The Search For Better Health
1. What is a healthy organism?

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

- Health is defined by the World Health Organisation (WHO) as “a state of complete physical, mental and social well-being and not merely the absence of disease” – therefore the absence of disease does not necessarily mean good health
- Example: a disease or illness free person may be physically unfit and unable to keep up with the exercise pattern of others
- The definition of health changes for different circumstances – an older person may still be healthy even if they have arthritis and have difficulty remembering but these same symptoms would be seen as unhealthy in a younger person
- Healthy people function well physically, mentally and socially – main condition impairing health is disease
- Disease prevents proper physical functioning by interfering with the structure of organs, tissues or cells or by altering normal metabolism but it can affect people in differing degrees e.g. cancer is much more serious than a common cold

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

- Genes control characteristics by either directly or indirectly controlling the synthesis (manufacture) of all the structural and functional compounds in living cells
- Multicellular organisms begin as a zygote with half its genes come from each parent – the zygote divides by mitosis (division of the nucleus) to form a ball of cells, mitosis is under genetic control – genes can switch it on or off
- At a particular stage the cells begin to differentiate into muscle cells, nerve cells, epithelial cells, etc – during differentiation only the genes necessary for the functioning of the specialised cell remain switched on the others are switched off (usually by proteins which block off unrequired genes) – this is gene expression
- During development differentiation allocates specific functions to specific cells and tissues
- Genes and mitosis maintain the health of the organism by replacing damaged or diseased cells through the mitotic division of nearby healthy cells with the same function – this is under genetic control
- Genes, mitosis and differentiation are important for development – major growth and differentiation only occur once in the life of an organism but the growth of new cells through mitosis is a regular occurrence
- If the genes that control mitosis go out of control cell division continues, forming tumours which spread to other parts of the body and this results in cancer

PRACTICAL

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

- Genes contain coded information for proteins – proteins made to repair and control the manufacture of tissue components are consistent for an organism because they are defined in the DNA – genetic information prescribes how and when an organism’s body tissues are maintained and repaired
- Other proteins that the body makes prescribed by the genetic code also influence health and disease – if a gene is faulty the protein made cannot perform its function then a disease will result
- Gene expression is controlled so that chemicals are produced at the required rate within cells – this can increase or decrease in response to disease so that a tissue is maintained and repaired as needed e.g. skin grows faster than normal when repairing a cut
- Mitosis occurs constantly in healthy organisms to replace old or damaged cells but in response to disease it replaces damaged cells and tissue – mitosis forms identical new cells and is controlled by genes, uncontrolled cell growth leads to disease, cancer and insufficient mitosis causes gradual tissue failure because damaged cells are not being replaced
- Gene expression influences the differences between cells (differentiation) so that they are suited to perform different functions (specialisation) e.g. cells in the brain are specialised as nerve cells, cancer cells do not differentiate so do not perform a useful function in tissue and this leads to disease
- Many cells are specialised to perform roles that maintain and repair tissue e.g. several kinds of white blood cells clear away dead cells or cell fragments, recognise and destroying invading parasites or produce an immune response
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 due to disease-causing organisms called pathogens, which are transmitted from one organism to another or from environment to an organism
- Non-infectious diseases are illnesses that are not caused by pathogens, because only pathogens cause infection – non-infectious diseases include inherited, environmental and nutritional (or deficiency) diseases

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

- Cleanliness and hygiene have been recognised as important for health for thousands of years:
  - Hebrews: about 3500 years ago, followed strict rules regarding washing of people and objects, food that could be eaten and the isolation of things that might spread disease
  - Chinese: about 2000 years ago within a religion called Taoism developed principles for good health which included hygiene rules, exercises using concentration and deep, regular breathing
- These principles helped to protect people from disease and some of these hygiene principles are still used today
- Good personal hygiene practices – like washing your hands before eating and covering coughs and sneezes reduces the spread of pathogens, washing your body and cleaning your teeth prevents the build up of bacteria that may cause disease
- Good community hygiene practices – like sewage and garbage disposal, city planning to prevent overcrowding and excess pollution, recreational space and regular time off from work and community health services, these all promote good physical and mental health. Other examples include regulations for the production and handling of food, and for sterilisation and disinfection in hospitals, child care centres and other places providing care
- Cleanliness in food – processing and preparation cleanliness reduces the risk of contaminated food, which could be poisonous by chemicals or pathogen. Cleanliness requires the food is fresh and properly stored, this helps ensure the nutritional value of food so that you get the vitamins and minerals it needs
- Cleanliness in water – clean water to drink and for food preparation also reduces contamination

**PRACTICAL**

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

- By placing stale bread which has been slightly moistened in a Petri dish with a lid and leaving it for a week colonies of fungi can be seen growing on the bread

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

- Pathogens are organisms that invade the host and cause disease
- There are two types of pathogens:
  - microscopic parasites: invisible to the naked eye and include viruses, bacteria, protozoa and fungi
  - macroscopic parasites: visible to the naked eye and include endoparasites (live inside the host) and ectoparasites (live on the host’s body)
- Pathogens usually need to be spread in large numbers to cause disease as they will probably be destroyed by the protective mechanisms of organisms, although some pathogens are virulent (e.g. only few smallpox virus particles are needed to cause a severe infection)
- Pathogens are able to survive outside a host (e.g. cholera bacteria can survive in food and water) or they can be readily transferred (e.g. hepatitis B is caused by a virus transferred in body fluids)
- Pathogens are able to enter the host and reproduce without being destroyed by the body’s defence systems (e.g. smallpox enters through the respiratory system while cholera enters via the digestive tract – both are virulent enough to overwhelm the body’s defence mechanisms)
Pathogens also need a mechanism to leave one host and enter another (e.g. smallpox can be spread by sneezing and coughing whereas cholera is typically spread when faeces contaminate water or food)

**PRACTICAL**

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

Steps in purifying and sanitizing water
- Screening – the water from the dam is initially screened to remove large debris
- Aeration - initially the water is sprayed into the air to increase the concentration of dissolved oxygen. In this step any hydrogen sulfide gas dissolved in the water and any iron salts are oxidised to form sulfate ions and insoluble iron oxides. Oxygenated water is also believed to taste better
- Flocculation - water from natural sources like rivers and reservoirs contains small, suspended particles that form a clay colloid within the water. These particles never settle to the bottom due to the repulsion by their negative surfaces. However, these particles can be made to precipitate by using a process called flocculation. Sydney Water uses a coagulant called Ferric Chloride (FeCl₃). When Ferric Chloride is added to the water it forms a gelatinous precipitate or floc of Ferric Hydroxide. The precipitate adsorbs suspended solids, precipitated iron and some bacteria into bigger masses, which assists in filtration
- Sedimentation - the treated water is left to stand so that the flocs settle to the bottom and form sludge. The sludge is then removed from the tanks periodically. After this step 95% of the suspended impurities have been removed
- Filtration - Water from the settling tanks is passed through sand and gravel filters to remove the remaining suspended particles, other minerals, bacteria and coloured matter. The water by this stage should be clear (have a turbidity less than 3 NTU). If the water is still coloured it is placed through layers of anthracite (high quality coal or activated carbon), which adsorbs the coloured matter onto its surface
- Chlorination - the clear water from the filter is chlorinated to kill bacteria and other microbes (potential pathogens). The chlorination process produces hypochlorite ions, which kills the microbes. Biochemists also test the water for bacteria called coliforms (e.g. *Escherichia coli* – *E. Coli* is responsible for food poisoning), which come from pollution from animal manure. The chlorine levels must be monitored to make sure carcinogenic (cancer causing agents) chlorinated alkanes are not produced
- pH adjustment (stabilisation) – the pH of water should be between 7 and 8.5. Ammonia is added to produce chloroamines that maintain the disinfection action of the chlorine. Buffering chemicals (e.g. carbonates and hydroxides) may be added to achieve the required pH – this is important because acidic water is corrosive
- Fluoridation - fluoride is added to the Australian water supply as part of the Fluoridation of Public Water Supplies Act 1957. The small amount of fluorine added is enough to strengthen tooth enamel and prevent dental decay. Chlorinated and fluoridated water can have a pH anywhere between 7 and 8.5 so lime is used to achieve the desired pH. This is especially important as the adjustment of the pH reduces the corrosion of water pipes
- Storage reservoir – the water is transferred to storage reservoirs and then to homes
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 disease

Louis Pasteur
- In the mid 1800s Louis Pasteur studied fermentation in wine and beer and stated that the products of alcohol and lactic acid were made by microbes
- When studying samples of beet juice he found small budding yeast cells in the alcoholic samples and small rod shaped organisms (bacteria) in the acidic samples
- Pasteur concluded that yeasts living on beet juice produced alcohol as a by-product and the other microbes (bacteria) produced a different end-product from the sugar in the beet juice – lactic acid, he found the same organisms in sour milk
- He demonstrated sugar without yeast never formed alcohol and rod-shaped organisms (lactobacilli) produced lactic acid from sugar – the tests established microbes were responsible for chemical changes that produced alcohol and lactic acid
- Later when wine makers were having problems with the souring of wines Pasteur suggested heating the wine to 50-60°C to kill of the microbe – wine could then be aged without going sour, today this is used to treat milk (pasteurisation)
- Pasteur applied his hypothesis to a disease situation and was able to demonstrate that microbes were responsible for causing a disease called pebrine in silkworms
- Pasteur proposed the germ theory of disease which stated that germs (microbes) cause disease when they invade and live inside the body, using this Pasteur went on to disprove the theory of spontaneous generation
- Pasteur became involved anthrax research (like Koch) and succeeded in producing a weakened culture of anthrax bacteria which injected into test animals enabled them to become immune to anthrax infection – was the 1st vaccine produced

Robert Koch
- Koch tested and extended Pasteur’s findings
- In the 1870s Koch demonstrated that a type of bacteria – Bacillus anthracis caused the disease anthrax and he proved this by injecting healthy mice with material containing anthrax bacteria, all the mice developed anthrax
- In the 1880s he showed that different bacteria produce different diseases: Mycobacterium tuberculosis causes tuberculosis and Vibrio cholerae caused cholera – this established the link between specific microbes and diseases they cause
- His discoveries encouraged other scientists to look for and identify particular micro-organisms that cause disease

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

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

- The symptoms of malaria have been described from the earliest times and it’s thought to have affected prehistoric populations. The symptoms usually include periodic fever, anaemia (reduced number of red blood cells therefore reduced ability to transport oxygen) and enlargement of the spleen
- Malaria causes death from lack of oxygen or when serious infections affect the brain and kidneys
- The name malaria comes from Roman times (2000 years ago) because people thought the disease was caused by “bad air”, particularly air from swamps
- Quinine, an extract from the bark of the Peruvian Cinchona tree was first used in Europe in the mid 1600s to treat malaria
- In 1880, Alphonse Laveran discovered the pathogen that causes malaria—plasmodium and its other species were discovered over the next 10 years, many affect mammals and birds but only four regularly cause disease in humans
- 1897 Ronald Ross discovered malaria was transmitted by Anopheles mosquitos explaining the main steps in the process
- 1898 Giovanni Battista Grassi demonstrated Anopheles mosquitos carry the plasmodium in their digestive systems
- Here is a summary of the main steps in the infection process:
  1. Plasmodium infects Anopheles mosquitos and enters their stomachs and is carried in their blood and salivary glands
  2. Female mosquitos need a meal of blood to make their eggs mature and when they bite they first inject substances from their salivary gland which may include immature plasmodium
  3. The immature plasmodia (sporozoites) are carried around in the animal’s blood reaching the liver where it invades liver cells (merozoites)
  4. Merozoites grow for 12 days and reproduce inside liver cells until they burst. Freed merozoites move into blood and inside RBCs
  5. The merozoites can begin a sexual cycle in the animal making male and female gametocytes that are taken up by mosquitos when they bite and they join in the mosquitos stomach to make sporozoites
  6. The merozoites can begin an asexual cycle in the animal, by reproducing rapidly inside a RBC, bursting it and spreading to other RBCs to continue the infection
- In the early 1930s an antimalarial drug called Atebrin was used to prevent infection during WWII but is no longer used because it has too many side-effects
- In 1944 synthetic quinine was developed from coal tar but it was not as effective as the natural form
- In the late 1940s chloroquine was developed, initially it was very effective but many strains are now resistant to it
- In 1948 all the stages of the life cycle of the Anopheles mosquito were identified and this provided a clear understanding of the spread of malaria-causing plasmodium
In the late 1950s WHO began a coordinated effort to eradicate malaria by destroying mosquitos (used methods such as introducing fish into swamps to eat mosquito larvae, widespread spraying with DDT, draining swampy land, and spraying oil onto pools of water) and extensive use of antimalarial drugs.

Through the 1960s drug-resistant strains were increasingly observed however occurrences of infections had reduced.

New antimalarial drugs are still being developed – drug-resistant strains continue to develop as does pesticide-resistance.

A malarial genome project was established in 1983 to find the genetic structure of pathogens and hopefully better ways to prevent and treat malaria.

Worldwide research into prevention and treatment continues: 2001 – trials of malarial vaccine began in Africa.

Malaria is still a problem in Central America, the Caribbean, Central and North Africa, India, China and South-east Asia.

### Distinguish between:

- prions
- viruses
- bacteria
- protozoans
- fungi
- 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</th>
<th>Example and disease caused</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prion</td>
<td>A tiny particle made of protein – is an abnormal form of a protein needed within the organism</td>
<td>Note: Prions are usually named after the disease they cause. They cause diseases of the brain like: Creutzfeldt-Jakob disease (in humans), Scrapie (in sheep).</td>
</tr>
<tr>
<td>Virus</td>
<td>A small particle containing RNA or DNA inside a protein coat – is only able to reproduce inside a living cell</td>
<td>Influenza virus – influenza (flu), Smallpox (variola) virus – smallpox (variola), Polio virus – polio (poliomyelitis).</td>
</tr>
<tr>
<td>Protozoan</td>
<td>A single-living eucaryotic animal-like cell</td>
<td>Plasmodium – malaria.</td>
</tr>
<tr>
<td>Fungus</td>
<td>A eucaryotic, non-photosynthetic cell with cell walls, that may be single-living or form more complex structures</td>
<td>Candida albicans – thrush, Microsporum – athlete’s foot (tinea).</td>
</tr>
<tr>
<td>Macro-parasite</td>
<td>A variety of animals including worms and insects that can cause infection</td>
<td>Tapeworm – tapeworm infestation, Head louse – head lice infestation.</td>
</tr>
</tbody>
</table>
**PRACTICAL**

*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
- control

<table>
<thead>
<tr>
<th>Disease:</th>
<th>Diphtheria</th>
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<tbody>
<tr>
<td>Cause</td>
<td>Bacterium called Corynebacterium diphtheriae</td>
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<tr>
<td>Transmission</td>
<td>Bacteria can spread by touch between people, from people to objects then to people, or sprayed into the air by coughs and sneezes and then inhaled</td>
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<tr>
<td>Host response</td>
<td>Acquired immunity can be developed to the infecting organism and to the toxin it produces however normal defences tend to be overwhelmed by the pathogen, 35-90% of untreated infections are fatal</td>
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<tr>
<td>Major symptoms</td>
<td>Initially sore throat, runny nose and swollen neck glands. A white or grey membrane may form at the back of the throat; this can block the windpipe causing suffocation. The bacteria also produce a toxin that can damage the heart and nerves and can cause death</td>
</tr>
<tr>
<td>Treatment</td>
<td>Antibiotics (such as erythromycin) to kill bacteria; antidote for the toxin</td>
</tr>
<tr>
<td>Prevention</td>
<td>Because disease is highly contagious, infected people are isolated applying strict hygiene to all objects used. People caring for patients may also be isolated. Health authorities must be notified of infection</td>
</tr>
<tr>
<td>Control</td>
<td>Immunisation is the only effective control. Three inoculations are given in the first year of life, then again at 18 months, 5 years of age and at 10 year intervals to maintain immunity</td>
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**Identify the role of antibiotics in the management of infectious disease**

- Drugs used to treat bacterial infections are called antibiotics – they kill or prevent many types of bacteria
- The term is often used loosely in terms of treating any infectious disease, but the terms should be as specific as possible e.g. antimalarial against malaria, antiviral against viruses and antibiotic against bacteria
- A variety of chemicals are antibiotics however the most well known are penicillins and sulfonamides
- Antibiotics disrupt bacterial cell function and different antibiotics affect bacterial processes in different ways, hence different types of antibiotics are effective against different types of bacteria – e.g. penicillins disrupt cell wall structure in some bacteria so these cells cannot replicate, sulfonamides prevent DNA synthesis in some bacteria
- Antibiotics can only treat bacterial infections. Antiviral drugs can be used against viruses but not other pathogens
- Correct antibiotics must be taken for an infection because only one kind of antibiotic will kill each group of bacteria e.g. bacteria that cause tetanus are killed by penicillins but bacteria causing urinary tract infections are killed by sulfonamides
Process information from secondary sources to discuss problems relating to antibiotic resistance

- Some bacteria can resist some chemicals, this is natural variation and the ability of bacteria to mutate and transfer these useful genes is an adaptation that enables them to survive in changing environments
- Normal populations of bacteria contain only some organisms that would be resistant to antibiotics
- Antibiotic resistance in populations of bacteria has only developed because humans use antibiotics to treat disease – this resistance in disease-causing bacteria is increasing
- The incorrect use of antibiotics is the main cause of antibiotic resistance, incorrect use includes:
  - using antibiotics when they are not needed, e.g. for a viral infection, antibiotics are completely ineffective
  - using the wrong antibiotics for an infection, e.g. using prescribed drugs for a different illness
  - not completing the full course of antibiotics so that slightly resistant bacteria are able to survive and resistance gradually increases
- Some cleaning products contain chemicals that particularly target microbes – this encourages resistance. Microbes will always be present in our environment only certain, dangerous types needed to be killed
- Antibiotics have been used to increase growth in farm animals – while profitable for farming and food production it has increased the speed of which antibiotic resistance has developed
- People continue to use antibiotics inappropriately so that even more bacteria will become antibiotic resistant
- Antibiotic resistance is a major problem in the treatment of some diseases like golden staph (staphylococcus aureus) – can cause skin infections that if untreated may poison blood and eventually cause death, the infections used to be treated with penicillin but strains have developed that are resistant to all antibiotics. Chemicals can be used to kill the bacteria but these are poisonous to human cells too. The bacteria can cause life-threatening infections especially in people that are already ill. Serious golden staph infections have become a risk during hospital treatment
- Antibiotics remain the main treatment for bacterial infections, however new and different antibiotics are becoming difficult to develop and this combined with antibiotic resistance creates difficulties for combating infections caused by bacteria

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
- other body secretions

- Most pathogens that reach the body do not require an immune response as barriers at the body’s surface repel them
**Skin** – is a tough coating that secretes chemicals like fatty acids and sweat (contains salt), both of which inhabit bacteria

**Mucous membranes and cilia** – Mucus secreted by cells lining the respiratory tract traps bacteria, which are swept upward to the back of the throat by the action of cilia (hairs that line most of the respiratory tract). Bacteria and mucus are swallowed, or removed by blowing your nose or coughing or sneezing

**Natural secretions** – many secretions of the body are bactericidal. Tears and saliva contain lysozyme, an enzyme that causes bacteria to burst.

**Chemical Barriers** – acid in the stomach kills many bacteria. Milk contains lacto peroxidase and semen contains spermine – both chemicals act against bacteria

**Natural flora** – many different bacteria are normally found on the skin, in the gut and (in females) the vagina. These bacteria are the natural flora of the body and are non-pathogenic in those areas. The presence of these bacteria inhibits the growth of pathogenic bacteria in those areas as they compete more successfully for the available space and nutrients. Antibiotics can sometimes kill these useful microflora which may lead to an imbalance

**Identify defence adaptations, including:**
- inflammation response
- phagocytosis
- lymph system
- cell death to seal off pathogen

- The inflammation response occurs when blood vessels around an infected area are supplied with extra blood making the area swollen and red. The release of histamines by the damaged tissue increases the permeability of the blood vessels which allows white blood cells to leave the blood vessels and move into the damaged tissue
- White blood cells called macrophages and neutrophils can easily change their shape so that they flow around particles and completely enclose them within their cell, where they are broken up by cell enzymes – this is called phagocytosis
- The lymph system returns intercellular fluid to the blood system, filters cell debris and produces the white blood cells responsible for the immune response
- 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 dies – cells dies to seal off the pathogen

**PRACTICAL**
*Gather, process and present information from secondary sources to show how a named disease results from an imbalance of microflora in humans*

- There is a balance of microflora on the body. This includes a yeast called Candida albicans, which inhabits mucous membranes of the mouth, large intestines and (in females) vagina
- A pathogen infects the body. For example, this could be a bacterial infection of the respiratory system. The patient takes an antibiotic, such as tetracycline, to kill the pathogen and cure the disease however the antibiotic also kills some of the normal microflora, causing an imbalance
- Candida albicans is able to grow in unusually large numbers causing a disease called thrush. It may cause lumpy white sores in the mouth (oral thrush) or white discharge and severe itching in the vagina (vaginal thrush). Sometimes Candida albicans causes diarrhea if it grows too profusely in the intestines
- Thrush is normally more a painful nuisance than a serious disease, however when patients are ill or when their immune systems are suppressed Candida albicans can invade body tissues and infect major organs causing serious disease

**Identify antigens as molecules that trigger the immune response**

- When micro-organisms enter body tissue despite the body’s defence barriers the immune response is triggered
- Immune response is triggered by foreign molecules entering living tissue – chemicals on the outer surface of the foreign organisms in the form of a coating and protein debris (antigens) trigger the response
- The body recognises antigens and begins to make antibodies (a protein that binds with an antigen to destroy it)
- Antigens on the outer coating of the foreign molecule trigger the production of antibodies that immediately destroy it or make it easier for a macrophage to engulf it

**Explain why organ transplants should trigger an immune response**
Biology Notes, Module 3, *The Search for Better Health*, by F.A

- The effectiveness of the immune response creates a problem when organ and tissue transplants are needed
- Molecules in the transplanted tissue are treated as antigens by the body and normal immune response destroys or rejects the transplanted tissue
- Patients receiving organ or tissue transplants (from other people or animals) must take drugs to reduce immune response

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

*Background:* Sir Frank MacFarlane Burnet was an Australian scientist who won the Nobel Prize for his research into physiology – he studies immunology and worked on the development of the influenza vaccine

**Identify the components of the immune response**
- antibodies
- T cells
- B cells

<table>
<thead>
<tr>
<th>Name</th>
<th>What it is</th>
<th>What it does</th>
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<tbody>
<tr>
<td>Antibodies</td>
<td>Proteins that the body produces when it detects antigens. Each different antigen stimulates the production of its own particular antibody. They are also called immunoglobins</td>
<td>Join with antigens so that they are clumped together and can be more easily recognised and destroyed by macrophages</td>
</tr>
<tr>
<td>B cell</td>
<td>A special kind of lymphocyte produced in the bone marrow (thus B cell)</td>
<td>When a B cell recognises an antigen, it divides repeatedly to produce a mass of identical cells (clones) that work as antibody producers (plasma cells). Some of the B cells differentiate into B-memory cells which have the same antibody-antigen specificity as the parent B cell. Plasma cells only last for a few days but B-memory cells can last for years and if there is a second infection they react faster and with more vigour – basis of vaccination</td>
</tr>
<tr>
<td>T cell</td>
<td>Another kind of lymphocyte, that is passed through the thymus gland (thus T cell)</td>
<td>T cells recognise an antigen and reproduce rapidly – similar to B cells but they do not make antibodies. Cytotoxic T cells (Tc) produce toxic substances that destroy cells that have been invaded by a virus. While helper T cells (Th) recognise antigens and stimulate B cell production – B cells will not reproduce without assistance from Th cells</td>
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**Describe and explain the immune response in the human body in terms of:**
- interaction between B and T lymphocytes
- the mechanisms that allow interaction between B and T lymphocytes
- the range of T lymphocyte types and the difference in their roles

- Interaction between B and T lymphocytes – interact as they are both attacking the same antigen, helper T cells (Th) stimulate B cells and T cells to clone
- B and T cells interact in the following ways as part of immune response:
  - B cells can prevent T cells from replicating and acting
  - B cells can kill T cells and vice versa
  - a B cell can concentrate antigens by collecting lots of them over the cell’s surface and these antigens can then be presented to T cells to stimulate a T cell response
  - T cells are able to pass an antigen between cells so that many T cells can quickly become involved with B cells in response to an antigen
- The range of T cells and their roles in immune response:
Cytotoxic T cells (Tc cells) Attack and destroy macrophages that have engulfed an antigen, they produce cytotoxins
Helper T cells (Th cells) Secrete chemicals that stimulate cloning in B and T cells
Memory T cells Remain in the body and reactivate quickly with subsequent infections by the same antigen
Suppressor T cells Stop the reaction when the antigen is destroyed

Each B cell produces a clone of plasma cells which make only one kind of antibody. Memory cells are also formed, they keep the person immune from the disease for years and even life

(a) When phagocytes ingest antigens some of the antigen attaches to the phagocyte surface (b) Helper T cells help B cells to recognise foreign antigens on the surface of the phagocytes (c) The B cells reproduce to form plasma cells which produce antibodies against the antigen

Outline the reasons for the suppression of the immune response in organ transplant patients
When an organ is transplanted the antigens are recognised by the body as being non-self and the body attacks the new organ as if it is an invading pathogen.

To overcome this problem, transplant patients are given powerful drugs to suppress their natural defences but this can lead to complications as the patient has reduced defences against any pathogen that they may encounter.

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

- When a person has an infection some of the B cells produced in response to the pathogen are stored in the lymphatic tissue – they are called memory B cells, and are ready to rapidly respond if the same pathogen later attacks the body.
- Vaccination is a way of introducing a person to an infection without the harmful side-effects so that they body responds by producing the appropriate B memory cells.
- The form of the vaccine depends on the pathogen, in the case of smallpox a similar but much less harmful pathogen (cowpox) was used. In other cases, the virus is made weaker and therefore harmless before being used in a vaccine, examples of this type include poliomyelitis, measles and whooping cough.
- Many pathogenic bacteria are harmful to the body because of the toxins they produce – for diphtheria these toxins are modified to produce the vaccine.
- Whatever the source of the vaccine, the effect is the same – it introduces antigens into the body so that B cells are activated to produce large amounts of antibodies and memory B cells are stored in the lymph system in preparation for a future attack by the particular pathogen.

**PRACTICAL**

**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**

- Immunisation programs involve administering vaccines so that the individual gains an artificial acquired immunity.
- Vaccines are antigens from living, dead, weakened or non-virulent strains of micro-organisms which are injected or ingested into the body, thereby passing the body’s first line of defence, vaccinations stimulate the body to develop resistance through the production of B lymphocytes (memory B cells) which in the event of a “real” infection can be called upon to fight off the disease. The vaccine brings about a specific immune response.
- Vaccination is possibly the cheapest and safest method to prevent diseases - most developed countries implement vaccination programs for the population and have thus stopped the spread and occurrence of many common diseases.
- In Australia, the incidence of a number of diseases – the bacterial diseases diphtheria (caused by *Corynebacterium diphtheriae*), tetanus (*Clostridium tetani*) and pertussis (also called whooping cough and caused by *Bordetella pertussis*) and the viral diseases measles, mumps and rubella (also called German measles) – has significantly decreased through the use of vaccines and diseases like smallpox and polio have been eradicated.
- The National Health and Medical Research Council (NHMRC) is responsible for producing the Australian Standard Vaccination Schedule. However, much of the world (namely the undeveloped and third world) is still unimmunised and six to eight million child deaths a year are preventable by early immunisation.

**Smallpox**

- Smallpox was a highly infectious disease that killed many thousands of people each year. It has been eradicated through vaccination programs – there are no smallpox infections anywhere in the world (last reported case in 1979).
- Immunisation against the disease is no longer needed because there is no risk of catching the disease.
- Some smallpox is kept for research purposes and there is concern that is could be used as a biological weapon.

**Polio (poliomyelitis)**

- Polio is a disease that causes severe nerve damage and paralysis to 50% of sufferers and death to 5%. It once affected thousands of people, particularly children, each year. Since the widespread introduction of immunisation in 1954 the infection rate has dropped dramatically – there have been no notified cases of polio in Australia for many years.
- However polio still occurs in other countries so immunisation is important. For effective immunity six inoculations are given through the first 20 years of life.

**Diphtheria**

- Diphtheria was a serious disease affecting many thousands of people. It had a death rate of almost 35% overall and up to 90% for some forms of infection – it was the main cause of death for children under 14.
Immunisation began in the 1920s. In Australia immunisation programs were gradually introduced in the 1930s and 1940s which led to a rapid drop in the incidence of the disease – the last notified case in Australia was in 1992.

The disease still occurs in some countries so immunisation remains important. Adults can be at risk because immunity tends to decrease with age. For immunity to be effective, six inoculations are spread through the first 20 years of life and booster shots should be given every 10 years.

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 (where they occur) and frequency (how often they occur) of diseases. It is useful because scientists can find patterns that enable the identification of the cause of a disease – they can then suggest ways to prevent or limit the disease.
- Epidemiological studies involve collecting and analysing large quantities of data, the main features include:
  - large quantities of data are used so that a general pattern may be established
  - information from different places is studied
  - information related to the disease is studied across an extended period of time
  - disease information is compared with information about other factors in the environment
- The relationship between smoking and lung cancer has been established through epidemiological studies.
- For many years cigarette companies denied any link between smoking and lung cancer – the relationship has been firmly established by epidemiological studies to compare people's smoking habits and the diseases that they suffer.

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

- In 1966, comparisons of smoking and non-smoking American groups showed that people who smoked were more than 10 times more likely to die from lung cancer than those who did not.
- From the 1970s, data from 1 million healthy American men was collected, including smoking habits and diseases they developed. There was clear correlation between smoking and incidence of lung cancer; the more cigarettes smoked each day, the greater the incidence of lung cancer. Similar research was conducted from the 1950s onwards in other countries. These studies all identified the same correlation between the number of cigarettes smoked and the risk of lung cancer.
- Comparisons of people living in different areas or conditions help make clear that other factors are not involved in causing the disease. For example, people who live in cities have almost twice the risk of lung cancer as people who live in the country. But non-smokers who live in the city are less likely to develop lung cancer than non-smokers in the country. So the increased risk of lung cancer is due to smoking and not a result of polluted city air.
- Patterns in smoking have changed through the 20th century. In 1900, few women smoked; most lung cancer deaths were of men. As women began to smoke, more cases of female lung cancer were observed. As female smoking increased so has the number of cases of lung cancer in women. By the 1990s, the proportion of men who smoke declined and so has the incidence of male lung cancer. Smoking in women is continuing to increase, so is the incidence of female lung cancer.
- It is impossible to conduct lab tests to prove that smoking causes lung cancer; it would be unethical to force people to smoke so that you could see if they developed lung cancer. However, the patterns that epidemiological studies have found demonstrate that smoking causes lung cancer.

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

- Inherited diseases
Inherited diseases
- Inherited diseases result from mutations that lead to the production of different or faulty enzymes, resulting in impaired body function (e.g. Down syndrome, colour blindness, haemophilia, sickle cell anaemia)
- Example: Down syndrome is an inherited disease caused by the non-disjunction of chromosome 21 which results in three chromosomes and not the usual two (trisomy 21). People with Down syndrome have a characteristic appearance and may have a shortened lifespan. Mothers who have children later in life are more prone to give birth to Down syndrome children

Nutritional deficiencies
- The effect of nutritional deficiencies depend on the kind of deficiency – in some parts of the world diets may be deficient in certain elements such as iodine, copper, iron or zinc (e.g. scurvy, rickets, beri beri)
- Example: 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

Environmental diseases
- Environmentally caused diseases include those due to lifestyle, such as smoking-related diseases as well as those caused by something in the environment such as lead or substances that cause allergies (e.g. smoking-related diseases, Minamata disease, lead or asbestos related diseases and melanoma)
- Example: Minamata disease causes deformity and mental retardation in a foetus and is a result of high levels of mercury in the food chain

PRACTICAL
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

Nutritional deficiency: iron deficiency

<table>
<thead>
<tr>
<th>Cause</th>
<th>Iron deficiency occurs when insufficient iron-rich food is eaten or when other disorders reduce the absorption of iron or increase the loss of iron (e.g. by frequent bleeding). Iron is obtained from foods such as meat and leafy greens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurrence</td>
<td>Iron deficiency is the most common deficiency worldwide. It is most common in women of childbearing age (because they bleed regularly). It is more common in vegetarians than in meat-eaters, and in poor communities (because they are less likely to eat or be able to afford meat and may be prone to other disorders that reduce iron uptake or cause bleeding)</td>
</tr>
<tr>
<td>Symptoms</td>
<td>The main symptoms are tiredness and muscle weakness (due to insufficient oxygen being carried to cells and from the absence of essential iron-containing proteins). Other symptoms include muscle cramps, and slowed growth rate and reduced ability to learn in children</td>
</tr>
<tr>
<td>Treatment and/or management</td>
<td>A deficiency can be detected from a blood test. Treatment usually begins with an iron supplement and counselling for better nutrition. Treatment of other conditions (such as worm infestations or bleeding bowel) may also be needed</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 plants and animals into Australia or across regions of Australia*

- Australia has been spared by the spread of plant and animal disease from other parts of the world because of its geographical isolation
- Quarantine seeks to prevent the entry of harmful diseases into Australia and to stop the spread of diseases within Australia
- These diseases cause huge financial losses to farmers in other countries – Australia is able to sell its produce overseas because of the absence of diseases like mad cow disease and foot-and-mouth disease
- Australia also has declared fruit-fly free areas where produce is sold with a guarantee of no fruit fly

**PRACTICAL**

*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*

- Within Australia there is a government authority called AQIS (Australian Quarantine and Inspection Service) that oversees the movement of people and goods into the country
- There are restrictions on substances that may be brought into Australia. Some items such as apples are forbidden. Other items are inspected; for example, AQIS officers inspect people, animals, shipments of animal and plant products (such as cheese and furniture) and objects (such as machinery for soil). Living plants and animals must be isolated in quarantine stations so they can be observed for pests and disease
- Australian quarantine has been effective against many diseases and pests. (Sadly, many diseases and pests were introduced from other countries before the importance of quarantine was identified in 1908). For example, Australia remains free of yellow fever, plague, rabies and mad cow disease that affect other countries. However there has been a gradual increase in diseases and pests that have evaded quarantine measures, such as malaria
- Australia cooperates with quarantine authorities in other countries
- Australia has a system of notifiable diseases. This ensures that plants and animals with serious diseases (such as Newcastle disease in chickens) are isolated from others and destroyed so that the diseases cannot spread
- Quarantine relies on Australians valuing our isolation from pests and disease and taking responsibility for supporting quarantine measures

*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 provide quarantine, sanitation, safe drinking water and immunisation and they are also responsible for advertising campaigns that target skin cancer and AIDS (e.g. Slip! Slop! Slap! Skin cancer advertisements)

Pesticides such as DDT have been used to destroy mosquitoes which are vectors of some diseases such as malaria and dengue fever – in 1956 WHO used DDT to eradicate mosquitoes in malarial areas even though it has been banned in many control because of its harmful ecological effects. This has rid many areas of malaria but not globally and many areas have DDT-resistant mosquitoes so now other pesticides such as organophosphates and pyrethrums are used

Genetically engineered cotton plants can now kill their own pests because of the insertion of a gene from soil bacterium – Bacillus thuringiensis (Bt), Bt cotton is a disease-resistant crop and was the first GE crop grown in Australia. It contains a gene that produces a toxin which kills the cotton pest Heliothis

**PRACTICAL**

*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*

- 150 years ago, many diseases of animals and plants tended to be considered only when organisms became diseased. Because there was limited understanding of the causes, people responded to disease rather than attempting to prevent it
- Increasingly, agricultural and other research is looking for ways to prevent known diseases and to plan risk management strategies to minimise the spread and impact of new diseases. This is advantageous because it improves the value of plants and animals (for example, by making food more nutritious and increasing crop yield) and it protects the economy (for example, by ensuring the constant availability of crops and keeping rural communities stable)
- Techniques being used to prevent and control disease include:
  - disease risk planning (for example, in 2002 Australia set a detailed emergency plan and new identification procedures in case of an outbreak of foot and mouth disease. This disease has not occurred in Australia since 1872 but outbreaks in other countries keep Australian authorities vigilant)
  - quarantine restrictions and eradication programs to limit disease (e.g. destruction of infected animals and immunisation programs to limit foot and mouth disease in North America and more recently in Britain)
  - selective breeding to make plant and animal crops more disease resistant (for example, the selective breeding of Australian durum wheat that is resistant to yellow leaf spot)
  - genetic engineering of disease-resistant crops (for example, Bt cotton) and herbicide-resistant crops so that crops would be unaffected by poison used against weeds (for example, Roundup Ready soybeans). Debate continues about the long-term health and environmental impact of these crops
  - Selective use of pesticides before infestations occur. This is supported by government and commercial agricultural organisations that offer services to identify pests and recommend control strategies
  - Epidemiological studies of plant and animal diseases
- In the future, it should be possible to eradicate more diseases and to closely control many others. But there will remain infections and infestations that are not controlled because they are too difficult or not important enough to overcome. Common garden pests are probably in the latter category