced and the immature form of plasmodium known as sporozoites. These then travels to the mosquito's salivary glands. When the mosquito next takes a blood meal, these parasites mix with the saliva, are injected with the bite, when this female mosquito bites the man for a blood meal, which it needs to nourish its eggs, it inoculates the parasites into human blood stream, thus spreading the infection and malaria transmission is complete.
- Once in the blood, the parasites travel to the liver and enter liver cells, to grow and multiply. After as few as seven days or as long as several years, the parasites leave the liver cells and enter red blood cells, which normally carry oxygen in the blood to tissues that need it.
- Once in the red blood cells, the malaria parasites continue to grow and multiply. After they mature, the infected red blood cells rupture, freeing the parasites to attack and enter other red blood cells. Toxins released when the red cells burst are what cause the typical symptoms of malaria.

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 by asexual reproduction through feeding on the nutrients, growing and dividing repeatedly 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.
- Malarial attacks present over 4 to 6 hours with shaking chills, high fever, and sweating, and are often associated with fatigue, headache, dizziness, nausea and vomiting.

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.

Prevention:
- Protective clothing, insect repellent, mosquito nets.
Control:

- Control often involves legal and economic factors in aim to stop the occurrence of the disease in individuals and limit the disease in the population.
- For example:
  - The use of drugs to destroy the malarial parasite or insecticides to destroy its vector, the mosquito.
  - The destruction of the breeding places of mosquito larvae.
  - The development of vaccines to produce immunity against the parasite.
  - Genetic engineering of mosquitoes to develop individuals that will resist the parasite.

Gather and process information to trace the historical development of our understanding of the cause and prevention of malaria:

- Causes:
  - 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, the name malaria comes from ‘mala’ (bad), ‘aira’ (air).
  - 1880: Charles Laveran observed micro-organisms in fresh blood from malarial patients and that malaria was caused by the plasmodium micro-organisms.
  - 1886: Camillo Golgi observed asexual reproduction of microbe in blood of patients, and described the immature plasmodium parasites as merozoites.
  - 1894: Patrick Manson proposed that malaria is transmitted by mosquitoes.
  - 1897: Ronald Ross established that the protozoan Plasmodium was the cause of malaria, he showed it can be transmitted and thus established the cycle of transmission through experiments with mosquitoes and birds.
  - 1898: Giovanni Grassi gave the names to different types of plasmodium, such as P.vivax and P.falciparum.

- Prevention:
  - 340 CE: Chinese used qinghao plant due to its anti-fever properties.
  - 1930: The drug atebrin was developed, used in world war II, but had too many side effects and was stopped.
  - 1944: Synthetic quinine was developed from coal tar, it was not as effective as its natural counter-part.
  - 1946: Chloroquine was developed, it was very successful, until the malaria attained resistant characteristics.
  - 1948: All stages of the life cycle of mosquito were identified, and all mosquitos that carried the vector parasite where identified, this allowed scientists to understand what to target.
  - 1950: World health organisation (WHO) began implying different method to eradicate malaria. Such as draining swamps, spraying of DDT.
  - 1960s till present: Many drug-resistant strains of malaria have increased, new antimalarial drugs are continually developed, however the best methods to prevent this ‘natural selection’ of the mosquito, is methods to inhibit their breeding, that is stop the places where they breed, such as swamps.
4. Often we recognise an infection by the symptoms it causes. The immune response is not so obvious until we recover:

- **Note:**
  - Our body is able to defend against many diseases, this is through the **immune system**.
  - An **immune system** is a system of biological structures and processes within an organism that protects against disease by identifying and killing pathogens.
  - The immune system can be split into 2 sections, the **innate immune system**, and adaptive immune system.

![Diagram of the defence mechanisms of the body](image)

- In each of sections, exist lines of defence:
  - The innate immune system involves of 2 ‘lines of defence’, that a pathogen must pass, they are first line of defence, and second line of defence. The most notable thing is the fact that the first and second line of defence act on ALL foreign particles, regardless if its regarded as good or bad, this is known as **non-specific defence**. And hence the name ‘in-ate’.
  - The adaptive immune system involves only 1 grade or ‘line of defence’, that is the third line of defence. The third line of defence acts on specific particles, known as **specific defence**. Hence the ‘adaptive’ system.
• Identify defence barriers to prevent entry of pathogens in humans:
  – Skin
  – Mucous membranes
  – Cilia
  – Chemical barriers
  – Other bodily secretions
– It is a form of first line of defence; it is non-specific type of defence present from birth.
– It uses both physical and chemical barriers to rid of pathogens. They include:
  – Skin (physical barrier):
    ▪ Forms a tough outer barrier that surrounds the body, thus preventing penetration by microbes.
    ▪ It is dry, which helps growth, as microbes need water. Also it is dead, thus when washed away carries the microbes.
    ▪ Outer layers contain keratin, which microbes cannot penetrate, unless the skin is broken – e.g. a cut.
    ▪ If the skin is broken, a seal (clot) is quickly formed by the blood-clotting mechanism to prevent pathogen entry.
    ▪ Skin has its own population of harmless bacteria. These keep the numbers of invading pathogens low by stopping them multiplying (competition).
    ▪ Oil glands (Sebaceous glands) secrete oils (sebum). The lipids in the sebum are broken down by the skin’s bacteria into acids which inhibit bacterial and fungal growth.
  – Mucous Membranes (chemical barrier):
    ▪ A mucous membrane is a membrane lining all body passages that communicate with the air, and having cells and associated glands that secrete mucus.
    ▪ The digestive, respiratory, reproductive and urinary tracts are lined with thick mucus, it is sticky and traps dust particles and pathogens. Mucus holds the pathogen, until it is removed by fluids such as saliva, tears and nasal secretions wash over mucus membranes and contain lysozyme, further this breaks down bacteria cell walls.
  – Cilia (physical barrier):
    ▪ Cilia are minute hairs that project from cells lining the nose, trachea and bronchial tubes.
    ▪ Cilia continuously beat and sweep mucus (containing dust and pathogens) towards the nose or throat opening where it is coughed out or swallowed to be destroyed by the stomach.
  – Chemical Barriers:
    ▪ These create conditions which makes the surfaces inhospitable for the potential pathogens. As remember enzymes are at optimum at a certain pH, any higher/lower and it can denature.
    ▪ Eg:
      ➢ The acidic environment in the stomach, hydrochloric acid.
      ➢ The alkaline environment in the small intestine, high conc. of water.
  – Other Bodily Secretions (physical and chemical barriers):
    ▪ Urine is sterile and slightly acidic; it flushes and cleans the ureters, bladder and urethra. Preventing growth of microbes.
- Tears contain **lysozymes** that destroy the cell walls of some bacteria. As tears are produced and the eyelid blinks, the surface of the eye is cleaned and the pathogens are washed away.
- Populations of harmless bacteria in the vagina act on dead body cells to create acidic conditions, these prevent bacterial and fungal growth.

- **Identify defence adaptations, including:**
  - Inflammation response
  - Phagocytosis
  - Lymph system
  - Cell death to seal off pathogen

  - It is the second line of the immune system is also non-specific (like the first line of defence), it is present from birth.
  - When pathogens are successful in penetrating the barriers that are in place to prevent their entry into the organism, second line is activated to try to destroy the invaders. It also use physical and chemical barriers, including:

  - **Inflammation Response (chemical and physical barrier):**
    - When body tissue is damaged, whether physically or chemicals by microbes, cell are injured, and the inflammation response begins.
    - The injured cells release chemical alarm signals (known as chemokines), which stimulate them to release the chemicals **histamine** and **prostoglandin**.
    - These two chemicals cause the following:
      - Blood vessels around the damaged area dilate and increase their permeability; this increases blood flow to the area.
      - The increased blood flow brings heat and fluids, which make the environment inhospitable to the microbes. Also, the increased blood flow brings **phagocytes** (type of white blood cell discussed later), these cells engulf foreign bodies.
      - Tissues begin to repair after the threat is removed.
    - This response is characterised by 4 symptoms – pain, redness, heat and swelling.

  - **Phagocytosis (chemical barrier):**
    - Phagocytes are specialised white blood cells (leucocytes) that can engulf foreign bodies, there are three kinds:
      - Monocytes
      - Macrophages (a macrophage is ‘differentiated’ monocyte)
      - Neutrophils
    - **Phagocytosis** is the process in which phagocytes change their shape, then engulfing and destruction of foreign bodies by the combing it with enzymes (lysozymes) produced in lysomes which kill it.
- **Lymph System (chemical barrier):**
  - Lymph is intercellular (inbetween cells) tissue fluid that has white blood cells. It is essentially plasma WITH white blood cells.
    - Note: they only contain another type of white blood cell known as lymphocytes.
  - 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 – these nodes are storage structures for lymphocytes and macrophages. As lymph passes through a node, bacteria and debris are removed by these. Lymph system is sometimes called the body’s drainage system.
  - **Extra (come to this, after finishing the topic):**
    - The lymph system contains organs which produce lymphocytes (hence the name ‘lymph’):
      - Bone marrow: where B cells mature
      - Thymus gland: where T cells mature
– **Cell Death to Seal Off Pathogen (physical barrier):**
  - When the body is unable to neutralize a pathogen, body cells are killed (poisoned) by macrophage nitric acid discharge, these dead body cells then surround.
  - The wall of dead cells form a capsule like structure, which is further surrounded by layers of macrophages, then lymphocytes, then fibroblasts, which produce a tough outer wall it is known as a cyst (*garnuloma*).
  - These cells die so the pathogen can no longer survive.
  - These structures are produced in diseases such as tuberculosis and leprosy.

– **Extra: Other Bodily Secretions (physical and chemical barriers):**

– **Anti-Microbial Proteins:**
  - The body also produces special proteins that assist in the second line of defence. They are interferons.
  - **Interferons** are a group of proteins produced (and secreted) by cells when invaded by viruses.
  - They cause surrounding cells to form their own anti-viral chemicals, preventing the spread of the virus.
    - Note: they acts only on viruses, and are non-specific; thus good for short-term infections.

– **The Complement System:**
  - It is a group of 20 proteins that assist other defence mechanisms. That is aid in a ‘cascade’ of reactions to destroy pathogens.
  - They are ‘**complement protein**’, meaning that the first protein causes the production of the second, and the second the third, and so on. For example stimulating phagocytes to become more active, attracting phagocytes to the site of the infection, or destroying membranes of the invading pathogen.
  - The final protein embeds itself in the pathogen’s cell wall (or membrane) causing it to die by lysis (cell-bursting).

- **Identify antigens as molecules that trigger the immune response:**
  - The third line of defence will act on ‘specific particles’ (heavily discussed later).
  - An **antigen** is a molecule that the body recognises as foreign and triggers the immune response.
  - **Antibodies** (discussed later) are proteins that the immune system produces to destroy/inactivate these antigens.
  - The name of antigen is derived from antibodies:
    - Antigen → **ANTI**body - **GEN**erating substance
  - The body recognises antigens, hence ‘specific particle’ targeted, because in the body, every un-forgein cell has a special chemical ‘marker’ molecule, that is recognised as ‘self’. When antigens enter a body, their surface shows a different chemical ‘marker’, hence being ‘non-self’. This causes the immune response to destroy it
  - Note: a major confusion is usually between Pathogen and Antigen, every pathogens have antigens (usually proteins) on their surface that incite the immune response. Hence every pathogen has an antigen, but NOT every antigen is a part of a pathogen, it does not only have to be pathogens, any debris or small particles can cause the response, even snake venom which isn’t pathogenic).
  - Eg:
- 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:**
  - When a person has an organ transplant, the new organ they are receiving from somebody else has, on the surface of its cells ‘marker’ molecules that are different to the marker molecules of their own cells.
  - 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. Thus when organs are searched for that specific person, their tissue type is identified such that organs of similar type are located to lessen the ‘violent’ immune response. However most of the times immunosuppressant drugs are given, which will lessen the immune response so the organ is not attacked.

- **Gather, process and present information from secondary sources to show how a named disease results from an imbalance of microflora in humans:**
  - **Microflora** (micro: small, flora: organisms) are micro-organisms that live on or in the body, and usually do not cause disease.
  - They lived mainly on the skin, and in the intestines, the colon, the mouth and the vagina (in women). Most are often part of the first line of defence, eg. the harmless bacteria that secrete acids to destroy pathogens.
  - The body supplies these microfloras with the nutrients and conditions they require to survive. In return, the presence of these micro flora inhibits the growth and multiplication of many pathogens by competition, thus protecting the body from contracting diseases.
  - If the conditions of the body change (for any reason), the balance of microflora is upset, thus the growth and multiplication of the harmful pathogens may not be controlled; this leads to an increase number, and development of disease.
  - **Candidiasis** (commonly known as ‘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, 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: (LEARN THIS)

- **Note:**
  - **Immunology**: the science that deals with how the immune response works.
  - The body has 3 lines of defence, the first 2 of which are non-specific, the 3rd being specific (that is they act specifically on one type of pathogen), this is known as the **adaptive immune system** and undergoes **adaptive response**.
  - The adaptive immune response provides the vertebrate immune system with the ability to recognize and remember specific pathogens (to generate immunity), and to mount stronger attacks each time, hence its ‘adaptive’ immunity because the body's immune system prepares itself for future challenges.
  - It is characterised by specific ‘pathogen fighting’ cells, which are white blood cells. They can be characterised as follows:

![Leukocytes diagram]

- The primary difference between **granular** and **agranular** leukocytes is that the former has visible granules, whereas the later does NOT have noticeable granules (ie visible structures when viewed under light microscope).
– There are three types of granulocytes:
  ▪ Neutrophil granulocytes
  ▪ Eosinophil granulocytes
  ▪ Basophil granulocytes
– There are two types of agranulocytes:
  ▪ Lymphocyte agranulocytes
  ▪ Monocyte agranulocytes
– Phagocytes (cells that can phagocytise pathogens) include: neutrophils, monocytes, macrophages.
  ▪ Macrophages are produced by the differentiation of monocytes.
– For the next section, lymphocytes are heavily looked at.
– Lymphocytes are a type of white-blood cells that act only against specific antigens.
– There are 2 types of lymphocytes, B cells and T cells, each of which have further sub-types.
  • Identify the components of the immune response:
    – Antibodies:
    – B Cells:
    – T Cells:
    – It is third line of defence, it acts only on specific antigens.
    – This immunity is NOT present at birth, it is gained through exposure to infection. It has a MEMORY.
    – It is ONLY carried out by lymphocytes.
    – It is characterised into two parts:
      ▪ Anti-body mediated immunity (aka humoral immunity): immunity that is mediated by the secretion of antibodies by lymphocytes. These antibodies are produced by B-Cell, there are literally thousands of antibodies, each specific for an antigen.
      ▪ Cell-mediated immunity (aka cellular immunity): is an immune response that does not involve antibodies but rather involves the activation of certain cells to destroy pathogens directly. These cells are T-Cells.
    – Essentially, anti-body response is a chemical response (by antibodies), and cell-mediated is physical (by cells). The reason a human has this amazing system is the fact that anti-body response, kills the pathogen causing disease, whilst cell-mediated kills the cell containing the pathogen. This is particularly useful for things like viruses in which move around and infect cells, or cancers in which are in cells.
    – B-Cells:
      ▪ B-Cells are lymphocytes that matured in the bone marrow.
        ➢ B - Cell  ➔ Bone marrow
After they have matured they are released into the blood and lymph nodes. B-Cells usually are found inactivated but are activated by the presence of antigens.

Once this ONE B-Cell is activated, it mass clones itself, and then differentiates into:
- **Plasma B-Cells:** These cells create the antibodies, the antibodies will then move to the site of the infection and combine with the antigen to form the **antigen-antibody complex** which deactivates 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 recognise the antigen if it appears again, hence having ‘memory’.

**– Antibodies (these go hand in hand with B-Cells):**
- Antibodies as previously mentioned are proteins that the immune system produces to destroy/inactivate these antigens.
- More specifically, they are a group of Y-shaped proteins called globulins, and are often referred to as **immunoglobulins**.
- There are 5 different classes of immunoglobulins (abbreviated Ig) known to be in humans, each having a specific role in providing immunity, they are (IgG, IgM, IgE, IgA, IgD).
- They are made and activated by **plasma B-Cells**.
- All antibodies have 2 “binding sites”, these are **specific** and bind to the antigens. Forming the **antigen-antibody complex** which is then engulfed by phagocytes.

**– T-Cells:**
- T-Cells are lymphocytes that mature in the thymus gland (the gland is found in the chest cavity).
  - T-Cell → Thymus gland
- After they mature, the T cells are released into the blood and lymph nodes.
- Each T cell has a special unique surface protein receptor, which can recognise an antigen, and hence becomes activated.
- After the 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. Yes there is an interaction between the B and T cells (discussed later).
  - Cytotoxic (Killer) T-Cells: These cells attach to infected cells and produce chemicals which destroy that cell (hence the antigen infecting it).
  - Memory T-Cells: Remain in the body and give long term immunity.
  - Suppressor T-Cells: They suppress the numbers of B and T-cells after 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:

- Immune system is characterised into two parts, the **Anti-body mediated** and **Cell-mediated** immunity.
- Each type of reponse made by these parts uses a different type of lymphocyte. The humoral is controlled by B-Cells, whilst the cell-mediated is controlled by T-cells.
- However to successfully defend the body against infection, there must be an interaction between these 2 cells.

**Extra:**

**Cytokines:**

- **Cytokines** are a group of **SIGNALLING COMPOUNDS** made of proteins or polysaccharides that are used for communication.
- This interaction between the two types of cells is regulated by a specific type of cytokine chemical called **interleukin** is further responsible for many of the processes involved.
- They are secreted by **Helper T-Cells** and **macrophages**.
- When these cells secrete interleukins, they are signaling, or stimulating, the other cells to differentiate, in response to an antigen – such as a B-Cell changing into a Plasma B-Cell.

**Range of T-Cells and difference in roles:**

- **Helper T-Cells:**
  - On surface exists 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 (both process discussed in detail below), it releases a cytokine chemical (interleukin-2) that stimulates the B-Cells and T-Cells to differentiate into their different forms, then these forms are **SPECIFIC** to this antigen (ie only stimulate the B and T-Cells with the same antigen-binding sites).
- **Cytotoxic T-Cells:**
  - Its function is to recognise and kill body cells that are infected by pathogens (they only work against infected cells, not directly against pathogens).
  - These cells are stimulated to produce many copies (clones) of themselves, then attack pathogens, when activated by either:
    - Helper T-cells or
    - Free antigens that display their surface markers
- **Extra:**
  - How they work:
    - Killer T-cells have a T cell receptor (TCR). TCRs work with body proteins called **major histocompatibility complexes** (MHCs). T cells search the surfaces of cells throughout the body for an MHC to match with its TCR.
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.

It then releases a chemical called **preforin**; this perforates (ie makes holes) in the cell membrane of the infected cell.

The body cell lyse; water rapidly enters by osmosis and it bursts.

The infected body cell is killed, together with the microbe inside it.

- **Memory T-Cells:**
  - Like all the other lymphocytes these cells are produced during the time of infection, ie the time when cytotoxic T cells are multiplying.
  - 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.

### Interactions Between B and T-Cells and the Mechanisms of Interaction:

- This is the work of MacFarlane Burnett, called ‘**clonal selection theory**’.
- The **clonal selection theory** has become a widely accepted model for how the immune system responds to infection and how certain types of B and T lymphocytes are selected for destruction of specific antigens invading the body.
- 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 THE ONE antigen-specific lymphocyte – the one that has the binding site which 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. For example, the Cytotoxic T-Cells and Plasma B-cells for influenza bacteria cannot kill the pneumonia bacteria.

Firstly, the antigen travels in the blood until it is engulfed by a macrophage (by phagocytosis; but wont kill it, it will fragment it into peptide pieces).

This is then transported to a lymph node where the macrophage then becomes an antigen-presenting cell that then displays the antigen it has engulfed on its surface.

The antigen-presenting macrophage then ‘alerts’ the antigen to either; a Helper T-Cell or B-Cell that has a receptor corresponding to that particular antigen. The immune system is thus known to the presence of antigens in the body.

Note 1: The B and T-Cells can be activated either by macrophage response, or activated directly by antigens. How they are activated by antigens:
  - For T-Cells infected cells display the antigens (MHC-I markers).
  - The B-Cells are also activated by free antigens in the blood.
The Helper T-Cells then produce the chemical INTERLEUKIN, which stimulates T and B-Cells to differentiate into their different types. The B-cell that detected the antigen can also stimulate the differentiation.

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 cell by preforin.

When the immune response has successfully defeated the infection, suppressor T cells are responsible for suppressing the activity of B cells, and cytotoxic T cells.

**Extra:**

A critical difference between B cells and T cells is how each lymphocyte recognizes its antigen. B cells recognize their antigen in its native form. They recognize free (soluble) antigen in the blood or lymph using their membrane bound-immunoglobulin. In contrast, T cells recognize their antigen in a processed form, as a peptide fragment presented by an antigen presenting cell's using its MHC molecule to the T cell receptor.

- Outline the reasons for the suppression of the immune response in organ transplant patients:
  - Similar to focus area 4 and why organs transplant trigger immune response. In the HSC you’re required to combine the two.
  - When a patient receives a donor organ, this organ will have, on its surface, ‘marker’ molecules that are different from the ‘marker’ molecules on the cells in the recipient's body. These marker molecules are recognised as ‘foreign’ material, and the immune response is initiated.
  - The cytotoxic T cells are activated and move to the transplanted organ to attack and destroy the cells. This causes the rejection of the transplanted organ.
  - SUPPRESSION of the immune system is needed to prevent the body from rejecting and destroying the organ.
  - The chances of rejection is reduced by matching the transplant organ tissue (known as tissue typing, such as in identical twins) with the tissue of the patient, and by providing immunosuppression drugs (such as cyclosporin).
  - The danger of this therapy is the inability of the patient to fight off any infections, since the immune system is suppressed.

- Outline the way in which vaccinations prevent infection:
  - When an antigen is first encountered by the immune system, the time taken to fight the infection is quite long. This is because; once the antigen has been identified, the appropriate T cells and B cells have to 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.
  - If sufficient antibodies are made to destroy all the infecting antigens, the person recovers completely. This is known as primary response.
  - If the same antigen were to re-enter the body in the future, the response would be a secondary one. That is the identification of the antigen, and it being destroyed, occurs much fast due to memory B-cells and T-cells.
- **Vaccination** (or *immunisation*) is the process of making people resistant to infection caused by a pathogen by giving people an injection or oral dose of a weakened strain of microbe of a certain disease (ie. *vaccines*).
  - Vaccines can be:
    - Live viruses
    - Killed or attenuated (harmless) strains pathogens
    - Inactivated toxins
  - Vaccines can give two types of immunity:
    - **Active Immunity**: this involves the vaccine having weakened strains of *antigen* of the pathogenic virus that is injected to the person. 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 cell 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.
      - Eg. 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
      - Eg. Tetanus serum

- Process, analyse and present information from secondary sources to evaluate the effectiveness of vaccination programs in preventing the spread and occurrence of once common diseases, including smallpox, diphtheria and polio:
  - Before much was known about the cause, treatment and prevention of disease. Many people lost their lives to diseases that today have been eradicated or low incidental.
  - Mass immunisation programs not only prevent the occurrence of the disease in individuals, but also help to decrease the spread of the disease throughout the population. If the majority of the population is immunised against a disease, the chance of an infected individual coming into contact with an unprotected person is extremely low and the transmission of the disease is effectively stopped. This is known as the principle of *herd immunity*. 


- **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 bubbles 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**: the science dealing with the transmission and control of disease.
  - **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 study **should be repeatable** by other investigators at different time, and different places, using different methods.
  - 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.

- **Gather, process and analyse information to identify the cause and effect relationship of smoking and lung cancer**:
  - **Lung cancer** is the uncontrolled growth of tumors in the lungs.
  - **Causes**:
    - Tobacco smoke contains over 4000 chemicals, many carcinogenic (causing cancer) such as:
      - Benzene: found in petrol fumes
      - Tar: road surfacing
      - Arsenic: rat poisen ing
      - Methanol: rocket fuel
  - **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 life expectancy.

A 1960 study by Horn in the United States, compared average smokers and non-smokers life expectancy, the smokers had 10 times greater chance of dying.

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.

Identify causes of non-infectious disease using an example from each of the following categories:

- Inherited diseases
- Nutritional diseases
- Environmental diseases

Recall:

- Non-infectious diseases are not caused by pathogens, and are not contagious (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.
- Eg:
  - Down Syndrome is an inherited disease that is caused by the inheritance of one extra chromosome in the 21st spot (trisomy 21).
  - Others include: minor disorders, such as myopia or serious such as haemophilia

Nutritional Diseases:

- These are caused by incorrect or insufficient diets.
- Eg:
  - 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.
  - Others include: over-eating (obesity) or under-nourishment (anorexia)

Environmental Disease:

- Many factors in the environment can cause disease
- They include radiation, heavy metals, pollution, etc
- Eg:
Asthma – this disease is where the muscles in the airways contract and can cause severe breathing difficulties. Causes include pollution, pollen and dust.

- **Analyse and present information about the occurrence, symptoms, cause, treatment/management of a named non-infectious disease:**
  - **Disease:** Down syndrome
  - **Cause:**
    - It is a genetic disease that is caused by the presence of an extra chromosome in the 21st position (known as trisomy).
    - This abnormality can be caused in several ways. The most common being a fault occurring in meiosis in the ovaries. During the lining-up of homologous chromosomes the members of pair 21 do not split (called non-disjunction) and go into one of the daughter cells together, resulting in half the gametes having twenty-four chromosomes while the other half only have twenty-two. The latter die. If an ovum with twenty-four chromosomes is fertilized by a proper sperm (gamete; sex cell) which has 23 chromosomes, one of which is normally in the 21st position, the grand total of chromosomes is forty-seven, with three copies of pair 21 as opposed to only two.
    - Remember, that each characteristic is created from 2 genes, each gene coming from a chromosome at the same genetic loci, one chromosome being maternal, and one being paternal.
  - **Symptoms:**
    - Lower than average mental ability, speech impairment, protruding heads, almond shaped eyes, shorter limbs, enlarged tongue and a high risk of heart failure.
  - **Occurrence:**
    - Approximately 1 per 733 live births.
    - The birth of Down's syndrome children has been associated with the age of the mother. Non-disjunction is more likely to occur in females over the age of thirty-five and the risk increases sharply with a rise in the mother's age over forty.
  - **Treatment/Management:**
    - There is no cure for Down syndrome. Every cell will contain 47 chromosomes and this cannot be altered.
    - The effects however, can be treated. For example:
      - The tongue can be surgically shortened to aid in eating, breathing and talking.
      - Special education programs can be established to help slow learners and assist them to gain certain skills that enable them to integrate easily into the community.
      - Physiotherapy may be needed, as children born with Down syndrome have weakened muscles, and shorter arms and legs.
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 enforced isolation of patients suffering from a contagious disease in order to prevent the spread of disease. This includes the import or export of diseased animals, plants, and other products.
  - Australian Quarantine and Inspection Service (AQIS) is responsible for this, for example:
    - **Border control:**
      - It involves checking passengers and cargo at entry point into Australia. A range of techniques are used by quarantine officers including: x-ray machines, detector dogs, surveillance and so on.
      - This prevents people entering Australia in brings things as plant seeds, fresh foods, eggs, meat. All of these items can contain many dangerous plant and animal pests and disease.
      - In an effort to deter the entry of these products, large fines are imposed, which have greatly reduced the incidence the spread of disease.
    - **Animal and plant quarantine:**
      - Many animals coming in Australia, are left in stations, where a number of tests are conducted to make sure the animal is free of disease, before they are allowed to enter the country.
      - MOST plants are not all allowed in the country, this is because even if they are free of disease, they maybe inhospital to Australian flora and fauna, and hence can contradict disease.
    - **Human quarantine:**
      - In aviation, most captains of aircrafts are required to notify AQIS if any passengers show signs of major infective diseases. These include rabies, SARS, malaria, yellow fever.
      - Also in all airports, there exists mosquito-trapping process after a flight has landed, this prevent any potential vectors entering the country.
    - **Other: public awareness programs and vehicle checking:**
      - These awareness programs have been implemented so that the travelling public and local residents are aware of the procedures and guidelines that in place. And the potential disasters that can occur.
      - Used vehicles and agricultural machinery are inspected and cleaned to ensure no soil/plant matter enters the country.
• Process and analyse information from secondary source to evaluate the effectiveness of quarantine in preventing the spread of plant and animal diseases into Australia or across regions of Australia:
  – The effectiveness of the quarantine service (AQIS) is very high when considering its success in preventing the spread of plant and animal diseases into Australia. For example the following that have NOT entered Australia:

  - **Animal disease: 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.

  - **Plant disease: Sorghum downy mildew:**
    - This disease has been prevented from entering into Australia
    - Caused by a fungus; the fungus inhibits the plants ability to make chlorophyll, which results in the death of the plant

  - **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

• Explain how one of the following strategies has controlled and/or prevented disease:
  – Public health programs
  – Pesticides
  – Genetic engineering to produce drug-resistant plants and plants

  - **Pesticides** are chemicals that are used to kill the pests of plants and animals, pathogens, and vectors that transmit pathogens from one organism to another.
  - If these pests and vectors are killed using pesticides, then the occurrence of disease will be prevented and the spread of disease through the population will be controlled.

  – An example is using pesticides to kill the insects acting as vectors for the malaria disease, or the killing of lice.
  – DDT (dichloro-diphenyl-trichloroethane) was also used to kill lice on the bodies of soldiers during WWII, the lice transmitted the pathogen which caused diseases such as typhus fever. The pesticide prevented thousands of deaths.
  – DDT is also used to kill populations of the *Anopheles* mosquito which carries the plasmodium protozoa that causes the disease malaria.
  – This controlled the spread of malaria, as transmission of the pathogen was prevented by the death of the vector. It was very effective in the beginning, and numbers of malaria sufferers went down, but then the mosquitos built up pesticide-resistance hence reducing its efficacy.
– This is one problem associated with use of pesticides, which is the ability of the insect vectors or disease-causing organisms to build up a resistance to the pesticide through the process of natural selection. This has the effect of decreasing the effectiveness of the pesticide and increasing the necessity for the development and use of different types of pesticides. The use of these pesticides is also being discouraged more and more due to their damaging effects on the environment.

• 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:

– **Treatment** of diseases involves strategies employed to either cure the disease or relieve its symptoms once an organism has the disease.

– **Control** of a disease involves reducing its spread through the population of organisms once it is already present.

– **Prevention** of disease involves the use of strategies that stop the occurrence of disease in organisms.

– **Management** of disease is a system that improve the outcomes of chronic (long-lasting) conditions and improve the quality of life of sufferers.

– When penicillin were discovered, the emphasis when dealing with diseases was on their treatment and control due to their significant impacts. However, the continual use of antibiotics has lead to resistance from the pathogenic population. The emphasis shifted towards the prevention and management of diseases.

– Many antibiotics are used to cure bacterial infections, plant diseases are also controlled by the use of pesticides. Some diseases such as AIDS, who cannot be successfully cured by treatment are forced to live with their symptoms for the rest of their lives. Many of these problems would not exist if the disease was prevented.

– Furthermore, bacterial diseases that were once successfully treated with antibiotics must now be treated with stronger or new types of antibiotics. This is due to the development of antibiotic resistance in the micro-organism that causes the disease. With the prevention of these disease, the use of drugs and the development of resistant strains of micro-organisms will be reduced.

– Preventative strategies reduce the occurrence and incidence of disease in the population. It means that there are reduced risks to organisms in the population, and this would lead to a better overall quality of life, with less suffering for humans.

– Less money would have to be spent on health and there would be less drug and pesticide resistance. This change was possible due to increased understanding of immune system and advanced technologies.

– 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

- **Perform an investigation to examine evidence of pathogens and insect pests on plant leaves and shoots:**
  - **Aim:** To examine plant shoots and leaves for evidence of pathogens and insect pests.
  - **Safety:**
    - Use gloves to prevent allergic reactions.
    - If you are examining insects or pathogens while they are still on plants, ensure that diseases are not spread from one plant to another.
  - **Method:**
    - Examine plant specimens provided using a hand lens, or microscope.
    - Look at areas of discolouration, patchy patterns, or other significant ‘unfitting’ traits, these should be evidence for invasion by a pathogen or attack by an insect pest.
    - Using reference material, determine the pathogens and diseases caused. Then record the results.
  - **Result:**
    - **Disease caused by pathogens:**
      - Bacteria cause rust, which are spots on the surface of the Banksia leaves.
      - Fungal infections cause black stem rot, which are shown by dark growths on the stems or on the undersides of leaves.
    - **Disease caused by insect pests:**
      - Azalea lace-bugs, affects many plants including azalea. These bugs inhabit the underside of the leaves and suck out the sap creating holes and damage, causing the leaves to turn speckled brown. Sugary liquid called honeydew is also secreted and sometimes a sooty mould develops on this, causing the leaves to appear a rusty colour.
      - Two-spotted mites, causes leaves to turn a dull green with pale mottling; then the leaves turn yellow and the webbing spun by the mites becomes visible. New growth is curled under and has a slightly brownish tinge.
Search for Better Health

1. **What is a healthy organism?**

1.1 **Discuss the difficulties or defining the terms ‘health’ and ‘disease’.

**Health:**

- State of complete physical, mental and social well being and not just the absence of disease or infirmity
- Health is relative to each person and is constantly changing, a person that is suffering from a disease could still be classified as healthy
- Problem with health is that the definition is very broad and specific and it is possible for a person to be healthy and have a disease at the same time

**Disease:**

- Disease is any condition that adversely affects the normal functioning of any part of a living thing. Disturbance of Homeostasis.
- Problems- “normal functioning” broken arm, pregnancy, absent mindedness
- Therefore the normal functioning may be at different levels for different individuals.

**Discuss the difficulties of defining the terms “health” and “disease”**

- It is relative- what one person classifies as healthy is different to another, it is also constantly changing and the definition is very broad and subjective.
- There are so many diseases and a person can have a disease “any condition that adversely affects the normal functioning of any part of a living thing” but be healthy at the same time- eg have a broken, as disease also includes minor conditions, such as a cut finger or an ant bite, as well as the more obvious diseases.
- A person who carries HIV may be ‘healthy’ if the symptoms of the disease AIDS have not appeared.
1.2 Outline how the function of genes, mitosis, cell differentiation and specialization assist in the maintenance of health

**Differentiation:** cells mature and take on different structural features, so that they become structurally suited to perform a specific function in the body

**Specialisation:** specific genes are “switched on” in order to perform a particular function in the body. To be specialized genes have to tell cells what to do.

- **Genes** are the units of inheritance. They control the process of protein synthesis. They assist the maintenance of health by regulating the cell cycle and limiting the growth and reproduction of cells. Genes provide the code for proteins that are needed for growth and repair. Enzymes, which control all body processes, are proteins and thus have been produced from the codes of genes.

- **Mitosis** is cell division that produces identical cells. These cells are important for growth and reproduction. Each day millions of cells die and are replaced by the process of mitosis.

**Describe an example of specialization and differentiation of cells**

- Nerve cells have a particular structure, and specific genes ‘switched on’ that allow the transfer of electrochemical messages
- Macrophages are cells that carry out the specific function of phagocytosis to help the body fight disease
- Differentiation and specialization enable cells to work together in a healthy body to carry out complex functions in a controlled and coordinated way in order to maintain and repair tissues. If differentiation and specialization of cells do not occur for any reason, the cells would not be able to function effectively and processes in the body would not be co-ordinated.
- Eg Organ transplants: eg liver cells differentiated (everyone has this) but are specialized to each individual (this is where rejection comes in)

**Justify the need for the correct functioning of mitosis and genes in the body.**

- It is necessary for genes to work correctly as the maintenance of health is dependent on the information stored in the DNA of each cell, as a gene makes up the hereditary unit that controls the production of polypeptides that make up the proteins in the cell. These proteins are responsible for normal cell function, growth and repair. A malfunction in a gene may result in the inability of the cells to function properly and lead to the onset of disease
- Eg Cystic Fibrosis is a genetic disease that is caused by the mutation to the CFTR gene. This information contained in genes prescribes how and when an organisms' body tissues are maintained and repaired, so that any malfunction in these genes will be detrimental to healthy cells.
Mitosis: cell division for
- genetic stability: in which there is a precise and equal distribution of chromosomes to each daughter nucleus, so that all the resulting cells contain same number and kind of chromosomes as each other and the parent cell
- this allows the cell to function normally and tissues in the body to be repaired and maintained. If cells damaged replaced by division growth and repair
- Genes: code for proteins which are responsible for the regulation of the cell cycle and mitosis in healthy cells
- The types of genes responsible for the regulation of the cell cycle and mitosis are

DNA Repair Genes: code for proteins that are responsible for stopping the cell cycle while other proteins remove the damaged regions of DNA and replace them with a new correct sequence

Proto-oncogenes: these code for proteins that stimulate cell growth and mitosis

Tumour Suppressor Genes: these code for proteins that slow down or stop cell growth and mitosis. These genes also code for proteins that induce cell death if there is an uncontrolled increase in cell numbers. Mutations to certain genes could cause uncontrolled cell death, which leads to degenerative conditions such as Alzheimer’s disease.

1A Use available evidence to analyse the links between gene expression and maintenance and repair of body tissues

What is meant by ‘gene expression’?

Each gene in a cell can be ‘switched on’ or off by a number of conditions both within the cell and outside the cell. A gene is expressed when it is switched on and the DNA code is converted into polypeptides that control the structure and functions of the cell.

Some genes (called constitutive genes) are continually expressed to maintain normal body functions. For example: the genes that code for the enzymes that are involved in digestion

Other genes (called facultative genes) are only expressed when needed.

Example: The links between gene expression and maintenance and repair of body tissues are demonstrated by the production of a regulating group of proteins in response to certain bowel conditions to bring about the necessary repair.

Outline the link between genes and proteins.

Proteins can repair genes

Genes code for protein synthesis (control proteins)
Describe the importance of protein production for maintaining and repairing body tissues.

It is very importance as correct gene expression is therefore necessary for the ongoing maintenance and repair of tissues.

Needed in mitosis

Outline the function of:

a) a tumour suppressor gene

Stop and slow downing mitosis

b) the BRCA1 gene

A tumour suppressing gene; responsible for coding for proteins involved in the repair of the PTEN gene

If this does not work: could lead a person susceptible to cancer

c) the PTEN gene

A tumour suppressing gene that limits the amount of cell division and encourages cell death. This regulates the cell cycle and prevents the excessive proliferation of cells that lead to tumours and cancer.

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

2.1 Distinguish between infectious and non infectious disease

Infectious disease refers to disease caused by pathogens such as prions, bacteria, viruses, protozoa, fungi or macroscopic parasitic animals. Infectious diseases can be spread from one organism to another by direct or indirect transmission.

Non-infectious diseases are diseases caused by genetic (inherited), environmental factors, diet or physiological malfunction, such as diseases associated with ageing and those through the mutations of cells and DNA. They cannot be spread from one organism to another. They do not have a vector.

Trisomy 21 (chromosomal), anorexia nervosa (physiological), cancer (mutation), scurvy (nutritional- vitamin C deficiency)
2.2 Explain why cleanliness in food, water and personal hygiene practices assist in control of disease.

- Provides an easy access for microscopic organisms to enter the body - usually have to get through more defence barriers
- Through proper sanitation, proper food handling, personal hygiene and water treatment processes, the spread of disease is controlled.
- The use of disinfectants, sterilisation and antiseptics decreases the spread of disease.
- Crowded conditions, poor sanitation and untreated sewage increase the spread of disease.

Cleanliness in Food:

- Diseases caused by microorganisms passed on through food
- Human tapeworm is caused by eating infected undercooked pork
- Cholera & dysentery can be caught by infected food
- Replication of bacteria
- Eg Salmonella poisoning, Hepatitis A (eating uncooked shellfish that has grown in waters polluted with sewage)
- Hands washed, utensils washed – prevent cross contamination, hot foods kept above 60 degrees, foods should be covered before storage

Factors in Food Poisoning:

- **Temperature** – ideal bacterial growth at 5 ° to 60°
- **Time**- Bacteria can reproduce 2 mill in 8 hours
- **Nutrients**- in food provide nourishment for rapid bacterial multiplication
- **Water**- needed for bacterial growth

Cleanliness in Water:

- Major prob 3rd world
- Most water ways full of pathogens- water needs to be purified
- Domestic water quality – complies with strict standards
- 1998- health scare cryptosporidium & giardia from faecal contamination. Boiling water prevented further contamination as high temps killed pathogen (vomiting, diarrhea)

Hygiene Practices:

Personal Hygiene:

- Regularly washing/ brushing teeth (prevent gingivitis)
- Reduce risk of pathogens entering bodies
Community Hygiene:

- Build up of pathogenic organisms in community and reduces spread of disease
- Breakdown of infrastructure: community hygiene breaks down and rapid spread of disease - Tsunami that hit South East Asia in 2005.
- Involves sewage and garbage disposal, sterilization of equipment in hospitals, city planning (overcrowding)

- Many disease causing organisms transferred by inhaling infected droplets Influenza & pneumonia:
- Impetigo: direct skin contact with infected person (extremely contagious)

2A Perform a first-hand investigation to identify microbes in food or water.

Aim: To plan, choose equipment or resources to perform a first-hand investigation to identify microbes in water.

Hypothesis: The pond water will contain the most microbe groups.

Risk Assessment:

<table>
<thead>
<tr>
<th>Identification of Risk</th>
<th>Description of Potential Harm</th>
<th>Strategies to minimise Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agar plates with microbial colonies</td>
<td>Exposure to colonies could cause serious disease</td>
<td>Seal of petri dishes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sterilize after use/dispose correctly</td>
</tr>
<tr>
<td>Sterilising inoculation loop</td>
<td>Burns caused by hot wire after heating inoculating loop</td>
<td>Ensure that only part of the inoculating loop that is touched is handle</td>
</tr>
<tr>
<td>Exposure to micro-organisms</td>
<td>Could cause disease</td>
<td>Wipe benches – disinfectant</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disposable gloves</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hands washed</td>
</tr>
</tbody>
</table>

Equipment:

- Pond water
- Fish tank water
- Distilled water
- Agar plate
- Alcohol spray
- Gloves
- Bunsen burner
- Incubator @ 25-30°C
- Sticky tape
- Inoculating loop
- Paper towels

Variables:

Independent – type of water used
Dependent – colour, size, shape, boundaries of colonies
Controlled – amount of water, conditions
Control – agar plate with nothing on it, time, temperature, dish.
**Method:**
1. Nutrient agar plates should be heated in a pressure cooker (autoclaved) to sterilise them.
2. All surfaces should be wiped with alcohol solution to minimise risk of contamination. All other objects should be moved out of the area if not used.
3. The inoculating loop should be sterilised using the Bunsen burner.
4. When opening the dish, the lid should not be lifted more than 45° and the opening should be pointing away from group members to avoid contamination.
5. Work as quickly as possible without breathing or coughing all over the dish.
6. Dip the inoculating loop into your sample of water and then gently move the loop over the surface of the agar in a zig-zag motion, being careful not to dig in the surface.
7. After the dish has been closed, it should be sealed all the way around the edge with sticky tape and labelled around the edge of the underside.
8. Place the agar plates upside down (to prevent condensation) in the incubator for a number of days.

**Results:** Pond water contained most, followed by fish water (filter) and then the distilled water (has been sterilized, all minerals taken out)

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

**Pathogen:** any organism or infective agent that lives in or on another living organism, and causes a disease

Prions, Viruses, Bacteria, Protozoans, Fungi, Macro parasites

- Transmission can be direct, where the pathogens pass directly from one person to another
- Transmission can be indirect, where the pathogen is transferred from the environment (air, food, water) to the person
- Person to Person by being carried by another organism (vector). **Mosquito is a vector that can transmit malaria parasite or Ross Rive fever virus from person to person**
### Disease | Infectious/Non Infectious | Reason
---|---|---
Common Cold | Infectious | Caused by virus
| | | Transmitted droplets in the air
Lung Cancer | Non-Infectious | Caused by malfunction in cell division
Multiple Sclerosis | Non-Infectious | Malfunction of the immune system
Genital herpes | Infectious | Virus (pathogen)
| | | Sexual Contact
Malaria | Infectious | Protozoan. Person to person by a vector (anopheles mosquito)
Stomach Ulcer | Infectious | Bacterium. Close contact with people or food and water.
Down Syndrome | Non Infectious | An inherited disease
| | | Causes large stomachs

*If a pathogen is to cause a disease it must be:*
- Able to **spread** in large numbers
- **Virulent** (able to cause an infection readily and often with serious effect)
- Able to **enter** the host or survive on the body without being destroyed.
- Able to **reproduce** without being destroyed by the body’s defence system.
- Able to **escape** from one host to the next.
- Able to **survive the transmission** from one host to the next.

*Ways in which pathogens may cause disease symptoms:*
- The **large numbers** of pathogens present are too many for the host tissue to function normally
- The pathogen **destroys cells or tissues**
- Bacteria produce **poisonous toxins**
- The pathogen may not directly harm the host, by an **excessive immune response** by the host may damage tissue.

2B **Describe ways in which drinking water can be treated and use available evidence to explain how these methods reduce the risk of infections from pathogens**

1. **Describe how each of these processes are used in the treatment of drinking water:**
   a) **sedimentation**
   - large matter that settles to the bottom
b) coagulation and flocculation

- Coagulation is changing to a solid state
- Flocculation: a substance that promotes the clumping together of particles ie wastes
- Then become heavy and sink to the bottom
- Coagulant:
- The removal of fine suspended particles by coagulation and filtration is important as these small particles attract and hold bacteria and viruses. This alone removes about 99% of bacteria and viruses.

c) filtration

- remove particulate matter that may harbour pathogens
- traditionally sand beds are used for filtration
- but increasingly membrane filtration is being used with an increased level of control of pore size
- activated carbon may be added to water containing dissolved toxins, colours, tastes, odours, as it absorbs many contaminants that can then be removed by filtration

Note: removal of fine suspended particles by coagulation and filtration is important as these small particles attract and hold bacteria and viruses. This alone removes 99% of bacteria

2. Identify and describe the most common form of disinfection used in water treatment in Australia

- NSW water is filtered, chlorine is added to kill bacteria and samples are tested for the presence of coliform bacteria, giardia and cryptosporidium.
- Most common is adding chlorine – killing pathogens

3. Identify and describe other forms of disinfection that can be used in water treatment

- Ozone: inactivates pathogens and breaks down organic molecules such as herbicides and pesticides. Such as algal toxins
- Eg water near farm/garden run off
- Chlorine dioxide (gas) - kills Giardia, but it is poisonous to fish - we use it in water that doesn't have organisms in it.
- Ultraviolet irradiation may also be used for disinfection

You may have noticed that a sudden summer storm leaves behind a very distinct smell, sort of a "fresh scent" which lasts for about an hour. In this case, you smell Ozone, which has been creating from lighting bolts during the electrical storm. Ozone is also created by the Sun's ultra violet rays.
4. Draw a flow diagram showing steps involved in treatment of water from its storage source until its distribution to consumers

H₂O Source
   ↓
Reservoir
   ↓
Sedimentation
   ↓
Add coagulant & floc is formed & sinks to bottom
   ↓
Chemicals such as Cl are added to disinfect H₂O
   ↓
Fluoride is added
   ↓
Storage tank for distribution

**Measuring Water Quality:**

- **Fluoride:** maintenance of dental health
- **Aluminium/Iron/Manganese:** occur naturally in water and may cause problems of staining and taste
- **Trihalomethanes:** by products of disinfection process

- **Turbidity:** measure of quantity of suspended particles in water which may make it appear cloudy
- **Coliforms:** Escherichia Coli – faecal contamination
- **Chlorine:** kill pathogens cause disease
• Drinking water is screened and filtered to remove large and small particles. Traditionally, sand beds have been used for filtration but, increasingly, membrane filtration is being used with an increased level of control of pore size.
• Activated carbon may be added to water containing dissolved toxins, colours, tastes, or odours as it absorbs many contaminants that can then be removed by filtration.
• Ion exchange resins can also be used to remove dissolved contaminants. Such materials form the basis of desalination plants.
• Often, a coagulant such as aluminium sulfate or ferric chloride is added. These react with suspended particles forming flocs that settle rapidly and can be easily filtered.
• Ozone or chlorine dioxide disinfect and oxidise a range of substances such as algal toxins, taste and odour compounds and even trace levels of insecticides in water.
• Ultraviolet irradiation may also be used for disinfection.
• Oxidising substances such as chlorine and ozone kill microorganisms.

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 contribution of Pasteur and Koch to our understanding of infectious diseases.
• In the 1860s many believed that life forms such as beetles, maggots and rats suddenly came to life from decaying matter (spontaneous generation). Diseases arose from non living matter
• Even after the invention of microscopes, there was very little understanding about infectious diseases and the link between microbes and disease.
• With his famous swan-neck flask experiment, he demonstrated that bacteria and mould cannot generate spontaneously and that microbes cause decay. Disprove Spontaneous Generation
• Establish ‘Germ theory of Disease’. Germs (microbes) cause disease and that all micro-organisms come from pre-exiting microorganisms
• Koch: each disease is caused by a specific microorganism
• Pasteur: Micro organisms in the Air cause infectious diseases. Microorganisms were the cause of wine, beer and vinegar spoilage. Solution was to heat these solutions long enough to kill the contaminating bacteria that were present after fermentation. Beginning of Pasteurization. Also rotting food was due to the activity of living organisms.

Pasteur’s classic experiment:
  - He placed broth in long neck flasks and then bent some of the necks into an s-shape while others were left straight as a control.
- He boiled the broths to kill the microorganisms.
- He left them for a while to observe the results
- Germs in the air could reach the sterile broth in straight neck flasks but the swan
  necked flasks trapped the dust and germs in the film of moisture on the humid
  curve.
- After a while the broth contained many organisms while the swan neck broth was
  still sterile.
- If the swan neck was broken off, both developed colonies of mould and bacteria.
- Since air alone did not cause the broth to develop mould and bacteria, the
  experiment showed microbes cause decay and there is no spontaneous generation.

- Learning of Pasteur’s theory that microorganisms caused disease, Robert Koch
  investigated, and in 1876 discovered the anthrax bacilli.
- Koch showed that bacteria were the cause of a disease called anthrax in horses, cows,
  sheep and humans.
- The germ theory became firmly established with Pasteur’s work with anthrax. In 1876,
  Robert Koch isolated the anthrax bacillus and suggested that sick animals be killed or
  burned as the bacterial spores survived for months in contaminated fields.
- Pasteur decided to work on anthrax and added one drop of blood from a sheep dying of
  anthrax to 50mL of sterile culture and grew the culture.
- The bacteria caused the disease as only the reproducing bacillus could escape dilution.
- His work with chicken cholera made Pasteur believe he could find a vaccine for anthrax –
  and eventually he did.
- Using 25 sheep as controls and 25 vaccinated, Pasteur gave all
  sheep a lethal dose of
  anthrax. Two days after the final inoculation, all control sheep were dead and all
  vaccinated sheep were alive and healthy.
- The publicity educated the world about microbes and vaccination. Establishing theory of
  immunity.
- He also demonstrated that bacteria were the cause of tuberculosis in humans.
- Pasteur: established vaccines against rabies.

- In 1884, Koch made a list of criteria needed to prove that a particular organism causes a
  particular disease. These are known as Koch’s postulates.
  1. It must be shown that the microorganism believed to be the cause of the disease is
     always present in the diseased organism.
  2. The microorganism must be isolated and grown in a pure culture – a culture
     containing only that microorganism. Have to be able to replicate it.
  3. Microorganisms from the pure culture, when injected into a healthy organism,
     must produce the disease.
  4. The organism must be re-isolated, grown in pure culture and compared with the
     organism first injected and shown to be identical.
3A: Perform an investigation to model Pasteur’s experiment to identify the role of microbes in decay.

**Aim:** To model Pasteur’s experiment in order to the role of microbes in decay.

**Equipment:**
- beef broth made using beef stock cubes, filtered to remove any cloudiness
- 2 conical flasks, each with single hole stopper
- glass tubing- S shape, fitted into one of the stoppers
- straight glass tubing fitting into the other stopper
- heating equipment

**Method:**
1. Dissolve a meat extract cube in hot water.
2. Set up equipment: a conical flask fitted with a one-holed stopper through which a glass tube bent into an S shape is passed to prevent the entry of air.
3. Set up an identical flask and stopped but containing a straight piece of glass tube.
4. Place equal amounts of broth in both flasks and gently boil for about 15 minutes.
5. Observe for several weeks, looking for changes to the broth, including odours.
6. Dispose of contaminated liquid by autoclaving.

**Controlled Variables:**
- Sterilised – heated to kill microbes (control variables)

**Control:** swan necked tubing – no bacteria Pasture already proved it

**Results:** The liquid in the container open directly to airborne microorganisms went cloudy, developed scum, bubbled and produced unpleasant odours, while the container with the ‘S’ shaped tubing remained unchanged. (Note: if the ‘S’ bend was insufficient to prevent the entry of microorganisms, the broth may also go cloudy)
Conclusion: Microbes could not grow spontaneously. Fermentation relies on the entry of microbes to the medium.

3.2 Distinguish between prions, viruses, bacteria, protozoans, fungi and macro-parasites and name one example of a disease caused by each type of pathogen.

<table>
<thead>
<tr>
<th>Type of pathogen</th>
<th>Description of Pathogen</th>
<th>Disease caused by Pathogen</th>
</tr>
</thead>
</table>
| Prions           | Or Proteinaceous Infectious Particle  
                   - Consists of only protein (no nucleic acid) - cable of causing disease  
                   - Don’t contain any genetic material  
                   - Proteins that have been altered to an abnormal shape.  
                   - Cause degeneration of brain tissue. Diseases caused by prions are called spongiform diseases because the brain tissue of individuals are full of holes- always fatal.  
                   - Smaller than all other pathogens  
                   - Normal prion proteins are coded for by genes. Unclear function but they are present mainly in the nerve cells of brains. These normal prions do not cause disease & can be destroyed by heat  
                   **Contract It:**  
                   - Eating tissue containing infectious prions  
                   - Surgery containing contaminated implements  
                   - Inherited mutated gene that codes for infectious prions  
                   - Mad cow disease  
                   - Kuru: (found in tribal people in Papua New Guinea) – brain doesn’t work- doesn’t tell body to pass nutrients around.  
                   - **Symptoms:** uncontrollable shaking continuous trembling, grimacing of the face which led to the name ‘laughing death’. Transmitted by eating during funeral ceremonies the infected brain |
### Viruses
- Non cellular pathogens – characteristics of living/non living
- Small (30-300 nm)- viewed electron microscope
- Nucleic acid (DNA or RNA). Able to pass on hereditary information and not composed of cells
- Core surrounded by protein coat that encloses genetic material- either DNA or RNA (depending on virus)
- RNA= retrovirus
- Reproduce only inside other cells, not on their own
- No cures for diseases caused by this type of pathogen.
- Vaccination reduces incidence. (rubella, measles, influenza)
- Virus attaches itself to cells, it then enters and takes over cell’s reproductive mechanisms to make many copies of itself. Cell becomes so full of copies of the virus that it dies and bursts increasing the new viruses so they can repeat the process with other host cells

### Bacteria
- Single celled (0.5 – 100 um)- larger viruses/smaller protozoans
- Prokaryotic (no nuclear membrane)
- Have cell wall but no membrane-bound nucleus or organelles
- Genetic material single large chromosome
- Reproduce by binary fission (dividing in 2)- asexual reproduction
- Cause disease by secreting toxins, invading cells and forming colonies
- Mostly harmless – involved in the decomposition of dead organisms and the recycling of nutrients in nature
- Classified by shape; spherical (coccus), rod (bacillus), spiral (spirillum)
- Treated Antibiotics; penicillin

### Protozoans
- Single celled (2-1000 um)
- Eukaryotic (genetic material surrounded by nuclear membranes)
- Classified by their form of locomotion. (e.g. flagella, cilia, pseudopods, sporozoa)

### Fungi
- Eukaryotic, possess a cell wall – membrane around organelles
- Do not contain chlorophyll- not capable of producing own food
- Can be unicellular (e.g. yeasts) or multicellular (e.g. mushrooms)
- Can be saprophytic (live on dead matter) or parasitic (live on a host)
- Can be treated with chemicals

### Macro-parasites
- Visible to the naked eye larger than other pathogens
- Multicellular Eucaryotic
- Endoparasites – live inside a host/long association with host e.g. flatworms. Disease Taeniasis Hydatidosis, elephantiasis
- Ectoparasites – live on a host (outside)/brief association with host/most are arthropods. Mosquitoes, flees, ticks, leeches
- Can be treated with chemicals
3.3 Identify the role of antibiotics in the management of infectious disease.

3.D Process information from secondary sources to discuss problems relating to antibiotic resistance.

Antibiotics play an important role in the management of infectious diseases. Antibiotics were discovered by Alexander Fleming in 1928. They are naturally occurring compounds produced by one organism to prevent the growth of bacteria. Before the discovery of antibiotics, many people died of what we now would think of as simple infections.

- Extracted from the mould penicillium
- Selectively toxic to living cells. Kill or inhibit the cells of microbes such as bacteria, but do not harm human cells.
- Used in syphilis, tuberculosis
- Penicillins interrupt cell wall in some bacteria
- Sulfonamindes prevent DNA synthesis in some bacteria

Resistance to antibiotics is an increasing concern. HAPPENS THROUGH NATURAL SELECTION
Among billions of pathogen cells there may be a few which have natural resistance to the antibiotic- when antibiotic kills others, the resistant cells survive and reproduce and evolution takes place. (MRSA)

Incorrect Use of Antibiotics cause of antibiotic resistance:
- Treat viral infection (antibiotics completely ineffective)
- Using wrong antibiotic for an infection, using drugs prescribed for a different illness
- Not completing full course of antibiotics – resistant bacteria are able to survive and increase.
- Increased use in farm animals; increased the speed of antibiotic resistance.
- Using cleaning products that target microbes. Water and soap sufficient unless huge pop of pathogens

- Many hospitals are now encountering Staphylococcus aureus (golden staph) infections that resist all treatments, whereas this type of bacterium was once easily controlled using the antibiotic penicillin, strong chemical can be used but harmful. Can lead to blood poisoning
- Since the late 1980s, there has been an increase in the antibiotic resistance of Streptococcus pneumoniae. This bacterium is the common cause of pneumonia, middle ear infections, sinusitis and bacterial meningitis.
- New antibiotics need to be developed as various strains of bacteria become more resistant.
- Preventing infections is also an important part of reducing the need for antibiotics.
### 3B Historical Development of our understanding of the cause & prevention of Malaria:

1. Recognizing symptoms of the disease and hypothesizing its cause
2. Discovering micro organism responsible for causing malaria
3. Determining life cycle and mode of transmission of the protozoan that causes malaria

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 CE</td>
<td></td>
</tr>
<tr>
<td>240 CE</td>
<td></td>
</tr>
<tr>
<td>2000 years ago</td>
<td><strong>Recognising the symptoms of the disease and hypothesizing as to the cause:</strong></td>
</tr>
<tr>
<td></td>
<td>Before Greeks: Chinese mythology three demons present; hammer, pail of cold water, third with a stove. “headache, chill, fever”</td>
</tr>
<tr>
<td></td>
<td>Ancient Greeks noted that the symptoms of malaria were common in people who lived in moist, low and hot districts near swamps</td>
</tr>
<tr>
<td></td>
<td>Caused by breathing bad air from the swamps therefore “mala” (bad) “aria” (air)</td>
</tr>
<tr>
<td>mid 1600s</td>
<td></td>
</tr>
<tr>
<td>1880</td>
<td><strong>Discovering the micro-organism responsible for causing malaria</strong></td>
</tr>
<tr>
<td></td>
<td>Pasteur and Koch’s work stimulated others to search for microbes that caused malaria.</td>
</tr>
<tr>
<td></td>
<td>Charles Laveran: discovered pathogen looking at blood of infected patients – Protozoan <em>plasmodium</em> Nobel Prize</td>
</tr>
<tr>
<td>1885</td>
<td>Golgi: established that there were two forms of this disease: fever on alternative days and another fever every third day. Each of these forms produced differing amounts new parasites- the peak of fever coincided with release of merozoites into blood</td>
</tr>
<tr>
<td>1890</td>
<td>Grassi &amp; Filetti = names for two parasites Golgi discovered (P vivax) and (P malariae)</td>
</tr>
<tr>
<td>1897</td>
<td><strong>Determining the life cycle and mode of transmission of the protozoan that causes malaria</strong></td>
</tr>
<tr>
<td></td>
<td>• Ross thought transmission from mosquitoes to humans when exposed to water infected by malaria</td>
</tr>
<tr>
<td></td>
<td>• Fed mosquitoes on malaria patients – subsequently tried to find malaria parasite growing in the body of these mosquitoes: UNSUCCESSFUL</td>
</tr>
<tr>
<td></td>
<td>• Then repeated with females: - after few days found cells not normally present. These were the malaria parasites growing in mosquitoes tissuses</td>
</tr>
</tbody>
</table>
In 1987, Ross found cysts in the stomach walls of the mosquito *Anopheles* and identified the cysts as the malaria-causing parasite. Suggested that mosquitoes (females) may be vectors as he couldn't show transmission from human to human.

**1898:** human malaria is transmitted in the same way as malaria in birds. Found thread like bodies in their salivary glands - indicated to him that malaria was passed back to birds through the mosquitoes saliva when birds are bitten.

Ross fed mosquitoes on infected birds and allowed them to bite healthy birds. All became sick. Control healthy birds not bitten didn’t get sick.

<table>
<thead>
<tr>
<th>Prevention:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Destruction of the malaria parasite using drugs</td>
</tr>
<tr>
<td>2. Destruction of vector (mosquito)/prevention of breeding/by means of insecticides, draining stagnant water, and introduction of fish to eat the parasites larvae -minnows</td>
</tr>
<tr>
<td>3. Protection of host: preventative use of drugs - take chloroquine one week before and six weeks after leaving. Chloroquine interferes with the development of the parasite. Protective clothing/insect repellents/vaccines. EDUCATION PROGRAMS</td>
</tr>
</tbody>
</table>

Prevention closely follows the discovery of the parasite that caused malaria and its life cycle.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>340 CE</td>
<td>Anti fever plant used</td>
</tr>
<tr>
<td>2000 years ago</td>
<td>Greeks/Romans used drains to remove stagnant water</td>
</tr>
<tr>
<td>1898</td>
<td>Mosquito responsible for transmission malaria - bodies water sprayed with oil – couldn’t breed, protective clothing worn</td>
</tr>
<tr>
<td>1901</td>
<td>Pyrethrum used: derived from chrysanthemum flower</td>
</tr>
</tbody>
</table>

**Reasons why there has been a large increase in the occurrence of malaria in the last 20 yrs**

- Development resistance strains of *Plasmodium* to drugs
- Resistance in mosquitoes to insecticides
- Greater population movement
- Greater population density in affected areas
Life Cycle of Malaria

1. If an infected mosquito bites a human, the protozoan passes into the human blood stream.
2. If the human is already infected, the protozoan can pass from the human to the mosquito and is therefore spread to other humans.

Mosquito has to get malaria from someone (infective stages- gametocytes sucked up)

Mosquito sucks Plasmodium from infected person gets malaria virus

Parasite forms gametes in gut of mosquito. Fertilisation to form a zygote which immediately undergoes meiosis; then forms a cyst in stomach wall of mosquito. Asexual reproduction continues.

Sporozoites break out of cyst and released into saliva (a motile sporelike stage in the life cycle of some parasitic sporozoans (e.g., the malaria organism) that is typically the infective agent introduced into a host.)

Injects Sporozoites in saliva containing malaria virus into human being.

Malaria enters into liver, reproduces asexually in cells in the liver.

Malaria virus multiples becomes Merozoites. Liver cells burst and parasites float freely in the blood.

Enters Red Blood Cell and flows through entire body, feed on hemoglobin in RBC
The parasite is picked up by the mosquito when it bites an infected human and sexual forms develop in the mosquito gut. The lifecycle is complete.

**3C Describe one named infectious disease in terms of its:**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause</td>
<td>The parasitic protozoan, <em>Plasmodium</em></td>
</tr>
<tr>
<td>Transmission</td>
<td>Anopheles mosquito is the insect vector. Blood from a malaria victim contains <em>Plasmodium</em> sex cells. These form zygotes in cysts in the stomach wall of the mosquito and mature into sporozoites. When a cyst bursts, the sporozoites travel to the mosquito salivary glands, from where they are transferred to the victim of the mosquito bite. The sporozoites travel to the liver, multiply and then enter the red blood cells, where they also multiply. When the infected cells burst, they cause the malarial fever. Male and female gametes are produced from these sporozoites, which are then taken in the blood the next time a mosquito bites.</td>
</tr>
<tr>
<td>Host response</td>
<td>When in the blood cells the host produces antibodies against <em>Plasmodium</em>, responsible for destroying bacteria that have invaded the body.</td>
</tr>
<tr>
<td>Major symptoms</td>
<td>Chills, fever, sweating, delirium and headache</td>
</tr>
<tr>
<td>Treatment</td>
<td>Anti-malarial drugs such as quinine and chloroquinine</td>
</tr>
<tr>
<td>Prevention</td>
<td>Cover up after dark and use personal insecticide, mosquito nets, malaria tablets</td>
</tr>
<tr>
<td>Control</td>
<td>Draining swamps, spraying with insecticides.</td>
</tr>
</tbody>
</table>
4. Often we recognize an infection by the symptoms it causes. The immune response is not so obvious, until we recover.

4.1. Identify defence barriers to prevent entry of pathogens in humans: skin, mucous membranes, cilia, chemical barriers and other body secretions.

4A: Show how a named disease results from an imbalance of microflora in humans.

<table>
<thead>
<tr>
<th>1st Line of Defence (non specific)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin</td>
<td>Cells fit tightly together to form a protective layer covered by dead cells. Consists of two major layers the <strong>Epidermis (multiple layers of tightly packed cells, few pathogens penetrate)</strong> &amp; <strong>Dermis (collagen fibers help skin resist abrasions that could introduce microorganisms)</strong>&lt;br&gt; Skin continuously grows by new cells being produced from below. &lt;br&gt; Outside layers of dead dry cells= virtually impossible for microbes to penetrate &lt;br&gt; When unbroken, skin prevents the entry of pathogens. Pores in the skin secrete substances that kill bacteria- antibacterial and antifungal substance . Sebum- keeps skin pliable and less likely to break or tear, lowers skin pH to a level inhibitory to many bacteria. &lt;br&gt; Difficult environment for a pathogen to grow &lt;br&gt; Skin flakes off – carrying microbes away</td>
</tr>
<tr>
<td>Mucous membrane</td>
<td>Occur along the alimentary (relating to nutrients) canal. &lt;br&gt; Line openings including mouth, throat, urinary/reproductive tracts that secrete a protective layer of mucus – traps pathogens &lt;br&gt; When there are many pathogens more mucus is produced to flush them out.</td>
</tr>
<tr>
<td>1st Line of Defence (non specific)</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| Cilia                            | Hair-like projections from cells lining the air passages  
                             | Constantly beating in an upwards direction to move the mucus containing the trapped pathogens towards the throat, where they are removed by coughing, sneezing or swallowing.  
                             | Eg mucus in breathing tubes moved upwards, until can be swallowed into acid of stomach  
                             | Coughing & sneezing reflexes move dust, mucus and trapped pathogens- out of breathing passageways |
| Chemical barriers                | Acid in the stomach; alkali in the small intestine (kills those resistant to acid in stomach)- kills pathogens  
                             | Stomach acid destroys pathogens, including those that are carried to the throat by cilia and then swallowed.  
                             | Urinary + Reproductive Openings: are mildly acidic enough to inhibit growth of many microbes |
| Other body secretions            | Secretions from sweat glands and oily secretions from glands in hair follicles  
                             | Contain chemicals that destroy bacteria and fungi.  
                             | **Tears:**  
                             | - contain antibacterial enzyme “lysozyme”. Destroy the cell walls of some bacteria. As the tears are produced and the eyelid blinks, the surface of the eye is cleaning and the pathogens are washed away.  
                             | **Flushing Mechanisms:**  
                             | - Regular emptying of the bladder flushes microbes from the bladder and urethra  
                             | - Production of tears and regular “blinking” wash & wipe microbes from the eyes.  
                             | **Reflex Actions:**  
                             | - Vomiting removes stomach contents that are making you nauseous, removing pathogens which have been swallowed. |
Microflora: Living in and on are many “friendly” microbes which share a symbiotic relationship with us. Some live in intestines and manufacture vitamins for us. Others live on skin and mucous membranes where they normally act as competitors to potential pathogens. They keep the population in check by outcompeting the pathogens, or by creating chemical conditions that pathogens cannot tolerate.

Microflora Imbalance Can Lead To Disease:

Female reproductive system is largely protected by its normal micro flora. Taking medications such as antibiotics, steroids, the Pill, pregnancy, malnutrition and diabetes mellitus can upset the normal balance. Yeast Candida albicans, which is always present in low numbers can take advantage and multiply rapidly. Results in Thrush.

Candida (Thrush):

<table>
<thead>
<tr>
<th>Causes</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance found on mucous membranes: found inside your cheeks covering your palate and inside vagina/anus</td>
<td></td>
</tr>
<tr>
<td>Mucous Membrane, looks speckled, with white clumps</td>
<td></td>
</tr>
<tr>
<td>Vaginal discomfort – itching or burning</td>
<td></td>
</tr>
<tr>
<td>A thick, white discharge with a ‘cottage cheese’ appearance and yeasty smell</td>
<td></td>
</tr>
<tr>
<td>Redness or swelling of the vagina or vulva</td>
<td></td>
</tr>
<tr>
<td>Stinging or burning while urinating or during sex</td>
<td></td>
</tr>
<tr>
<td>Splits in the genital skin.</td>
<td></td>
</tr>
</tbody>
</table>

Causes: This overgrowth may be due to:

- Antibiotic use
- Oral contraceptive use
- Diabetes
- Pregnancy
- Menstrual cycle changes
- General illnesses like diabetes, iron deficiency and immune system disorders
- Associated vulval skin conditions.

Treatment:

- **Antifungal creams or vaginal pessaries (tablets)** – these are put inside the vagina with a special applicator and are used from one to six days, depending on the instructions. Occasionally a second course of treatment is required. Repeated topical treatments (applied to the skin) may occasionally cause skin irritation.

- **Oral tablets** – these are called fluconazole and are designed to be swallowed. This treatment is more expensive than other options and is not recommended for pregnant women or as a ‘first line’ treatment. If you are on other medications or are pregnant, consult with your doctor or pharmacist before taking fluconazole.
4.2 Identify antigens as molecules that trigger the immune response

**Antigen:** is any molecule the body recognizes as foreign and that triggers the immune response

**Difference between Pathogen and Antigen**

- A pathogen can be anything dodgy but it becomes an antigen when it triggers an immune response

**Identify the role of a maker molecule**

- Surface of cells in the body are ‘marker’ molecules that identify the cell as belonging to the body. It marks it has your own cell saves it from attack by its own immune system, therefore when an unwanted cell comes along that does not have a marker cell it fights it.

**Describe how an antigen triggers an immune response**

- Pathogen enters body- have chemical markers ‘antigens’ on their surface- body recognizes it doesn’t belong to society- immune response is activated

**Identify what has antigens**

- Pathogens have antigens
- Any foreign cell, cell fragment, protein debris or toxin produced by bacteria can also contain antigens

4.3 Explain why organ transplants should trigger the immune response

**Explain why organ transplants trigger an immune response**

- The organ that a person receives has somebody else’s ‘marker’ molecules that are different to the marker molecules on their own cells. The transplanted organ is therefore recognized as foreign and an immune response is activated to attack the organ
- Prevent this: Tissue type of the donor is matched to the recipient as closely as possible so there is a high number of matching ‘marker’ molecules- fewer antigen molecules on the surface- less violent response
- **Immunosuppressant Drugs:** Lessen immune response so transplant organ is not attacked. Disadvantage of making the patient more susceptible to infection from pathogens and they must take precautions (isolation) to reduce their potential exposure to any exposure.
Identify defence adaptations, including inflammation response, Phagocytosis, lymph system and cell death to seal off pathogen.

2\textsuperscript{nd} Line of Defence (non specific defence):

**Inflammation response**

- Non specific defence mechanism occurs at sight of infection
- When cells are infected/inured in some way, they release chemical alarm signals such as histamines and prostaglandins- increasing the permeability of the blood vessels, which allows white blood cells to leave the blood vessels and move into the damaged tissue as well as phagocytes from the blood into the tissues so they can attack invading pathogens.
- These chemicals cause the blood vessels to dilate (expand) as blood brings oxygen & WBC- increasing blood flow to the sight of infection or injury and causing the area to become red, hot & swollen

1. Bacteria enters
2. Chemical signals released histaines
3. Cause blood vessels to dilate & more permeable
4. WBC & Platelets move to site attack invading pathogens

**Phagocytosis (not specific)**

- Phagocytes (specialised white blood cells- leucocytes ), called **macrophages** and **neutrophils**, can very easily change their shape so that they flow around foreign particles (bacterium) and completely enclose them within their cell, where they are broken up by cell enzymes.

1. Phagocytes move to bacterium
2. Phagocyte changes shape – completely encloses bacterium
3. Lysosomes contain destructive enzymes
4. Enzymes are released and destroy bacterium
5. Harmless particles are released from phagocyte
Neutrophils:

- First to be called upon and move to site of infection/inactivating pathogen. **Short acting**
- Self destruct after a few days
- Body uses them to fight acute (short, severe) infections
- Eg Gun shot

Macrophages:

- Long lasting phagocytosis that can either stay in the tissues or travel from blood vessels to infected tissues
- 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.

Lymph system

- Blood circulates around the body, some of the plasma moves out of the capillaries into the tissues and becomes part of the tissue fluid
- This tissue then moves into a system of vessels – lymphatic system
- Which returns intercellular fluid to the blood system, filters cell debris and produces white blood cells responsible for the immune response.
- Drain from all parts of the body to a section near the heart.
- If there is infection nodes that are positioned along the vessels filter and destroy foreign cells and debris by macrophages.
- Lympathetic System: lymph (milky fluid), nodes, vessels, thymus, spleen, tonsils, adenoids

Cell death to seal off pathogen

For some pathogens, macrophages and lymphocytes completely surround a pathogen so that it is enclosed in a cyst.

The white cells involved die, so that the pathogen is isolated from its food supply and also dies.
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.

**Antigen**: a toxin or other foreign substance that induces an immune response in the body, esp. the production of antibodies.

**Pathogen**: a bacterium, virus, or other microorganism that can cause disease.

5.1 Identify the components of the immune response: antibodies, T cells and B cells.

3rd Line of Defence: Specific Immunity:

*Refer to Mind Map*

- Red Blood Cells have no role in immunity.

**Antibodies: Are Proteins**

**Antigen**: any molecule that body recognizes as foreign and that triggers the immune response.

**Antigen**: tetanus vaccine- bodies makes antibodies specific

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>What are they</th>
<th>What do they do</th>
</tr>
</thead>
<tbody>
<tr>
<td>T Cells</td>
<td>Produced in bone marrow</td>
<td>Are lymphocytes</td>
<td><em>Kill infected cells, produce antibody that matches to antigen</em></td>
</tr>
<tr>
<td></td>
<td>Mature in thymus gland (which is situated in the thoracic – chest cavity)</td>
<td></td>
<td><em>Each T cell has a particular surface receptor protein that can recognize a specific antigen.</em></td>
</tr>
<tr>
<td></td>
<td>After they mature, the T cells are released into the blood, spleen, tonsils and lymph nodes.</td>
<td></td>
<td><em>When T cells encounter antigen in the body that matches their receptor protein, they become activated and produce many clones of cytotoxic (killer) T cells specific to that antigen.</em></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><em>Move to site of infection, release chemicals that destroy infected cell</em></td>
</tr>
</tbody>
</table>
### Cell Mediated Immunity
- bacteria/viruses inside cells
- protozoa/fungi/flatworms and roundworms
- cancerous cells and transplanted foreign tissue

### B Cells
- Produced & mature in bone marrow
- After matured they are released into blood, spleen, tonsils and lymph nodes.

### Lymphocytes
- On its surface, each mature B cell has a different antibody that will only respond to a specific antigen.
- Only live for a few days if they encountered their antigen they will become activated, if not they will die.
- When becomes activated, it makes many copies of itself an each of these cells form plasma cells that produce antibodies specific to particular antigen.
- Antibodies, will then move to site of infection and combine with antigen to form antigen-antibody complex which deactivates the antigen

### Antibodies
- Proteins – immunoglobulin’s
- Are produced in response to the presence of an antigen in the body.
What they have in common:

- Identify specific antigens
- Released into the blood, lymph modes, spleen and tonsils.
- Meditated immunity
- Defend against bacteria and viruses

5.2 Describe and explain the immune response in the human body in terms of interaction between B and T lymphocytes and the range of T lymphocyte types and the difference in their roles.

Interaction between B and T lymphocytes

B and T lymphocytes interact as they are both attacking the same antigen. Helper T cells stimulate B cells and T cells to clone.

Refer to Diagram

- Macrophage encounters a foreign particle with an antigen attached to its surface, it surrounds and engulfs it in the process of phagocytosis. In destroying foreign material the antigen that was present on its surface is moved to the surface of the macrophage, which then transports it to the lymph nodes.

When appropriate B cells are activated they form plasma cells that produce antibodies, the antigen binding sites of which match the shape of the antigen they are specific for.

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.

Antigen destroyed: immobilizing it, blocking and neutralizing the active binding site of the antigen, or by causing the antigen antibody complex to clump together making it easier to eliminate by phagocytosis.
• Antigen presenting macrophage is then presented to the helper T cell that as the T cell receptor that corresponds to that particular antigen. This has the effect of activating the helper T cell.

• The helper T cell can also be activated by B cells. When a B cell encounters the antigen that corresponds to its surface antibodies it binds these antigens to these antibodies. It then processes the antigen, attaches it to its surface molecules and presents this to the helper T cells that have the matching T cell receptors.

• Chemical signs in the form of cytokines are then secreted by the helper T cells and also macrophages. A specific cytokine chemical produced by the helper T cell activates the production of clones of the B cells that are specific to that antigen.

• Immune response for suppressing the activity of the B cells and cytotoxic T cells.

Mechanisms for interactions between B and T Cells

• To help B & T cells interact successfully, there is a system that allows these cells to identify that they both belong to the body and prevents them from attacking each other.

• MHC molecules allow the recognition of cells from the body. MHC molecules also allow the identification of cells that are foreign. Cells that are foreign will have different MHC molecules on their surface.

Two types of MHC molecules

1. **MHCI molecules**: present on all cells that have a nucleus and are involved in the recognition of antigens by T cells. The infected cell holds the antigen on its MHCI molecule on the surface so that the cytotoxic T cell can identify it and destroy it.

2. **MHCII molecules**: present on only B cells and macrophages and are involved in the recognition of antigens by B cells. The macrophage holds the antigen on its MHCII molecule on the surface and is recognized by the helper T cell that has the same antigen receptor. The helper T cell then activates the appropriate B and T cells.

Interaction between B and T: also helped by close proximity to each other and regulation of their activities by the secretion of chemicals called cytokines by helper T cells.

The T lymphocytes that help B lymphocytes are called helper T cells (Th cells). If a B cell has an antigen on its surface, there is a risk that a T cell will recognise the antigen and attack it together with the B cell. This does not happen because T cells are able to recognise “self” molecules that are on the surface of B cells. Every person has their own particular "self" molecules, so there are millions of different B cells. They are like personal identity used to identify cells to T lymphocytes. This means that, in the case of organ transplants, T cells can recognise cells that have come from a different body and so help B cells to destroy them. Only identical twins have the same “self” molecules on their B cells.
The range of T lymphocytes types and the difference in their roles

<table>
<thead>
<tr>
<th>Type of T cell</th>
<th>Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cytotoxic Killer T cells (T&lt;sub&gt;c&lt;/sub&gt; cells)</td>
<td>Cells are stimulated to produce many copies (clones) of themselves when activated by the helper T cells and also when they detect cells that have displayed on their surface antigens that match their own surface receptor protein. Once activated by helper cells, they move to the site of infection release chemicals called cytotoxins that attack and destroy macrophages that have engulfed an antigen.</td>
</tr>
<tr>
<td>Helper T cells (T&lt;sub&gt;h&lt;/sub&gt; cells)</td>
<td>Interact with phagocytosis to set off specific immune response Has receptor protein to recognize specific antigen. When reacts with antigen releases chemicals called cytokines that stimulate cloning in B and T cells</td>
</tr>
<tr>
<td>Memory T cells</td>
<td>Produced at the same time as the Tc cells are multiplying Remain in the body and reactivate quickly with subsequent infections by the same antigen</td>
</tr>
<tr>
<td>Suppressor T cells</td>
<td>Stop the action of the immune response when the antigen is destroyed</td>
</tr>
</tbody>
</table>

5.3 Outline the way in which vaccinations prevent infection

- When an antigen is first encountered by the immune system, the time taken to fight the infection is quite long; as clones of B cells & T cells must be made.
- Time is also needed for the cytotoxic T cells (killer cells) to kill the infected cells and for the B cells to produce plasma cells that then secrete antibodies and bind with the antigen to neutralize it
- If sufficient antibodies are made to destroy all the infecting antigens, the person recovers completely – this is known as a primary response.

**Secondary Response:**

- If the same antigen were to re-enter the body in the future, this response is known as a secondary response
- After identification of the antigen, the memory cells will activate the production of cytotoxic T cells and the B cells.
- Secondary Response:
  - is more rapid and requires less antigen to initiate it
  - produces a much greater quantity of antibodies
Active Acquired Immunity:

- Immune response occurs and memory cells are produced is called **active acquired immunity** it is naturally induced as the body has to undergo the immune response and suffer the symptoms of disease in order to develop immunity to it.
- Can also be artificially induced through the use of vaccines, which cause the production of memory cells without the body experiencing the symptoms of the disease.

Vaccines:

- Contain cultures of microorganisms, which may be either:
  - Living but attenuated (weakened) and therefore harmless (rabies, measles)
  - Dead – still has antigen but microorganism dead (typhoid, whooping cough)
  - Contain modified toxins (tetanus, diphtheria)- replicate antigen scientifically

- Harmless to the body will not cause the disease that they are specific for antigen
- Antigens cause the body to undergo an immune response, B cells activated to produce large amounts of antibody for that particular antigen and stored in lymph system for future attack.
- If body is exposed to that antigen in the future, the secondary response will be activated and the antigen destroyed
- Vaccination involves introduction of a vaccine into the body

Immunization:

- Process in which the body reacts to the vaccine by going through the immune response
- Produces memory cells for the antigen and confers immunity to the body. Vaccination is a way of giving a person the “experience” of having had an infection without actually having it, so that the body responds to the “experience” by producing the appropriate memory B cells.
- In some cases the numbers of memory cells decrease over time and booster injections have to be given to increase the number circulating memory cells.

Passive Acquired Immunity:

- Involves the introduction of antibodies (immunoglobulin’s) into the body to prevent a disease from developing
- These antibodies have been produced by another organism that has suffered the disease
- Example: If you have been exposed to hepatitis A, you may be given injections of immunoglobulin’s (antibodies) to prevent you contracting disease. This immunity will last for only a couple of months as no memory cells have been produced.
- Eg if you have tetanus virus- they will not just give you vaccine- as vaccine requires time for body to develop antibodies and create a response; therefore they will just give you the antibodies straight away.
5.4 Outline the reasons for the suppression of the immune response in organ transplant patients.

- When an organ is transplanted it is recognised by the immune system in the body as non-self as on the surface it will have ‘marker’ molecules that are different from the molecules on the cells in the recipient’s body. These marker molecules act as antigens that identify the organ as foreign material, and the immune response is initiated. The body attacks the new organ as if it is an invading pathogen and causes the body to reject the new tissue which will make the organ fail to live. As the cytotoxic T cells are activated and move to the transplanted organ to attack and destroy cells.

- To overcome this problem, transplant patients are given powerful drugs to suppress their natural defences such as Cyclosporin. These drugs act to reduce the activity of the T cells as these are the principle cells that attack the transplanted organ.

- This is beneficial as the whole immune system is not suppressed and can still act to defend the body against other disease causing organisms. This can lead to complications, as the patient has reduced defences against any pathogen that they may encounter as normal interactions between B and T cells will no occur.

5.A Evaluate the effectiveness of vaccination programs in preventing the spread and occurrence of once common diseases, including smallpox, diphtheria and polio.

Refer to Printed Sheets
6. Epidemiological studies involve the collection and careful statistical analysis of larger quantities of data. Such studies assist the casual identification of non-infectious diseases

6.1 Identify and describe the main features of epidemiology using lung cancer as an example.

- The main features of epidemiology, using lung cancer as an example are the use of statistical analyses to understand epidemics, including common factors in groups of affected people such as the correlations between active and passive smokers and lung cancer.

Epidemiology: the scientific study of patterns of occurrence of disease in human populations and the factors that affect these patterns. Investigates the distribution and frequency patterns of the disease and all possible risk factors.

Can be used to study both infectious and non-infectious diseases as well as events such as suicides, car accidents and work related accidents. Highly quantitative using statistics to determine the probability of the cause and effect relationship.

Involves public health authorities develop strategies to control disease and improve public health. Also evaluate strategies that are already in place.

3 Types of Epidemiology:
1. Descriptive Studies:

- First type of study when investigating cause of disease
- Patterns of disease, frequency of disease, which section population is affected (age, gender, occupation, socio economic status), geographical location, whether there was a particular time period in which individuals were affected.

Lung Cancer:

- launched to determine the cause of lung cancer, the data collected included amongst other things information about the age, sex, smoking habits, diet, occupation and drinking habits of both smokers and non smokers.

2. Analytical Studies:

- Used to collect more data, which is then statistically analyzed to develop hypotheses as to the likely cause (s) of the disease
- The morbidity (number of cases of the disease) and the mortality (percentage of the population that dies from the disease) are two indicators that can be used in these studies.
- Data about incidence and prevalence.
3. **Case-control Studies & Cohort Study:**

- **Case Control Studies:** compare people with the disease (case) to people with the disease (control) and look for differences in exposure to the possible causes of the disease.
- **Richard Doll:** compared patients with lung cancer to patients with other conditions. Most with lung cancer smokers suggests link.
- **Cohort Studies:** two or more similar groups of people who are free of the disease. Differing in their exposure to the potential cause of the disease. **Followed over a long period of time to compare the incidence to the disease.**
- 40,000 doctors over 10 year period; one group smokers the other group non smokers. **Smokers higher incidence and the greater amount of cigarettes the more susceptible one is to dying.**

**Intervention:**

- Test the effectiveness of a treatment (clinical trial of new drug) or effectiveness of a public health campaign to change the behavior of the population as a whole in order to decrease the incidence of the disease. **Evaluating ‘Quit’ campaign**

**Epidemiological Studies:**

- be conducted over long period of time
- study very large sample sizes
- collect a range of relevant data from a large group of both affected and unaffected people (case control). This relevant data could include age, sex, diet, occupation, lifestyle and exercise habits.
- Have participants that represent a broad range of society and lifestyles
- Control groups who are not exposed to potential cause of disease but are similar in all other respects to the test group (cohort studies)
- Analyse data to identify patterns and trends in the occurrence of the disease
- Possible cause of the disease and any risk factors
- Develop a management plan with strategies to control or eliminate the disease and educate public
- Evaluate effectiveness of control and treatment programs

6A: Gather, process and analyse information to identify the cause and effect relationship of smoking and lung cancer.

- The cause and effect relationship of smoking and lung cancer can be described as very convincing. Profiles of smoking patterns in men and women and the incidence of the disease are in close parallel.
- Don and Hill in England and Hammond and Horn in the US established that cigarette smoking markedly increased the chances that a person would develop lung cancer.
Other evidence comes from comparisons of trends in smoking rates across sexes and trends in lung cancer.

The NSW Cancer Council reports the following results from its research:
- Smoking is a major cause of lung cancer
- Workers exposed to industrial substances such as asbestos have a significantly higher risk of developing lung cancer
- There is a link between passive smoking and lung cancer
- From 1995 to 2004, the age-standardised incidence rate of lung cancer fell by 18% in males and rose by 11% in females
- It is projected that 1 in 30 Australians will develop lung cancer by the age of 75.
- Lung cancer in 2003 was the leading cause of cancer-related deaths of males.

6.2 Identify causes of non-infectious disease using an example from each of the following categories: inherited diseases, nutritional deficiencies and environmental diseases.

Inherited diseases
Inherited disease refers to disease that is brought about because of mistakes in DNA, single gene caused by mutation (hemophilia) or chromosomes that have been transmitted from parent to offspring or arisen by mutation that lead to the production of different or faulty enzymes, resulting in impaired body function.

- **Examples**
  - Examples of inherited diseases are Down syndrome- Trisonmy 21, colour blindness, haemophilia, phenylketonuria, thalassaemia and sickle cell anaemia.
  - Down’s syndrome has been shown to be caused by an additional chromosome 21. Individuals with the disease usually suffer mild to moderate mental retardation and have poor muscle tone. Eyelids aren't formed. Delay in cognitive ability. IQ 50 compared to adults 100
  - People with Down syndrome have a characteristic appearance (almond shaped eyes- due to epicanthic fold of eyelid, shorter limbs and protruding tongue) and may have a shortened life span. Delay in physiological growth.
  - Mothers who have children later in life are more prone to produce Down syndrome children.
  - Health concerns for those include congenital heart defects, recurrent ear infections and obesity.

Nutritional deficiencies
Nutritional deficiency is lack of required substances, such as vitamins, minerals and protein, which are essential for normal functioning or growth. They can also be caused by psychological conditions that lead to inappropriate diets (anorexia/bulimia).

Nutritional deficiencies can lead to obesity and malnutrition diseases such as scurvy or night blindness that are caused by protein or vitamin deficiencies. Inadequate or imbalanced diets have a role in diseases such as arthritis, heart and circulatory problems, kidney, liver or gall bladder disease.
- **Examples**  
  Examples of nutritional diseases are scurvy, anaemia, goitre, kwashiorkor (*deficiency in protein and resulting in swelling of tissue, enlarged liver, irritability*) and beri beri (*weakened heart muscle, digestive disorders, lack of vitamin B*).  
  Scurvy is caused by a deficiency in vitamin C. Symptoms include bleeding gums and tooth loss. It is treated by increasing the intake of food and drinks containing vitamin C, such as citrus fruit.  
- Vitamin C important in the production of connective tissue, bones, dentin. Deficiency weakens the blood capillary wall, leading to bleeding and bruising  
- **Initial symptoms:**  
  - Pain and tenderness in the legs  
  - Swelling of the long bones  
  - Swollen, purplish and spongy gums  
  - **More advanced symptoms:**  
    - gangrene  
    - reopening of old wounds  
    - spontaneous hemorrhaging  
    - purple/black spots on the skin  
    - separation of once healed broken bones  
    - bleeding of the membrane covering in front of the eyes of the eyelids  
    - If left untreated death will arise.  
- **Treatment:** inclusion of vitamin C in diet  

**Environmental disease**  

Environmental disease is a disease caused by the conditions of the surroundings such as toxins or particles in the air, water or soil. Many forms of cancer have a link to some environmental causes.  

Environmentally caused diseases include those due to lifestyle (diseases substance abuse—alcoholism as well as smoking-related diseases), as well as those caused by something in the environment, such as lead or substances that cause allergies or exposure to chemicals such as lead poisoning. Disease caused by physical factors such as skin cancer caused by UV radiation (Melanoma).  

**Melanoma:**  
  - Malignant tumour of melanocytes. Responsible for producing colour of skin  
  - Occurrence 48,000 worldwide  
  - Surgical removal—caught early cure high  
  - ABCD  
  - Non specific symptoms: loss of appetite, nausea, vomiting, fatigue
1. Earliest stage of melanoma starts with melanocytes begin to grow out of control in the outer layer of the skin
2. Early stage of disease called radial growth phase- cancer cells not yet reached the blood vessels down in the skin. Not likely to spread
3. Tumour cells start to move in different direction the behavioru of the cells change dramatically. **Next step invasive radial growth; when individual cells start to acquire invasive potential** – capable of spreading. Vertical growth of tumour; can spread around body through blood of lymph vessels.

**6B: Identify data sources, plan and perform a first-hand investigation or gather information from secondary sources to analyse and present information about the occurrence, symptoms, cause and treatment/management of a non-infectious disease.**

**Melanoma Assignment**

7. **Increased understanding has led to the development of a wide range of strategies to prevent and control disease**

7.1 **Discuss the role of quarantine in preventing the spread of disease and plants and animals into Australia or across regions of Australia.**

**Quarantine:**

- Prevents the spread and entry of disease and plants and animals into and across regions of Australia.
- Fortunate because of geographical isolation
- Diseases cause huge financial losses to farmers in other countries. Australia is able to sell its products to overseas markets because of the absence of diseases, like mad cow disease and foot-and-mouth.
- Declared fruit-fly free areas where the produce is sold with a guarantee of no fruit fly. This can be done by having inspections and bins to put fruit in when entering particular fruit growing areas.

**AQIS: AUSTRALIAN QUARANTINE AND INSPECTION SERVICE**

- Tourists can’t bring in plant products animal products.
- People who bring in animals must go through the quarantine process to ensure the animal is disease free. It is placed in isolation and regularly examined.
- People who visit risky parts of the world must show proof of vaccination against certain diseases
The Success:

- Foot and mouth disease
- Malaria & Rabies
- Downy Mildew (plant disease- takes out agriculture system; wheat, rice)

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

Genetically Modified Food:

- Caterpillar (Boll worm): chews holes in cotton tomatoes + peanut crops

Insecticides: don't work they have built up resistance.

Plan 1:

- transferred a gene from a bacteria into the cotton plants
- this gene carries a toxin deadly to the caterpillar
- slowly becoming resistant

Plan 2:

- Research into a virus that only infects the caterpillar
- Virus causes a disease in the caterpillar and no other species
- Huge implications for future use in Agriculture

Public health programs:

* These provide quarantine, sanitation, safe drinking water and immunisation.
* Public education such as advertisements about the effects of alcohol, smoking and unprotected sex; mass immunisation procedures in schools; screening for high blood pressure, cervical cancer and breast cancer; maintaining of central registers and informing the public when tests are overdue; and laws requiring that HIV/AIDS are notifiable and people with Rubella or Chickenpox are isolated.
* NSW Health uses these strategies to reduce disease incidence.
* Examples of successful health campaigns are the Slip! Slop! Slap! Skin cancer advertisements,
* Women are encouraged to check their breasts for lumps and have regular mammograms for women of 50 yrs to aid the early detection of cancer and therefore increase survival chances and controlling the disease.
* The QUIT program could prevent occurrences of lung cancer. It is designed to prevent people from smoking and therefore reduce occurrences of lung cancer and other diseases associated with smoking.

Pesticides:

* Pesticides, such as DDT, have been used to destroy mosquitoes, which are the vectors of some diseases, such as malaria and dengue fever.
* A good example of a strategy to control or prevent disease is the pesticide control of the disease malaria.
Adult mosquitoes can be destroyed by chemicals such as DDT, dieldrin, or by safer chemicals, such as pyrethrums. In 1956, the World Health Organisation was responsible for a major campaign using a residual form of DDT. DDT has been banned in many countries of the world because of its harmful ecological effects, but it is still used for mosquito eradication in malarial areas. This has rid many areas of the world from malaria but has unfortunately not reduced it globally and malaria is still a major killer of children today. Many areas have DDT-resistant mosquitoes. Other pesticides, such as organophosphates and pyrethrums, have become popular. In some areas, bed nets have been sprayed with pyrethrums and have been found to be effective in controlling mosquitoes.

**Genetic engineering:**

- Genetic engineering uses biotechnology to change the genotypes of organisms. It is used to produce disease resistant plants and animals to elevate human food sources and commercial products.
- Bt cotton was the first genetically engineered crop grown in Australia.
- The bacteria contain a gene that produces chemicals that kill certain insects. By taking that gene from the bacteria and inserting into the genome of plants, the plants now produce the chemical that will kill insect pests.

**7A: Investigation to examine plant shoots and leaves and gather FHI of evidence of pathogens and insect pests.**

**Leaf Galls**

- Is plants response to an infection or irritation caused by a microscopic pathogen or macro-parasite
- Plant grows layers of tough, woody tissue around the infection site in an attempt to “wall off” the pathogen and prevent the infection spreading.
- Often occur in response to insects/mites feeding on leaves

**Lerps on Gum Trees**

- Australian insect- defoliates eucalyptus trees
- Are protective covers made as they excrete honeydew on the leaf surface and the sugars and amino acids crystallise in the air to form lerps
- Leaves can look black and sooty when sooty moulds grow on the honey dew.
### 7B: Evaluate the effectiveness of quarantine in preventing the spread of plant and animal disease into Australia or across regions in Australia

<table>
<thead>
<tr>
<th>Description of quarantine measures</th>
<th>How these measures assist in preventing the spread of disease</th>
<th>Occurrence and spread of disease in Australia/across regions of Australia</th>
<th>Judgment of effectiveness of quarantine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant Disease</strong> <strong>Phyloxera</strong></td>
<td>Presence of phyloxera exclusion zones, phyloxera infested zones and phyloxera risk zones. Movement severely restricted Certificates to authenticate origin of grapevines before can be moved Items associated with grapevines- should be treated before moved. Treatment sheds for harvesters</td>
<td>Zones: allows identification of areas that are infested or at risk. Decreases risk of spread of pathogens to areas that are free of phyloxera Treating all equipment; spread of pathogen reduced</td>
<td>5 phyloxera infested zones in Australia, with Queensland &amp; most of Victoria classed as risk zones. Rest of Australia free</td>
</tr>
<tr>
<td><strong>Animal Disease</strong> <strong>Foot &amp; Mouth</strong></td>
<td>Inspection of people and cargo at all pts of entry into Australia Prevention of entry of all normally restricted items as well as cloven hoofed animals and their products Passengers from affected areas thoroughly processed- disinfection of their shoes Mail from infected areas also inspected to ensure no items contain pathogen All cloven animals in area are killed, burnt, buried – isolation of everyone in the area - inspection reduces chance of pathogen spreading as does disinfection</td>
<td>Australia has been free of foot and mouth disease since 1872</td>
<td>Highly effective – preventing spread of Foot and Mouth Disease No cases since 1872 Foot Mouth Disease costs 6 mill plus 8 mill each day 12 months to regain major markets No vaccine to prevent</td>
</tr>
</tbody>
</table>
7C: 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.

- As little as 150 years ago, there was very little understanding of disease. Attempts were made to treat diseased people but they often died.
- Early preventative vaccines were developed by Pasteur in the late 1800s.
- Other preventative measures such as quarantine have been used since early times.
- Genetic epidemiology will contribute to the discovery of new drug treatments that could be tailored to an individual’s genetic make-up as well as the prediction of the individual’s likelihood of getting a particular disease. This will continue to change the emphasis of health care from treatment to prevention.
- Before 1974, vaccinations were not widespread.
- In 1974, WHO launched immunisation of 6 diseases and prevented 3 million deaths each year by 1997. This also helped control the spread of diseases like diphtheria, polio, smallpox, whooping cough, tetanus and measles.
- Antibiotics now help control and treat bacterial disease and therefore prevention is being increased which reduces the occurrence of disease and less money is spent on health and less drug resistance occurs. However now stronger antibiotics must be used as resistance has arisen.
- Pesticides used to control malaria; DDT kills mosquito vector, however detrimental effect on the environment, development of resistant strains of the vector or the pest.
- The flu vaccine is now readily available, preventing the incidence of the flu and therefore its occurrence.
- STD’s are being prevented through educational campaigns for safe sex.
- In preventing the occurrence of these diseases, fewer drugs are needed for treatment and less occurrence in the population.
- International health regulations were revised in 2005 to provide a global framework to address these needs through a collective approach to the prevention, detection and timely response to any public health emergency of international concern.

**Australian Female Scientist:** Dr Elizabeth Blackburn- biochemistry; study of telomeres, the protective caps on the ends of chromosomes, the discovery of which holds out hope of a deeper understanding of growth, ageing and disease

**Australian Male Scientist:** Ian Frazer- Immunology - He is working on a VLP-based vaccine against hepatitis C, as well as for dengue fever and Japanese encephalitis vaccines. Professor Frazer expects (50% effective) HIV vaccines to be available by 2028.[38] He is already overseeing trials of the first vaccine for skin cancer (the Squamous cancer,[39] caused by HPV) which might be ready before 2020.[40]

**Qualitative:** Whats present
Quantitative: How much of something is present

Magnitude: the great size or extent of something:
Destructive: causing great harm (eg destroys material being tested)
Non Destructive: doesn’t destroy material being tested

Control: Agar
Bottled Water

Refilled
Tap water
Pond water

### Bacterial Choices

<table>
<thead>
<tr>
<th>Source of Water</th>
<th>Number of Colonies</th>
<th>No Different Types</th>
<th>Description of each type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agar</td>
<td>1) least amount</td>
<td>3</td>
<td>Red, yellow, cream</td>
</tr>
<tr>
<td>Bottled Water</td>
<td>Yellow colonies 3) 20+</td>
<td>3</td>
<td>Fungi: 1 green patch, Grey, light yellow, golden yellow 2 fungi: large green, furry cloudy one with black centre</td>
</tr>
<tr>
<td>Refilled Bottle</td>
<td>4) 15</td>
<td>2</td>
<td>Green/ grey Fungi: furry white with green centre, red, yellow cloudy/furry green centre</td>
</tr>
<tr>
<td>Tap water</td>
<td>2) 10</td>
<td>2</td>
<td>Red, yellow cloudy/furry green centre</td>
</tr>
<tr>
<td>Pond water</td>
<td>5) some bacteria more bacteria 50+ white branching cloudy 1 colony (large)</td>
<td>1 colony (large)</td>
<td>The worst one: more fungi than bacteria</td>
</tr>
</tbody>
</table>
1. What is a healthy organism?

- 1.1 Discuss the difficulties of defining the terms 'health' and 'disease'

Health is defined as the wellbeing of an organism - physical, mental and social status of the individual. Different people have differing perceptions of the levels of wellbeing. E.g. person who has cancer

Disease - any condition that adversely affects the normal function of any part of a living organism. Hence, this can range from a scrape on the knee to serious organ malfunction. Broad and imprecise e.g. pregnancy

- 1.2 Outline how the function of genes, mitosis, cell differentiation and specialisation and specialisation assist in the maintenance of health

Genes
Gene is a heredity unit which controls the production of polypeptides to produce a protein. Malfunction occur which can result in the disruption of metabolic pathway and disease occurring.

Mitosis
Important for growth and repair of damaged tissue/cells, replacing dead cells and genetic stability - precise and equal distribution of chromosomes to each daughter nucleus.

DNA repair genes, Proto-onco genes and Tumour suppressor genes = responsible genes.

Proto-oncogenes produce proteins that stimulate cell growth and division.

Tumour suppressor genes produce proteins that slow down or stop cell growth and division.

Cancer - disruption of cell replication and division. Uncontrollable growth leads to the formation of cancers.

Cell differentiation and specialisation
Process that causes a cell to become specialised to perform specific function, e.g. skin cell, brain cell

Particular genes are 'switched on' causing the cell to differentiate and become specialised.
Proto-oncogenes code for proteins that regulate differentiation and cell growth. If these become defective and become an oncogene that results in tumour cells. Mutations ----> uncontrollable production of cells and prevent cell death.

For example, there are specialised blood cells that produce antibodies to attack a disease causing micro-organism.

- 1.3 Use available evidence to analyse the links between gene expression and maintenance and repair of body tissues

Gene is 'switched on'

DNA code converted into the structures and functions of a cell. Can cause the production of a variety of enzymes that repair damaged DNA, e.g. some repair enzymes can cut out the damaged DNA to replace it.

Lead to the replacement of some cells e.g. the lining of the intestine, as these cells are too damaged by the digestion process.

If you cut yourself, the genetic code contained in all your cells is used to form the new tissue to repair the damage from the cut.

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

- 2.1 Distinguish between infectious and non-infectious disease

Infectious- caused by infective agent aka pathogen and can be passed from person to person. e.g. malaria, AIDS

Non-infectious - Is NOT caused by a pathogen and cannot be passed from person to person. e.g. downs syndrome, breast cancer

- 2.2 Explain why cleanliness in food, water and personal hygiene practises assist the control of disease

Food: Bacteria multiplies quickly in food if the conditions are right e.g. availability of nutrients, temperature, moisture. Strict guidelines have been introduced for the protection of health.

Water: Pathogens able to multiply and transmit from person to person through water. Can be contaminated with animal faeces, may contain unsafe levels of pathogens such as protozoans Cryptosporium and if consumed may cause stomach cramps, diarrhoea, nausea and vomiting.

Personal hygiene: keeping the human body, and any openings clean. Reduce risk of pathogens to enter the body, or transmission of these pathogens to others. Contributes to build up of micro-organisms on body. e.g. influenza transferred by inhaling infective droplets from 'sneeze' when mouth not covered.

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

A pathogen can be defined as any organism or infective agent that lives in or on another organism and causes a disease.
2.4 Identify data source, choose equipment or resources to perform a first-hand investigation to identify microbes in food or water.

Petri dishes containing agar jelly which is able to support bacteria and fungi. Inoculated agar plate using inoculating loop. Incubated agar plates for a week. Colonies of organisms found. Waste material disposed of.

2.5 gather, process and analyse information from secondary sources to 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

Water is chlorinated. Chlorine gas injected into the water to kill germs.

Water is also filtered. Using semi-permeable membrane - removes large infectious particles such as bacteria. For people who have alternative drinking supplies, water is often boiled for a few minutes to be then stored in different lab containers.

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 diseases

3.1 Describe the contribution for Pasteur and Koch to our understanding of infectious diseases

Pasteur - proposed germ theory of disease. Showed that micro-organisms come from pre-existing organisms and cause decay. Discovered VACINE - chicken pox, rabies, cholera and anthrax. Led to new branches of science and medicine i.e. immunology and molecular biology.

Koch - discovery of the link between specific diseases and the bacteria which causes them. Developed agar plate technique and used it to cure anthrax.

Koch's postulates

- Suspected micro-organisms must be common in all cases
- Make a pure culture (grow them) of the suspected organism + isolate
- Infect healthy suitable host with organism
- Isolate suspect micro-organism and show link to first culture

Limitation = not all bacteria are cultivable in-vitro, or may be no suitable animal or model of infection.

Pasteur and Koch proved micro-organisms cause disease and they come from other micro-organisms.

3.2 perform an investigation to model Pasteur's experiment to identify the role of microbes in decay

Method -
1. Make clear broth using beef stock cube and add to each conical flask.
2. Fit stoppers, use glass tubing bent into an S-shape to replicate Pasteur’s 'swan-necked' flask.
3. Place a piece of straight necked glass in the other flask
4. Heat each flask so that it boils gently, for 15 minutes.
5. Leave both flasks for several weeks, out of direct sunlight.
6. Observe each every 2 - 3 days to compare the contents of each flask.

Results -
3.3 Distinguish between: Prions, Viruses, Bacteria, Protozoans, Fungi, Macro-parasitesAnd name one example of a disease caused by each type of pathogen

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Distinguishing feature</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prion</td>
<td>Protein which has been altered from its normal function. Causes holes to form in the brain.</td>
<td>Creutzfeldt - Jakob disease</td>
</tr>
<tr>
<td>Virus</td>
<td>Consist of DNA or RNA in closed in a protein. Miniscule</td>
<td>HIV, herpes, measles, influenza</td>
</tr>
<tr>
<td>Bacteria</td>
<td>No internal membranes</td>
<td>Tetanus, Cholera</td>
</tr>
<tr>
<td>Protozoan</td>
<td>Single celled organisms with internal membranes</td>
<td>Amoebic Dysentery, Malaria</td>
</tr>
<tr>
<td>Fungi</td>
<td>Heterotrophic organisms, membrane bound nucleus, a cell wall and no chloroplasts</td>
<td>Foot tinea, ringworm</td>
</tr>
<tr>
<td>Macro-Parasites</td>
<td>Visible to the naked eye</td>
<td>Human tapeworm, ticks</td>
</tr>
</tbody>
</table>

3.4 Gather and process information to trace the historical development of our understanding of the cause and prevention of malaria

<table>
<thead>
<tr>
<th>Date</th>
<th>Historical development</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 BCE</td>
<td>Romans described and named malaria ('bad air') as a disease that comes from swamps</td>
</tr>
<tr>
<td>1820 CE</td>
<td>Quinine used to prevent malaria</td>
</tr>
<tr>
<td>1880</td>
<td>Charles Laveran observed the malarial parasite</td>
</tr>
<tr>
<td>1886</td>
<td>Golgi observed asexual reproduction in <em>Plasmodium protozoan</em></td>
</tr>
<tr>
<td>1896</td>
<td>Grassi named <em>Anopheles mosquito</em> as the carrier of a malarial parasite</td>
</tr>
<tr>
<td>1897</td>
<td>Ross identifies <em>Plasmodium</em> as the cause of malaria</td>
</tr>
<tr>
<td>1940</td>
<td>First synthetic antimalarial drug - chloroquinine used</td>
</tr>
</tbody>
</table>

3.5 Identify data sources, gather process and analyse information from secondary sources to describe one named infectious disease in terms of its cause, transmission, host response, major symptoms, treatment, prevention and control

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause</td>
<td>The parasitic protozoan, <em>Plasmodium</em></td>
</tr>
<tr>
<td>Transmission</td>
<td><em>Anopheles mosquito</em> is the insect vector. Mosquito injects <em>Plasmodium</em> sex cells into victim. The sporozoites travel to the liver, multiply and then enter the red blood cells, where they also multiply. When the infected cells burst, they cause the malarial fever.</td>
</tr>
<tr>
<td>Host response</td>
<td>produces antibodies against <em>Plasmodium</em></td>
</tr>
<tr>
<td>Major symptoms</td>
<td>Chills, fever, sweating, headache, anaemia, jaundice</td>
</tr>
<tr>
<td>Feature</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>Treatment</td>
<td>Antimalarial drugs. e.g. chloroquine</td>
</tr>
<tr>
<td>Prevention</td>
<td>Mosquito nets, insect repellent, preventative medication</td>
</tr>
<tr>
<td>Control</td>
<td>Insecticide spraying, avoid water logging</td>
</tr>
</tbody>
</table>

- 3.6 identify the role of antibiotics in the management of infectious disease

Antibiotics destroy/prevent the growth and development of disease causing bacteria. e.g. penicillin.
- Accumulate in the cells of bacteria and prevent them from forming new cell wall when dividing
- Destroy cell membrane
- Interfere with protein synthesis

- 3.7 process information from secondary sources to discuss problems relating to antibiotic resistance

During normal process of natural selection, bacteria developed strands that are resistant to antibiotics that are used - causes the bacteria to stay alive after the course of antibiotics. **Resistance being accelerated by:** over use, not finish whole course of antibiotic, food producing animal fed antibiotics to prevent infections, cleaning products that contain antibiotic ingredients. **Solutions** = only prescribe for bacterial infections, should only target pathogen, take whole course of antibiotic.

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

- 4.1 Identify defence barriers to prevent entry of pathogens in humans:
  - skin
  - Mucous membranes
  - Cilia
  - Chemical barriers
  - Other body secretions

**Skin**
Tough outer barrier. Fairly dry which helps to prevent growth of pathogens.

**Mucous membranes**
Covered with membranes that produces a thick layer of mucus that traps entering pathogens. Pathogens held in mucus until removed by either coughing or sneezing. May contain antibody.

**Cilia**
Tiny "hairlike structures" line Respiratory surface of the trachea and bronchial tubes. Constantly beating upwards to move mucus containing trapped pathogens towards the throat where they are removed by coughing, swallowing or sneezing

**Chemical barriers**
Various types of chemicals are secreted in parts of body act as barrier to the invading pathogens.

Search For A Better Health Summary 2012
Alimentary canal – pathogens entering with food/drink can be destroyed by acidic or alkaline conditions in stomach. Urinal, vaginal and skin surface slightly acidic.

Other body secretions
Sterile/slightly acidic urine, tears and saliva containing lysosomes kill bacteria and entering pathogens.

- 4.2 Identify antigens as molecules that trigger the immune response

Antigens are any molecule in the body that recognises as foreign and triggers an immune response

- 4.3 Explain why organ transplants should trigger an immune response

Immune response is the way the body acts when it detects something it considers foreign. Body may reject organ as ‘marker’ molecules (antigen) may be different of the ‘marker’ molecules on their own cells. Hence why transplant patients blood type as closely matched as possible.

- 4.4 Identify defence adaptations, including:
  - Inflammation response
  - Phagocytosis
  - Lymph system
  - Cell death to seal off pathogen

Inflammation response
Infected cells release chemical alarms causing blood vessels to dilate, increasing blood flow to site of injury which allows for movement of phagocytes. Plasma moves to tissue bringing more phagocytes - producing swelling - forcing tissue fluid into lymph and taking debris with pathogens. Chemicals which increase temperatures inactivate some enzymes and toxins.

Phagocytosis
Specialised white blood cells.
Phagocytosis = phagocytes change their shape so they can surround foreign particle.

Two main type of phagocytes:
1. Neutrophilllis - first to be called upon, move to site of infection, inactivates pathogen. Short-acting and self-destruct after few days. Used to fight acute infections.

2. Macrophages - long lasting, stay in tissue or travel from blood vessels into infected tissues. Used to fight chronic infections. Once destroyed forgein particle, parts of antigen displayed on surface. Not always successful.
lymph system
Filters pathogen as it travels through lymph nodes.

At lymph nodes, foreign particle and cancer cells are engulfed by phagocytosis.

Lymphatic system = lymph (milky fluid), lymph nodes, lymph vessels, thymus, spleen, tonsils and aclemoids

B cells make up antibodies against particular pathogen antigens already in body.

Cell death to seal off pathogen
Prevents the infection from spreading

Wall of dead cells form a 'capsule' = granola or cyst, cells inside then die to destroy the pathogen. Debris inside granola destroyed by macrophages.

- 4.5 Gather, process and present information from secondary sources to show how a named disease results from an imbalance of micro flora in humans

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Fungus, Canadia albicans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptoms</td>
<td>Vaginal discomfort, itching or burning, think white discharge with 'cottage cheese' appearance, yeasty smell, redness or sweating of the vagina or vulva, stinging or burning while urinating and during sex, splitting in genital area.</td>
</tr>
</tbody>
</table>
| Treatment and prevention | Anti fungal creams, or 'virginal peccaries'
Wipe bottom, avoid using soap/perfumed spray/toilet paper in genital area. |
| Why disease is not always present | Usually kept low by competition from other microorganisms. Can develop during suppression of immune system, diabetes, mellitus, steroids, pregnancy and oral contraceptives, These circumstances often provide a chance for yeast to proliferate and thrive. |

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

MacFarlane burnet extensively researched infectious diseases, viruses and immunology, which led to the development of vaccines. He increased understanding of home the immune system works, how the B-cells respond to specific antigens and how the body recognises its own tissues.
5.1 Identify the components of the immune response:
- Antibodies
- T cells
- B cells

Antibodies
Are proteins called immunoglobulin's. Produced in response to the presence of an antigen in the body. Seek out the antigen and bind to part of it, forming the antigen-antibody complex to deactivate the antigen.

T cells
Lymphocytes that are produced in bone marrow and mature in the thymus gland. When encounter antigen that matches their receptor proteins, become activated and produce many clones of cytotoxic (killer) t-cells specific to antigen. Control cell mediated immunity in defending pathogens.

B cells
Lymphocytes that are produces and mature in the bone marrow. Have a specific antibody that responds to specific antigens. When activated, make clones and form plasma cells that produce antibodies specific to antigen. Antibodies combine with antigen to form antigen-antibody complex. Control antibody mediated (humeral) immunity which defends the body against bacterial viruses outside toxins produced by bacteria.

5.2 Describe and explain the immune response in the human body in terms of:
- Interaction between T and B lymphocytes
- The mechanisms that allow interaction between B and T lymphocytes
- The range of T lymphocyte types and the difference in their roles

The range of T lymphocyte types and the difference in their roles
1. Helper t cells: have receptor protein that recognises only one type of antigen. When activated release cytokine chemical that activates cytotoxic T cells and B cells specific for this antigen.
2. Cytotoxic/killer T cells: stimulated to produce many clones of themselves when activated by helper T cells and also when they detect cells that have displayed on their surface antigens that match their own surface receptor protein. Army of identical cytotoxic T cells move to the site of infection, bind with infected cells and release chemicals that destroy he infected cells.
3. Memory T cells: multiply and remain in the body so the body can respond more quickly to future invasions by that pathogen.
4. Suppressor T cells: stop the immune response when infection has been defeated.

Interaction between T and B lymphocytes
- B and T lymphocytes both attack the same antigen.
- Helper T cells stimulate b cells and T cells to clone.
- Once the immune response has successfully defeated the infection, suppressor T cells are responsible for suppressing the activity of the B cells and cytotoxic T cells.

The mechanisms that allow interaction between B and T lymphocytes
- To prevent T cells from attacking B cells, B-cells have ‘marker’ molecules that T cells recognise.
- Helper T cells secrete interleukins which encourage B cells to make antibodies
- Interaction between T and B cells is also helped by their close proximity to each other and the regulation of their activities by the secretion of chemicals called cytotoxins by the helper T cells.
Cell mediated immunity

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 immunity

- antigen-presenting B cells
- antigen-presenting macrophages
- helper T cell with T cell receptor matching antigen is activated
- activates B cells specific for antigen
- many clones of the specific B cells are produced
- most B cells form plasma cells, which remain in the lymph nodes
- plasma cells secrete antibodies specific to antigen
- antibodies travel to the site of infection
- antibodies combine with antigen to form antigen–antibody complex
  - inactivation of pathogen or its toxin
  - increased inflammation
  - increased phagocytosis
  - destruction of pathogen
- some cells become memory B cells
- memory B cells remain in the body
- when re-exposed to the same antigen, plasma cells clone rapidly
- results in the quick production of large quantities of antibodies
• 5.3 Outline the way in which vaccinations prevent infection
  - Vaccines contain antigens that stimulate production of antibodies and introduce acquired immunity to specific diseases.
  - B- memory cells remain in body to allow response to read antigen if present in the body again.

• 5.4 Process, analyse and present information from secondary sources to evolve the effectiveness of vaccination programs in preventing the spread of and occurrence of once common diseases including smallpox, diphtheria and polio

Once common diseases such as small pox, polio, and diphtheria have been successfully prevented through the introduction of vaccination programs.

**Diphtheria** – five doses of a diphtheria-containing vaccine given Intramuscularly
  - First developed diphtheria vaccine in 1921
  - No deaths since 1980

**Small pox** – small pox was the first disease for which a vaccine was developed in 1796
  - Mass immunisation programs worldwide
  - So successful that the WHO has declared small pox eradicated

**Polio** – polio first occurred thousands of thousands of years ago, causing many children to become paralysed.
  - Polio Vaccine first developed in 1952
  - Polio Vaccine program has reduced worldwide occurrence by 98%

• 5.5 Outline the reasons for the suppression of the immune response in organ transplant patients

Organ will have 'marker' molecules on the cells in the recipients body. Marker molecules act as antigens that identify the organ as foreign, causing the immune system to be initiated. Cytotoxic cells activated and move to transplanted organ to attack and destroy cells. Causes rejection of transplanted organ.

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

• 6.1 Identify and describe the main features of epidemiology using lung cancer as an example

Epidemiology is the study of patterns of occurrence of disease in human population and the factors that affect these patterns.

Studies should:
- Be conducted over a long period of time
- Study large sample size
- Collect range of data
- Use a control group
- Collect data on incidence, prevalence, mortality and morbidity
- Identify possible cause and any risk factors.
- Develop management plan with strategies to control or eliminate disease and educate public.
6.2 Gather, process and analyse information to identify the cause and effect relationship of smoking and lung cancer

The more cigarettes smoked for longer, the more deaths to lung cancer.
- Death rates of non-smokers, significantly lower than that of smokers
- Older the age group, and the more cigarette smoked the more occurrence of lung cancer

6.3 Identify causes of non-infectious disease using an example from each of the following categories:
- Inherited diseases
- Nutritional diseases
- Environmental diseases

Inherited – genetically transmitted and caused by errors in genetic information
  e.g. – cystic fibrosis caused by mutation of cystic fibrosis trans-membrane regulator on chromosome 7.

Nutritional – caused by diets lacking in proper amounts and balance of nutrients and physiological conditions leading to inappropriate diets.
  E.g. scurvy caused by a lack of vitamin C in the daily diet.

Environmental – many types; lifestyle, physical factors in the environment and disease caused by exposure to chemicals.
  e.g. skin cancer caused by excessive exposure to ultra-violet radiation in sunlight.

6.4 Identify data source, plan and perform a first-hand investigation or gather information from secondary sources to analyse and present information about the occurrence, symptoms, cause, treatment/management of a named non-infectious disease

<table>
<thead>
<tr>
<th>Name of disease</th>
<th>Rickets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of disease</td>
<td>Nutritional</td>
</tr>
<tr>
<td>Occurrence</td>
<td>Most likely to occur during periods of rapid growth, when body demands high levels of calcium and phosphate.</td>
</tr>
<tr>
<td>Symptoms</td>
<td>Pain in the bones of Arms, Legs, Spine, Pelvis</td>
</tr>
<tr>
<td></td>
<td>Skeletal deformities including Bow legs, Forward projection of the breastbone, Funnel chest, &quot;Bumps&quot; in the rib cage and Asymmetrical or odd-shaped skull.</td>
</tr>
<tr>
<td></td>
<td>Spine deformities (spine curves abnormally, including scoliosis or kyphosis).</td>
</tr>
<tr>
<td></td>
<td>Pelvic deformities.</td>
</tr>
<tr>
<td></td>
<td>Increased tendency toward bone fractures.</td>
</tr>
<tr>
<td></td>
<td>Dental deformities.</td>
</tr>
<tr>
<td></td>
<td>Delayed formation of teeth.</td>
</tr>
<tr>
<td>Cause</td>
<td>Deficiency in Vitamin D.</td>
</tr>
<tr>
<td>Treatment /management</td>
<td>Relieving symptoms and correcting underlying cause to prevent recurrence. If condition is not corrected while children are still growing, skeletal deformities and short stature may be permanent, but if it is corrected while the child is young, skeletal deformities often reduce or disappear with time. Surgery is also an option to correct bone deformities.</td>
</tr>
</tbody>
</table>
7. Increases understanding has led to the development of a wide range of strategies to prevent and control disease

- 7.1 Discuss the role of quarantine in preventing the spread of disease and plants and animals into Australia or across regions of Australia

Minimise risk of exotic pests and diseases from entering Australia.
AQIS has many strategies:
- Border control – checking passengers and cargo at entry points. X-ray machines, detector dogs, surveillance and inspection. Prevented from bring plant seeds, fresh fruit, eggs, egg products, dairy products, meat and all prok products.
- Animal quarantine – all animals coming into Australia spend time at quarantine stations
- Examination of plants
- Human quarantine – human who are displaying symptoms of prohibited diseases are reported to AQIS. i.e. rabies, SARS and malaria.

- 7.2 Process and analyse information from secondary sources to evaluate the effectiveness of quarantine in preventing spread of plant and animal disease into Australia or across regions of Australia

<table>
<thead>
<tr>
<th>Description of quarantine measures</th>
<th>Explanation of how the quarantine measures assist in preventing the spread of disease into Australia or across regions of Australia</th>
<th>Occurrence and spread of disease in Australia/across regions of Australia</th>
<th>Judgement of effectiveness of quarantine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant disease (phyloxera)</strong></td>
<td>There are designated phyloxera-infested zones, phyloxera risk zones and phyloxera free zones. Movement of grapevines and materials associated with them is severely restricted to prevent the spread of the disease.</td>
<td>By grouping the grapes into zones, the different strains of the diseases are able to be kept away from each other</td>
<td>Phylloxera is spread in the southern east areas of Australia.</td>
</tr>
<tr>
<td><strong>Animal disease (Foot and mouth disease)</strong></td>
<td>The primary means of eradicating an FMD outbreak is With the vaccination of livestock against FMD, the disease is</td>
<td>Minor outbreaks of possible FMD are believed to have occurred in Australia</td>
<td>Extremely well as the disease has not occurred in</td>
</tr>
<tr>
<td>Description of quarantine measures</td>
<td>Explanation of how the quarantine measures assist in preventing the spread of disease into Australia or across regions of Australia</td>
<td>Occurrence and spread of disease in Australia/across regions of Australia</td>
<td>Judgement of effectiveness of quarantine</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>the humane destruction of infected animals. Other measures, such as the control of movement of livestock, are also essential. Vaccination may be an important component of the response.</td>
<td>able to be successfully controlled.</td>
<td>in 1801, 1804, 1871 and 1872.</td>
<td>Australia for many decades</td>
</tr>
</tbody>
</table>

- **7.3 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** - DDT kills insects acting as vectors controlled the spread of malaria by destroying the vector that transmitted the pathogen.
  - Very effective. However, reduced by mosquitos building up a resistance.

- **7.4 Perform an investigation to examine plant shoots and leaves to gather first-hand information of evidence of pathogens and insect pests**

<table>
<thead>
<tr>
<th>Plant name</th>
<th>Pathogen/insect</th>
<th>Description of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rose</td>
<td>Rose mosaic virus</td>
<td>Black/brown spots on leaves</td>
</tr>
<tr>
<td>Zucchini</td>
<td>Rust</td>
<td>Brown spots on leaves</td>
</tr>
<tr>
<td>Mandarin</td>
<td>Stink bug</td>
<td>Bug on plant</td>
</tr>
<tr>
<td></td>
<td>Spotty mould</td>
<td>Black spots</td>
</tr>
</tbody>
</table>
7.5 Gather and process information and use available evidence to 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.

<table>
<thead>
<tr>
<th>Treatment and control of disease</th>
<th>Example</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pesticides</strong></td>
<td>DDT to kill mosquito vector of malaria</td>
<td>Control the spread</td>
<td>Detrimental on environment Development of resistant strains of vector or pest</td>
</tr>
<tr>
<td><strong>Antibiotics</strong></td>
<td>Penicillin to kill bacterial infections</td>
<td>Reduces symptoms and kills infection</td>
<td>Over use causing resistant strains</td>
</tr>
<tr>
<td><strong>Prevention and management</strong></td>
<td>Vaccinations</td>
<td>Against diphtheria</td>
<td>Prevents individual from contracting diphtheria</td>
</tr>
<tr>
<td><strong>Drugs</strong></td>
<td>Drugs</td>
<td>Help HIV</td>
<td>Quality of life improved</td>
</tr>
<tr>
<td><strong>Garden sanitation</strong></td>
<td>Garden sanitation</td>
<td>Cleaning up garden</td>
<td>Fungus removed</td>
</tr>
</tbody>
</table>