The search for better health
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**COMMONWEALTH OF AUSTRALIA**

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**Writer:** John Johnstone

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**Module overview**

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During your studies you have learned how the internal workings of an organism function. You have seen how organisms and groups of organisms relate to each other within communities and food webs and you have learned much about the reproductive and genetic processes involved in continuing a species. Your studies in evolution have provided an important unifying theme to much of your work and have explained how species change over time. Now it is time to look at disease.

The syllabus title for this module, *The search for better health*, is a little misleading. Certainly you will investigate the health and disease aspects of a variety of infectious and non–infectious diseases in both plants and animals. However, you will also study some very elegant methods of scientific research and learn much about the life cycles of disease organisms.

Our focus is as much on the health of a *diseased* organism as it is on the *disease causing* organism itself. A better title for the syllabus section would have been *Disease*, because this section is far broader than the health aspects of disease.

This module is a brief introduction to aspects of medical, veterinary and plant sciences. If you intend to branch into any of those fields then this will provide a basic introduction.

Of course, the need for a basic understanding of diseases and health extends well beyond the health profession. As far back in human history as 3000 years ago the Chinese and Hebrews were advocating the need for cleanliness in food, water and personal hygiene. The need for cleanliness as a basic understanding of disease transmission has not changed.

No matter what you decide to do beyond your HSC studies we are sure that you will take away something of use from this module.
Outcomes

This module increases students’ understanding of the history, nature and practice of biology and the applications and uses of biology, and implications of biology for society and the environment.

Indicative time

The search for better health should take 30 indicative hours to complete. Each part of the module is approximately five hours work.

Resources

Here is a list of things you may like to get before you start this module. Most of the items will probably be in the kitchen cupboard already. You will use these items in some of the practical work for this topic.

Part 1
• 1 packet of jelly (any flavour/colour you like)
• 1 tablespoon of Bonox®, Marmite®, Vegemite® or AussieMite®
• cling wrap
• 4 small jars with screw cap lids to fit
• 2 small cans of baked beans or creamed corn.

Part 6
• plants
• pencil
• paper
• hand lens or magnifying glass
• access to a gardener or farmer (optional).
Icons

The following icons are used within this module. The meaning of each icon is written beside it.

The hand icon means there is an activity for you to do. It may be an experiment or you may make something.

You need to use a computer for this activity.

Discuss ideas with someone else. You could speak with family or friends or anyone else who is available. Perhaps you could telephone someone?

There is a safety issue that you need to consider.

There are suggested answers for the following questions at the end of the part.

There is an exercise at the end of the part for you to complete.
## Glossary

The following glossary provides the scientific meaning for many of the scientific terms used in your syllabus for module 9.4 *The search for better health.*

The HSC examiner will expect you to understand the meaning of every scientific term used in the module. If you find a term that you do not understand then look it up in a scientific dictionary or ask your teacher for assistance.

<table>
<thead>
<tr>
<th>Term</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>aerobic respiration</td>
<td><strong>Respiration</strong> that requires the presence of oxygen.</td>
</tr>
<tr>
<td>anaerobic respiration</td>
<td><strong>Respiration</strong> that does not require the presence of oxygen.</td>
</tr>
<tr>
<td>antibody</td>
<td>A substance produced by the body in response to an antigen. Antibodies are proteins that are able to combine with antigens to deactivate them.</td>
</tr>
<tr>
<td>antigen</td>
<td>A substance that causes the production of a particular antibody.</td>
</tr>
<tr>
<td>apoptosis</td>
<td>Programmed cell death</td>
</tr>
<tr>
<td>bacteria</td>
<td>(singular: bacterium). Microscopic <strong>procaryotes.</strong> There are many different types of bacteria and they are associated with important processes such as decay and nitrogen fixation from the atmosphere. Some bacteria are responsible for infectious diseases in plants and animals.</td>
</tr>
<tr>
<td>carcinogens</td>
<td>Chemicals that cause cancer</td>
</tr>
<tr>
<td>cardiovascular disease</td>
<td>Disease of the heart or circulatory system. Cholesterol deposits in arteries and faulty heart valves are examples of cardiovascular diseases.</td>
</tr>
<tr>
<td>coagulation</td>
<td>For a fluid to thicken or congeal.</td>
</tr>
<tr>
<td>coliform</td>
<td>With reference to the bacteria of the colon (lower intestine).</td>
</tr>
<tr>
<td>congenital</td>
<td>Existing at or from one’s birth. Congenital diseases are those with which you are born eg. certain defects of the heart, lungs or circulatory system.</td>
</tr>
<tr>
<td>cyst</td>
<td>A protective coat often used to protect internal parasites.</td>
</tr>
<tr>
<td>disease</td>
<td>Any disturbance of structure or function of the body. Most diseases are associated with characteristic structural changes to the body and with</td>
</tr>
</tbody>
</table>
characteristic symptoms.

Diseases fall into five broad categories.

- Congenital and hereditary diseases
- Inflammatory diseases
- Degenerative diseases
- Metabolic diseases
- Abnormal cell growth (neoplastic) diseases

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down syndrome</td>
<td>Genetic disease caused by either an additional chromosome number 21 (3 chromosomes 21 rather than 2) or by an additional piece of chromosome 21.</td>
</tr>
<tr>
<td>haemophilia</td>
<td>Genetic disease in which those suffering the disease are unable to repair wounds. Even minor cuts can be life threatening because the blood would not clot to prevent further bleeding. Before modern medical intervention haemophiliacs rarely reached puberty – they bled to death. The gene for haemophilia is sex linked.</td>
</tr>
<tr>
<td>health</td>
<td>A state of physical, mental and social well-being and not merely the absence of disease or infirmity.</td>
</tr>
<tr>
<td>host</td>
<td>Any organism from which a parasite gains nutrition. The life cycle of the parasite may include intermediate as well as final (primary) hosts.</td>
</tr>
<tr>
<td>incubate</td>
<td>To maintain a bacterial culture at the optimum temperature for development.</td>
</tr>
<tr>
<td>inflammation</td>
<td>Reddening of tissue and/or increased temperature of tissue. Can include swelling of tissue. For example, the flesh around a splinter is often reddened or warmer (inflamed).</td>
</tr>
<tr>
<td>inoculate</td>
<td>Introduce a micro–organism that causes a disease usually by injection.</td>
</tr>
<tr>
<td>lymphocyte</td>
<td>A type of white blood cell involved in the immune response.</td>
</tr>
<tr>
<td>macrophage</td>
<td>Large phagocytic cell.</td>
</tr>
<tr>
<td>metabolic</td>
<td>Referring to metabolism. Metabolism is the sum of the processes or chemical changes in an organism. It includes the synthesis of new compounds from food and the breaking down of food into simpler compounds.</td>
</tr>
<tr>
<td>microbe</td>
<td>A microscopic organism such as a bacterium or protozoan.</td>
</tr>
</tbody>
</table>
mosaic: In reference to mosaic viruses this term refers to a patchy variation of colour.

multicellular: Organism made of many cells. Often the cells of multicellular organisms specialise to form tissues and organ systems.

necrosis: Death of tissue.

oncogene: A gene that leads to the growth of tumours.

parasite: An organism that obtains its nutrients from another organism (host) without providing any benefits in return to the host eg. tapeworm.

pathogen: A disease causing organism.

phagocyte: Cell that engulfs food by wrapping around.

prion disease: A group of diseases caused by abnormal prion protein eg. CJD and Kuru.

procaryote: Unicellular organism without membrane bound organelles. Procaryotes were the first cellular organisms to evolve.

proto oncogene: The precursor to oncogenes.

respiration: Biochemical process by which energy is released within a cell.

saprophyte: Organism that feeds on dead organic matter. Many bacteria and fungi are saprophytes.

sebum: Fatty secretion of sebaceous gland.

serum: Fluid often obtained from blood (human or other animal) that contains antibodies to stimulate B–cell and T–cell production.

spontaneous generation: Spontaneous generation was the theory that living things could arise from non–living things ie. that living things could be generated without the need for parenting organisms.

subterranean: Existing below the surface of the ground.

tumour: A swelling caused by the growth of new tissue. The tumorous tissue usually exhibits unrestricted growth.

turbid: Opaque or muddy. Turbidity refers to the clarity of a fluid.

unicellular: Organism made of a single cell such as a protozoan or bacterium.
vector  An organism that transmits a pathogenic organism from one place to another. For example, the mosquito *Culex annulirostris* is a vector for the Ross River fever virus.

vertebrate  An animal that has an internal skeleton with a vertebral cord running inside the dorsal surface. The cord is encased within a series of bones (vertebrae). All vertebrates are also chordates (animals that have a notochord at some stage in their development). Vertebrata is a sub-phylum of Chordata.

viscous  Thick or glutinous. Honey is more viscous than water.

zoonose  Any disease that is transmitted from animals to humans by either direct contact or through animal products eg. food.
The search for better health

Part 1: Health and disease
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</table>
Over 3000 years ago the Chinese and Hebrews were advocating cleanliness in food, water and personal hygiene. It took western civilisation a much longer time to realise that micro-organisms spread disease. Doctors in hospitals were moving from one patient to the next without washing their hands or changing their clothes.

In this first part of the module you will be looking at the definition of a healthy organism and the effect of pathogens on host organisms.

In this part you will have the opportunity to learn to:
• discuss the difficulties of defining the terms ‘health’ and ‘disease’
• outline how the function of genes, mitosis, cell differentiation and specialisation assist in the maintenance of health
• distinguish between infectious and non-infectious disease
• explain why cleanliness in food, water and personal hygiene practices assist in control of disease
• identify the conditions under which an organism is described as a pathogen.

In this part you will have the opportunity to:
• use available evidence to analyse the links between gene expression and maintenance and repair of body tissues
• identify data sources, plan and choose equipment or resources to perform a first-hand investigation to identify microbes in food or in water
• 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.

This version November 2002.
Defining health

Extracts from the Macquarie Concise Dictionary reproduced with the permission of the publishers, The Macquarie Library Pty Ltd, North Ryde

The World Health Organisation defines health as:

‘A state of physical, mental and social well-being and not merely the absence of disease or infirmity.’

This is a fairly broad definition of health. That said, this is a suitable definition of health for your HSC studies into disease.

Many terms used in science are also used in general conversation. Sometimes these words have different meanings in common usage to scientific usage. Try doing the activity below.

Look up the word health in a dictionary. Does the definition in your dictionary agree with the definition given by the World Health Organisation above?

Do this now, before you read further.

You probably found that your dictionary gave a definition that said that you were healthy when you were not diseased. Here is how the Concise Macquarie Dictionary defines health:

‘Soundness of body; freedom from disease or ailment.’

The definition above says that you are healthy if you are not diseased. This definition is adequate for common usage, but scientists and health professionals need a definition that is a little more detailed. Your HSC examiners will also require a more detailed explanation.
Defining disease

Go to your dictionary again. This time look—up the meaning of the word disease.

Do this now, before you read any further.

You probably found that your dictionary defined disease as a sickness or an illness. Here is how the Concise Macquarie Dictionary defines a disease:

‘An illness, sickness or ailment of some organ or part of a plant or animal body.’

A previous course in HSC biology defined disease as:

‘Anything that impairs functioning (of an organism).’

The interesting thing about most common definitions of disease is that they are imprecise. For example, a broken arm is an ailment, but not considered to be a disease. For that matter, a pregnant woman may, at times, feel sick yet her pregnancy is not a disease.

Clearly we need a better working definition of disease for the purpose of scientific study.

The best way to define disease is to use a general definition and then to limit the use of that definition to particular circumstances. Such a definition would exclude things like pregnancy and broken arms by the limits placed upon the definition.

Any disturbance of structure or function of the body of an organism is a disease. Most diseases are associated with characteristic structural changes to the body and with characteristic symptoms.

Our definition of disease now becomes:

Any disturbance of structure or function of the body of an organism is a disease. Most diseases are associated with characteristic structural changes to the body and with characteristic symptoms.
Types of disease

Diseases fall into five main categories: congenital and hereditary diseases; inflammatory diseases; degenerative diseases; metabolic diseases and abnormal cell growth (neoplastic) diseases.

Congenital and hereditary diseases

These diseases are caused by genetic abnormalities or injuries received within the uterus to the foetus. For example, haemophilia or congenital heart defect in the foetus that results from the mother contracting German measles.

Inflammatory diseases

The body can react to injury by inflammation. Insect bites, bacterial or viral infections and even internal parasites can all cause inflammation.

Degenerative diseases

The degradation of various parts of the body can be considered as a disease. For example, the hardening of arteries and some types of arthritis fall into this category.

Metabolic diseases

These result in a disturbance or disruption to metabolic processes within the body. Examples include diabetes and disorders of the thyroid gland.

Abnormal cell growth (neoplastic) diseases

When cells fail to divide normally or fail to stop dividing then cancers, growths and tumours can result.

The World Health Organisation has an extensive web site. You can find information about new diseases as well as diseases that have been around for some time. The fact sheet section of the site is particularly good for information relevant to this disease topic.

How do you find the World Health Organisation? You can search the words World health Organisation or try this address: http://www.who.int
The question below will help you think about the definition of disease. For each ailment in the left hand column place a tick in the middle column if it is a disease and a cross if it is not a disease. In the right hand column give your reason for deciding if it was or was not a disease.

<table>
<thead>
<tr>
<th>Ailment</th>
<th>Disease?</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>influenza</td>
<td></td>
<td></td>
</tr>
<tr>
<td>intestinal tapeworm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cut finger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>common cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>hereditary baldness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>measles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cold sore</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Check your answers.

Do Exercise 1.1 now.
Genes, mitosis and cell differentiation

Genes, mitosis, cell differentiation and cell specialisation all assist in the maintenance of health.

Let’s start with definitions of the above terms to make sure you understand them. Match the terms with their meaning.

- **genes**: cell division that results in identical cells
- **mitosis**: each cell has the potential code to change into different cell types
- **cell differentiation**: the units of inheritance that codes for inheritance.
- **cell specialisation**: each cell type carries out different cell functions

Check your answers

**Gene function and health**

Genes help to maintain health by:
- coding for chemicals and processes that maintain body health.
- regulating the cell cycle
- placing limits on mitotic division and replacement.

**Chemicals and processes**

Genes code for many of the body chemicals and processes. For example, **phagocytes** engulf foreign matter entering the body. The digestive enzyme used by the phagocyte to break down the foreign material is produced as a result of genetic code.
Regulating the cell cycle

Proteins produced by genes regulate the cell cycle. You learned about the cell cycle in the preliminary part of this course.

The cell cycle starts with mitosis producing new cells. After mitosis the new cells are reduced in size by half so the first stage is a growth period. This is followed by DNA synthesis and then a second growth period.

At the end of the second growth period mitosis occurs and the cycle continues.

When a cell divides there are proteins that ensure the DNA is correctly copied. If the copied chromosome is not accurate then mutation would be passed on to the next generation of cells.

Limits to division and replacement

Dead and injured cells are replaced. How is this process initiated?

Chemicals produced by the genes can either ‘switch on’ or ‘switch off’ cell division depending upon need. Occasionally the process may get out of hand and cell division may not be stopped when replacement is complete. This results in the production of a tumour.

Mitosis and health

Each day millions of cells die in your body. Many of the deaths will be among the erythrocytes (red blood cells) which are short lived. Other deaths will come from malfunctioning cells that are killed so they can be replaced by healthy cells and from cells killed by diseases.

The apparent large number of deaths is a normal process. The cells that die are replaced by the process of mitosis, which, you will remember from previous studies, creates cells that are genetically identical to the parent cell. Mitosis is responsible for both growth and replacement of cells.

White blood cells that fight disease are replicated by mitosis when a disease enters the body. This replication process increases the number of white cells available to fight the disease. You will examine this process in some detail later in this module.
Cell differentiation and health

Undifferentiated cells have all the information within them to form an adult organism. When they differentiate they become specialised as different types of cells.

Cell differentiation is the process by which cells specialise. Some differentiated (specialised) cells have very important roles for the maintenance of health. For example some leukocytes (a type of white blood cell) are responsible for the production of antibodies to fight infections. You will learn more about leukocytes later in this module.

Other cells are specialised as phagocytes. A phagocyte is a cell that engulfs food. Some phagocytes are specialised to engulf and digest bacteria and other foreign material that enters the body.

Of course, all cells are potentially important for an organism’s health since the malfunction of a cell can be either be disease causing or can leave the organism open to attack.

Gene expression

What is gene expression?

The term ‘gene expression’ refers to the way in which a gene exhibits itself. A person homozygous for blue eyes has two blue eye colour genes. The expression of these genes is to produce blue eye colouring.

During development from a fertilised egg, different stages of expression occur. This development is called cell differentiation. Not all of the genes are expressed at the same time. Genes are switched on and off at various times of the life cycle.

Let’s consider a minor repair.

You have a small cut. The body will repair the cut and replace the missing skin and lost blood. Most importantly, your body will replace the missing skin with an equivalent piece of skin. Your genetic code has all the details required to produce a new bit of skin that exactly fits the bit left uncovered by the cut. The genes that control skin cover express themselves by repairing/ replacing the skin over the cut.
The genes for skin cover express themselves, in the first instance, by giving you the total skin cover you have at birth. These genes continue to express themselves by maintaining your skin cover during your life. Holes in the skin are repaired, lost skin replaced and as you grow, more skin is produced to maintain body cover.

As long as your genes remain unaltered, the genes will continue to express themselves in the correct way during your life. Unfortunately, genes do not always remain unchanged. For example, skin cells may lose the ability to stop dividing when the correct amount of skin has been replaced. When skin cells (and indeed other body cells) lose this ability cancers and tumours result.

The link between gene expression and maintenance and repair of body tissues

When DNA replicates it normally produces exact copies of itself. This process is ensured by DNA repair genes and other genes called proto oncogenes and tumour suppressor genes. These all control normal cell replication. When mutations occur in these cells it contributes to the development of cancer.

Oncogenes are genes that cause cancer. They are formed by a mutation in proto oncogenes and result in cells making proteins that stimulate excessive cell growth and thus uncontrolled cell replication. Only one oncogene needs to be formed because they are a dominant allele. The result is a tumour consisting of uncontrolled cell division.

Another link between gene expression and the maintenance and repair of body tissues occurs because of the failure of apoptosis. This process is the normal death of cells, sometimes called cell suicide. If this fails to happen then this may form a tumour.

It would be a good idea to follow up the issue of gene expression.

If you have access to a library or the Internet, research cancers and tumours. Find the name of two different cancers or tumours and the name of the body organ(s) they are associated with

There are some sites for you to start with at:
http://www.lmpe.edu.au/science

Do Exercise 1.2: Genes, mitosis and cell differentiation.
Infectious and non-infectious disease

An infectious disease can be passed from one organism to another. A non–infectious disease can not be passed from one organism to another. A disease that you can ‘catch’ by contact with another organism or the wastes or tissues of another organism is infectious. For example:

- contact with another organism that either has or carries the disease (a mosquito bite, contact with another person, contact with blood from an infected organism or contact with wastes such as faeces from an infected organism)
- contact with air, food or water containing a disease organism.

A disease that can not be ‘caught’ by contact with an organism with the disease is non–infectious. For example: genetic diseases and lifestyle diseases such as obesity caused by overeating.

Try this exercise. It should help you clarify the difference between infectious and non–infectious diseases. Complete the table, then check your answers.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Infectious</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>common cold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>haemophilia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mumps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chicken pox</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Down syndrome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>skin cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cardiovascular disease</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do Exercise 1.3: Infectious and non–infectious diseases.
Prevention of infectious diseases

Many of your personal hygiene practices are related to preventing the transmission of infectious diseases.

Consider the table below. The left–hand column lists the hygiene practice and the right hand column lists the reason. Two items have been left blank in the right–hand column so that you can write your own answers to these.

<table>
<thead>
<tr>
<th>Hygiene practice</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>washing hands after going to the toilet</td>
<td>Removal of bacteria to prevent transmission to others or to yourself.</td>
</tr>
<tr>
<td>cooking meat</td>
<td>Kills bacteria and flatworm cysts in the meat. Modern meat inspection practices ensure that the occurrence of parasites is far less common in meat.</td>
</tr>
<tr>
<td>bathing/showering</td>
<td>Removes accumulated bacteria living in fats, oils and moisture on skin. Interestingly there is one school of thought that says that by not washing at all the bacteria on the skin eventually reach a natural balance that is not harmful to the body.</td>
</tr>
<tr>
<td>brushing teeth</td>
<td></td>
</tr>
<tr>
<td>boiling water when travelling</td>
<td>Kills micro–organisms in the water. Those local to an area often develop a resistance to microbes in the local water, but travellers are frequently susceptible to the new micro–organisms they encounter.</td>
</tr>
<tr>
<td>covering mouth and nose when sneezing</td>
<td></td>
</tr>
<tr>
<td>washing a wound and then covering</td>
<td>Removes bacteria by washing. Covering prevents airborne bacteria from entering.</td>
</tr>
</tbody>
</table>

Cleanliness and hygiene are important to reduce the transmission of disease. At a personal level this means washing your hands before eating and using tongs when handling food. At a government level it includes sewage disposal, water treatment and safe food handling laws.
Food preparation hygiene

The World Health Organisation states:

'The World Health Organisation regards illness due to contaminated food as one of the most widespread health problems in the contemporary world. In infants and the elderly, the consequences can be fatal.'

The World Health Organisation recommends the following practices.

- Use safely processed foods. For example, food exposed to ionising radiation (which kills microbes) is preferable to food that has not been processed this way.
- Food should be cooked thoroughly to kill micro–organisms present. All parts of the food must reach at least 70°C.
- Cooked food must be eaten immediately. As food cools micro–organisms invade and multiply in the warm food.
- There should be careful storage of cooked foods. If stored hot, food must be kept at least 60°C. If stored in a refrigerator it must cool quickly. Large volumes of food cool slowly allowing bacteria to multiply.
- Wash hands repeatedly before and after food preparation.
- Keep all kitchen surfaces meticulously clean.
- Use only clean water to wash and cook food.

Do Exercise 1.4: Prevention of infectious diseases.

Microbes in food and water

A microbe is a microscopic organism such as a bacterium or protozoan.

Most microbes are so tiny that they can only be seen under very powerful microscopes. Fortunately techniques exist to identify many microbes without using a microscope at all!

So how can you identify a microbe without actually seeing it?

Let’s imagine that you have one unicellular microbe and that it has plenty of food to grow. After a short period of time the cell divides (by mitosis) into two cells. The two cells make four, the four make eight, the
eight make 16 and so on. Before too long you have millions of these cells, all produced from the one microbe.

If you have one unicellular microbe how many would you have after one day? Assume that your microbe has plenty of food and that the microbe divides every two hours.

Check your answers when you have done the calculation.

You may have realised that there is a short cut to the whole process. Instead of working the result manually, you could have expressed the calculation as 2 to the power of 12 (\(2^{12}\)). The power of 12 is used because there are 12, two hour periods in the day. The 2 is used because the bacteria double each time.

How many microbes would there be in a week?

The calculation for the number of bacteria in a week becomes:

\[2^{\text{the number of 2 hour periods in one week}}\]

There are 12 two hour periods in one day and seven days in each week. This gives 84 two hour periods in a week. The number of bacteria after one week is:

\[2^{84}\]

\[= 19\,340\,000\,000\,000\,000\,000\,000\,000\]
This can be expressed as $1.934 \times 10^{25}$

Millions of microbes in the one place make a fairly substantial colony. The colony can be so big that you can see it easily with the naked eye. Colonies of microbes have an interesting characteristic. The colonies made by different types of microbes will appear different. The size, shape and colour of these will differ from one type of microbe to the next.

To overcome the problem of identifying a microbe that is too small to see, we identify them by their colony characteristics rather than by trying to view individuals under a microscope.

**Identifying the presence of microbes**

Let’s see how easy it is to identify the presence of microbes in food.

Complete the experiment below. It can be set up now. Depending on how warm it is when you do this experiment, this will take between three and seven days to get a result.

**What you will need:**

- 1 packet of jelly (any flavour/colour you like)
- 1 tablespoon of Bonox®, Marmite®, Vegemite® or AussieMite®
- boiling water
- cling wrap
- 4 small jars with screw cap lids to fit.

**What you must do:**

First you must sterilise your jars to remove any bacteria.

Be very careful when using boiling water. If you are doing this at home make sure that young children are kept away from the experimental area while you are sterilising your jars.

1. Thoroughly clean your jars and lids. Pour boiling water into the jars. Tip the boiling water out after about half a minute and quickly turn the jar upside down onto a clean sink. DO NOT dry the jar with a tea-towel under any circumstances!
Now carefully clean your lids. Pour boiling water into the lids. Wait half a minute and then turn upside down onto the clean sink.

Wash a mixing bowl with boiling water. Mix the jelly crystals with a tablespoon of Bonox® (or similar substitute) and half the water recommended on the jelly packet into the bowl. Use boiling water only to make the jelly. Stir the jelly–Bonox® mix quickly with a spoon and immediately cover the bowl with cling wrap.

Pour about 2–3 cm of the jelly mix into one of your jars. Immediately cover the jar with cling wrap and place the lid on top. Repeat for the other three jars.

Place the jars into a refrigerator or in a cool place for four hours. Discard any jelly solution remaining in the bowl. (Do not eat the jelly remaining it will taste truly terrible!)

Wash your hands before the next step.

Select some food you are going to eat for a meal. Perhaps some bread, meat, salad or whatever is on your lunchtime sandwich. You only need a very tiny sample of say four ingredients in your lunch.

Select one jar and one of your food ingredients. Use a pair of sterile forceps or tweezers (dip them into boiling water just before you use them) to carefully touch the surface of the jelly with the food in three or four different places. Touch the jelly as if you were lightly stamping the jelly with the food. You must work very quickly on this step. The lid must be off the jar for as little time as possible.

Replace the cling wrap and the lid on the jar as soon as you have stamped the surface. Label your jar so you will know which food was used to stamp the surface.
10 Repeat the last two steps for each of the remaining jars. Each jar will be used to test a different food.

11 Place your jars on a warm window sill and leave.

Bacteria will grow on your jelly. To avoid infection from the bacteria follow these safety instructions.

- Do not touch the bacteria.
- Do not remove the cling wrap.
- Do not place your nose near the open top of the jar.
- Wash your hands thoroughly with soap and warm water after handling the jars.

After you have recorded your results it would be best to leave the jars covered and to dispose in the garbage.

Write up this experiment in Exercise 1.5: *Identifying the presence of microbes in food.*

Use the headings Aim, Method, Result and Discussion. If you need help in writing up the practical then look at the section on experiments in your *Science resource booklet.*

Your aim is to determine if microbes occur in the food samples you selected. Your method is the steps outlined above.

Your result should be four carefully drawn diagrams to show the bacterial colonies that develop on your jelly after 3–7 days. Be very careful to draw the colonies accurately. Each different colony should be given a number (colony type 1, colony type 2, etc). Remember that different colonies will appear different. If you have difficulty with this then read the next section which will provide some examples to help you.

Your discussion will compare the types of bacteria found on each sample. Did the same bacteria occur on each sample or did different food samples have different bacteria?

After you have written your report, answer the questions

1 What is the purpose of adding Bonox® to the jelly?
2 Why do the jars need to remain sealed during the experiment?

______________________________________________________

______________________________________________________

______________________________________________________

3 Why is it necessary to wash your hands in step 7?

______________________________________________________

______________________________________________________

______________________________________________________

4 Why should you not dry the freshly sterilised jar with a clean tea towel?

______________________________________________________

______________________________________________________

______________________________________________________

Check your answers.

Pathogens in water

A pathogen is an infectious agent that causes disease. Pathogens include prions, viruses, bacteria, protozoans, fungi and macro–parasites.

You have just arrived in a new country. You are worried about the cleanliness of the local water supply. Many of the tourists are sick from bouts of 'Bali belly' and another more vigorous form of diarrhoea called 'Tutenkamen’s revenge'. You are thirsty and your only source of water is from the tap over the sink. What do you do?

You probably decided to boil the water. Water that has been boiled for around three minutes is reasonably safe to drink. Only a few micro–organisms can survive three minutes at the boil.

Another option for the seasoned traveller is to add water 'purification' tablets to a bottle of the water. The water needs to be left for a time while the tablet dissolves and takes effect. The tablet releases chemicals that are toxic to many micro–organisms (but thankfully safe for human consumption).

Whichever option you chose you would have been involved in water treatment. Modification of the water supply is called water treatment.

Do Exercise 1.6: Pathogens in water.
**Water treatment for large towns and cities**

The treatment outlines above is fine for your thirst in a strange location, but what about the treatment for whole towns and cities? Clearly you would not be in a position to boil every drop of water before putting it into a pipe and sending it to the people living in the town.

Between July and September 1998 Sydney was unable to drink from its water supply. This was because of two protozoans, cryptosporidium and giardia. Both of these organisms are transmitted to water through contamination with faeces or direct contact with infected individuals.

![Cryptosporidium attached to intestine.](Photo © Key Centre for Microscopy Sydney University)

![Giardia.](Photo © Key Centre for Microscopy Sydney University)
Sydney Water in their Report Number 5 covering the period December 1999 to February 2000 state that they test for both microbiological and physical/chemical factors. The physical/chemical factors relate to water taste, colour and turbidity. The microbiological testing is mainly for coliform bacteria.

Coliform bacteria are usually associated with faeces. Faeces can enter water supplies from septic run off and grazing activities in the water catchment. All water supplies naturally have these bacteria (as do the colons of animals including humans). The presence of coliforms is an indicator that other diseases that can be transmitted by faecal contamination may also be present.

*Escherichia coli* is the bacteria that Sydney Water use as an indicator species for faecal contamination
(Photo © Key Centre for Microscopy Sydney University).

Sydney Water, like most other water suppliers, adds chlorine to the water supply to kill the coliform bacteria. This chlorine treatment also acts against much other disease causing organisms associated with faeces.

A similar process is used in swimming pools to prevent infection to swimmers. Sufficient chlorine is added to the drinking water to kill the coliforms and to retain sufficient chlorine content to keep the water safe right to the household tap.

Other methods of water treatment are filtration, chloroamination and ozone filtration.

The diagram below shows the steps in water filtration for a large water supplier such as Sydney water.
Contact your local water supplier to ask for information about water treatment. If you are on tank water and depend on rainfall rather than a pipe linking you to a dam you can still contact one of the bigger water suppliers for information.
What types of micro–organisms are treated in your water supply? Does your water supplier also test for Cryptosporidium and Giardia? If so why?

There are some useful sites to gain this information from the Internet.
http://www.lmpc.edu.au/science

There is also some information in the Additional Resources section of this part.

Do Exercise 1.7: Water treatment for large towns and cities.
Giardia

Giardia is a unicellular parasite that normally inhabits the intestines of animals and humans.

Symptoms

Diarrhoea, cramps, nausea followed by weight loss and dehydration. It is spread by putting objects in your mouth that have been contaminated with faeces. People working with children are particularly at risk.

Treatment

There are prescription drugs available that kill the parasite.

Prevention

To prevent Giardia infection wash your hands after you go to the toilet and before you prepare food. Don’t drink untreated water. Avoid swimming pools if you are infected to stop the spread.
Cryptosporidium

Cryptosporidium is a parasite that causes the disease Cryptosporidiosis. It appears in the warmer months and can survive chlorination. The disease is spread when Cryptosporidium is taken in through water, personal contact or food.

Symptoms

Symptoms of infection include:

Watery diarrhoea, cramps, fever and vomiting. It is spread by putting objects in your mouth that have been contaminated with faeces. People working with children are particularly at risk.

Treatment

There is no treatment and healthy people recover within two weeks. People with weakened immune systems should take special care with the water they drink.

Prevention

Personal hygiene practises reduce the risk of the disease. To prevent infection wash your hands after you go to the toilet and before you prepare food. Don’t drink untreated water. If you have diarrhoea don’t prepare food for others, avoid swimming pools if you are infected to stop the spread and keep away from people with lowered immunity.
## Types of disease

<table>
<thead>
<tr>
<th>Ailment</th>
<th>Disease?</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>influenza</td>
<td>✓</td>
<td>Body function is disturbed. Influenza has a characteristic set of symptoms. Inflammation and metabolism effected.</td>
</tr>
<tr>
<td>intestinal tapeworm</td>
<td>✓</td>
<td>Body function disturbed. Inflammation and metabolism changes possible.</td>
</tr>
<tr>
<td>cut finger</td>
<td>✓</td>
<td>Function disturbed but no other characteristics of disease. The pain of the cut does not qualify it as a disease. Any inflammation is the result of secondary infections ie. the result of bacteria entering the cut.</td>
</tr>
<tr>
<td>common cold</td>
<td>✓</td>
<td>Body function disturbed. Colds have a characteristic set of symptoms. Inflammation and metabolism changes possible.</td>
</tr>
<tr>
<td>hereditary baldness</td>
<td>✓</td>
<td>Body function not disturbed. This is not a disease.</td>
</tr>
<tr>
<td>measles</td>
<td>✓</td>
<td>Body function disturbed. Measles have a characteristic set of symptoms. Inflammation and metabolism changes possible.</td>
</tr>
<tr>
<td>cold sore</td>
<td>✓</td>
<td>Body function disturbed. Cold sores have a characteristic set of symptoms. Inflammation and metabolism changes possible.</td>
</tr>
</tbody>
</table>
**Genes, mitosis and cell differentiation**

- genes  → cell division that results in identical cells
- mitosis  → each cell has the potential code to change into different cell types
- cell differentiation  → the units of inheritance that codes for inheritance.
- cell specialisation  → each cell type carries out different cell functions

**Infectious and non-infectious disease**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Tick if infectious ✓ cross if non-infectious ✗</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>common cold</td>
<td>✓</td>
<td>Can be transmitted by droplets (from a sneeze) in the air from one person to another.</td>
</tr>
<tr>
<td>haemophilia</td>
<td>✗</td>
<td>Is inherited. Can not be 'caught' by association with diseased person.</td>
</tr>
<tr>
<td>mumps</td>
<td>✓</td>
<td>Can be transmitted by droplets (from a sneeze) in the air from one person to another.</td>
</tr>
<tr>
<td>chicken pox</td>
<td>✓</td>
<td>Can be transmitted by droplets (from a sneeze) in the air from one person to another.</td>
</tr>
<tr>
<td>Down syndrome</td>
<td>✗</td>
<td>Is inherited. Cannot be 'caught' by association with diseased person. You could even accept a blood transfusion from a Down syndrome person without risk of catching this disease.</td>
</tr>
<tr>
<td>skin cancer</td>
<td>✗</td>
<td>Cannot be transmitted. Caused by a malfunction of cell division.</td>
</tr>
<tr>
<td>cardiovascular disease</td>
<td>✗</td>
<td>Cannot be transmitted. Caused by genetic predisposition and/or lifestyle factors.</td>
</tr>
</tbody>
</table>
Identifying microbes in food and water

After 24 hours you would have 4096. The table below shows how you could have calculated this manually.

<table>
<thead>
<tr>
<th>Time</th>
<th>Number of bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>1</td>
</tr>
<tr>
<td>After 2 hours</td>
<td>2</td>
</tr>
<tr>
<td>After 4 hours</td>
<td>4</td>
</tr>
<tr>
<td>After 6 hours</td>
<td>8</td>
</tr>
<tr>
<td>After 8 hours</td>
<td>16</td>
</tr>
<tr>
<td>After 10 hours</td>
<td>32</td>
</tr>
<tr>
<td>After 12 hours</td>
<td>64</td>
</tr>
<tr>
<td>After 14 hours</td>
<td>128</td>
</tr>
<tr>
<td>After 16 hours</td>
<td>256</td>
</tr>
<tr>
<td>After 18 hours</td>
<td>512</td>
</tr>
<tr>
<td>After 20 hours</td>
<td>1024</td>
</tr>
<tr>
<td>After 22 hours</td>
<td>2048</td>
</tr>
<tr>
<td>After 24 hours</td>
<td>4096</td>
</tr>
</tbody>
</table>

Identifying the presence of microbes in food

- Bonox® provides a food supply to the bacteria.
- Bacteria are in the air. In still air they fall as a constant, invisible, rain. The jelly would quickly become contaminated by airborne bacteria if it were not covered. We are interested in the bacteria on the food, not in the bacteria in the air.
- To reduce the chance of bacteria on your hands contaminating the experiment.
- Even a fresh tea towel straight from the washing line will be covered in bacteria and spores. Spores and bacteria are constantly falling like rain from the air and will have collected on the towel. Anything left in air gets covered in bacteria and spores and this includes you, your pet Fido, your clothes and your food. A grim thought really.
Exercise 1.1: Defining health

Define the words health and disease and then discuss the difficulty of the definition.

Health

___________________________________________________________________________

___________________________________________________________________________

Disease

___________________________________________________________________________

___________________________________________________________________________

Difficulty of definition.

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________
Exercise 1.2: Genes, mitosis and cell differentiation

a) Outline how the following assists in the maintenance of health:
   - function of genes
     ________________________________________________________
     ________________________________________________________
   - mitosis
     ________________________________________________________
     ________________________________________________________
   - cell differentiation
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
   - cell specialisation
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________

b) Analyse the links between gene expression and maintenance and repair of body tissue.

     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________
     ________________________________________________________

Exercise 1.3: Infectious and non-infectious diseases

Distinguish between infectious and non–infectious diseases.
Give examples of each.

_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________

Exercise 1.4: Prevention of infectious diseases

Explain how cleanliness in food preparation, personal hygiene and water assist in the control of disease.

_________________________________________________________
_________________________________________________________
_________________________________________________________

Exercise 1.5: Identifying the presence of microbes in food

a) Record your experiment.

Aim:

_________________________________________________________
_________________________________________________________
Method:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Result: (Draw your result)

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Discussion:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

b) Assess the risks involved in this experiment and then describe how you reduced these risks by using safe working practices.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Exercise 1.6: Pathogens in water
What is a pathogen?
_________________________________________________________
_________________________________________________________
_________________________________________________________

Exercise 1.7: Water treatment for large towns and cities
a) Outline some of the ways that water is treated and suggest why this reduces the risk of infection by pathogens.
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________
_________________________________________________________

b) Draw a flow diagram outlining the treatment of water from source to consumer.
The search for better health

Part 2: The causes of disease
In this second part of the module you will be looking at organisms that cause disease. Several scientists have played a major role in uncovering the causes of disease. During the second half of the nineteenth century, Louis Pasteur and Robert Koch stimulated the search for disease–causing micro–organisms.

This was followed by the work of Ronald Ross who identified that insects could be carriers of disease to humans.

Once the cause of a disease is identified, steps can be taken to prevent and treat the disease.

You will need two small cans of baked beans or creamed corn during this part.

In this part you will have the opportunity to learn to:

• describe the contribution of Pasteur and Koch to our understanding of infectious diseases

• distinguish between:
  – prions
  – viruses
  – bacteria
  – protozoans
  – fungi
  – macro–parasites

  and name one example of a diseases caused by each type of pathogen

• identify the role of antibiotics in the management of infectious disease
In this part you will have the opportunity to:

• perform an investigation to model Pasteur’s experiment to identify the role of microbes in decay

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

• 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.

• process information from secondary sources to discuss problems relating to antibiotic resistance

• gather, process and present information from secondary sources to show how a named disease results from an imbalance of microflora in humans.

The idea that disease could be caused by organisms so tiny that they could not be seen with the naked eye is comparatively recent. There were two problems in identifying micro–organisms as the cause of some diseases.

- Micro–organisms were only discovered after the advent of microscopes. Bacteria, for example, were discovered by Leeuwenhoek in 1676.
- Experiments using scientific method were required to identify particular micro–organisms as the cause of particular diseases. This was a difficult task given that not all micro–organisms cause disease.

Most of the important work linking micro–organisms to disease was done in the mid 1800s. At that time there existed a substantial body of knowledge about the diversity and structure of micro–organisms. The time was ripe for conducting controlled experiments with micro–organisms.

You will look at some of the controlled experiments conducted by Pasteur and Koch in this part of the module. You will also look at the circumstances under which the tubercle bacillus (bacterium) was identified as the causal agent of tuberculosis in cattle and *Bacillus anthracis* was identified as the causal agent of anthrax in sheep.
The work of Pasteur

Some history

Before looking at some of Pasteur’s experiments you can take a quick look at the scientist himself.

Louis Pasteur was born in 1822 and died in 1895. He studied chemistry and in 1848 was appointed to Dion as Professor of Physics. From Dion he moved to Strasburg where he taught chemistry and in 1867 he was appointed Professor of Chemistry at the Sorbonne (University of Paris). In 1888 he became Director of the Pasteur Institute which he established.

Pasteur performed considerable research in chemistry and was well known for his work on the optical properties of tartaric acid. While at the Sorbonne, Pasteur’s attention moved from chemistry to fermentation. Fermentation was the basis of many important industries such as brewing, cheese making and winemaking.

Pasteur showed that fermentation has both a chemical and biological basis. He was also able to show that the souring of milk was caused by bacteria. These experiments put medical science onto the track of finding the causes of many diseases that were caused by micro-organisms. This is called the germ theory of diseases.

One of Pasteur’s first studies into disease was to identify the bacterium causing a silkworm disease. This disease was crippling the important silk industry in France and the cure he developed after three years of research certainly saved the industry at that time.

In his later years, Pasteur concentrated on diseases and did important work on anthrax, chicken cholera, diphtheria and rabies.

Pasteur’s work was highly commercial. Much of his research into micro-organisms and disease was to solve problems in the food industry. Some of his research lead to later discoveries and adaptations by other scientists to identify and treat human and other diseases.

Some trivia

Pasteur developed a serum to treat rabies (you will learn more about this type of treatment when you study immunity). Joseph Meister was the first person to receive the treatment. Meister at age nine had been bitten
by a rabid dog and was treated by Pasteur. Meister later became an
employee of the Pasteur Institute.

We could leave the trivia here except there is one last, tantilising, fact.
Meister committed suicide in 1940. He had been ordered to open
Pasteur’s crypt by German soldiers occupying Paris at the time.
Rather than comply, Meister committed suicide.

**Want more?**

There are numerous Internet sites dealing with the life and times of Pasteur
as well as a number with links to the current activities of the Pasteur
Institute. Search the terms Pasteur or Pasteur Institute and you will soon
find plenty of material.

You could also try: http://www.lmpc.edu.au/science

**Micro-organisms cause decay**

Pasteur’s major contribution was his discovery that micro–organisms:

- were responsible for decay
- came from other micro–organisms.

**Baked bean experiment**

**What you will need:**

You require two small tins of baked beans or creamed corn. You can
substitute the baked beans for any other inexpensive canned vegetable.

**What you must do:**

1. Place two cans of baked beans near a window and open the top of one
   of the cans. The second can must remain sealed.

2. Leave the cans for about one week or until bacterial and mould
   colonies form on the beans in the open can.

3. Open the unopened can of beans. Can you see mould or bacteria in
   the unopened can?

Dispose of the tin of beans that has remained open during the experiment.
The bacteria and mould will make the beans unsuitable for use even as
pet food.

Do not feed the beans to Fido, Tweetie or Sooty!
When baked beans are placed into a can, high temperatures are used to kill all micro–organisms on the interior of the can and in the baked beans. There are no bacteria or moulds inside the unopened can of baked beans.

Answer the following questions.

1. What evidence do you have that there were no bacteria and moulds inside the unopened tin of baked beans?
   _______________________________________________________
   _______________________________________________________
   _______________________________________________________

2. Where do you think the bacteria and moulds that grew on your opened tin of baked beans came from?
   _______________________________________________________
   _______________________________________________________
   _______________________________________________________
   _______________________________________________________

3. Many canned goods have warnings only to open the tin when you are ready to use the contents. Why?
   _______________________________________________________
   _______________________________________________________
   _______________________________________________________
   _______________________________________________________

Check your answers.

The answers you gave to the questions will be very different to the type of answers your ancestors would have given. You are already familiar with the ideas that micro–organisms exist and that some micro–organisms can cause disease and decay.

In the mid 1800s the cause of decay was unknown and the sudden appearance of moulds on food was blamed upon spontaneous generation. Spontaneous generation was the theory that living things could arise from non–living things ie that living things could be generated without the need for parenting organisms.

As you read the next section keep in mind what ground breaking stuff this was at the time Pasteur made his discoveries. It was an era when surgeons performed operations in their street clothes, without facemasks.
and without sterilisation. Thousands died each year from micro–organisms because the need for good sanitation and clean food handling practices was unknown.

**Experimental evidence**

**The hypothesis**

Pasteur noted that broth (soup) would spoil and become contaminated with bacteria and moulds. He hypothesised that this contamination was caused by micro–organisms and their spores entering the broth from the air.

**How the hypothesis was tested**

To test the hypothesis Pasteur placed broth into two different glass flasks. One flask had a top that was a long S–bend (the experiment) while the other had the S–bend broken off near the base (the control). The S–bend allowed air to enter, but spores of bacteria and mould became trapped in the liquid in the S–bend and could not enter the flask.

Pasteur boiled the broth in each flask to kill any micro–organisms in the broth. The steam from the boiling sterilised the walls of the flasks. Both flasks were then allowed to stand in a room.

**The result**

The flask with the S–bend broken near the base (the control) quickly developed bacteria and mould on the surface. The broth spoiled.

The broth in the flask with the S–bend (the experiment) did not spoil. Bacteria and mould did not form on the broth.
How the result was interpreted

Both the experiment and control had been sterilised to kill micro–organisms at the start. Micro–organisms only infected the flask that allowed micro–organisms and their spores to enter from the air (the control). Micro–organisms did not infect the experimental flask.

Pasteur drew two conclusions.

• Micro–organisms were responsible for the spoiling of broth. When micro–organisms were not present the broth did not spoil.
• Micro–organisms did not spontaneously generate. There had to be either micro–organisms or their spores for them to occur.

Some trivia

Pasteur performed a series of experiments over a number of years, all of which gave the same result. There were minor differences between each of the experiments as he tested his hypothesis under different conditions and with slight modifications in his experimental equipment.

If you read other textbooks you may find slight differences in the way Pasteur’s experiment is described. These differences occur depending upon which of Pasteur’s experiments is described.

Pasteur performed one of his experiments on a glacier so he could use pure mountain air for one of his tests. In another he took his flasks to many different towns to see if the experiment worked in different locations.

Pasteur’s experiment disproving spontaneous generation is one of the more famous experiments. It is important that you understand this experiment.

Answer the following questions to see if you have understood the experiment then check the answers.
1 What was the difference between the set up of the experimental and control flasks in Pasteur’s experiment?

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2 One theory that was popular at the time of Pasteur’s experiment was that bacteria were created spontaneously from air. What aspects of Pasteur’s experiment disprove this theory?

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3 Pasteur’s experiment is similar, but not identical, to the baked bean experiment you conducted earlier. Outline one difference between the two experiments and explain the significance of this difference.

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Check your answers.

**Anthrax**

Anthrax is a disease of cattle, sheep and horses. Pasteur performed a classic experiment to show that anthrax was caused by a rod shaped bacteria called *Bacillus anthracis*.

Pasteur took a flock of fifty sheep. He infected twenty–five of them with a weakened form of the bacteria. This weakened form was not strong enough to kill the animals but produced an antibody reaction in them. Then, several days later he injected the whole herd with a lethal form of the bacteria. The half that had the weakened form previously all survived while the untreated animals all died.
The first inoculation with the weakened (attenuated) form of the bacteria gave those sheep a way of fighting the disease using their natural immune system. They were then prepared with a defence system when they were exposed to the deadly form of the bacteria. This same method is used today in vaccination programs when attenuated vaccines are given for measles, rubella, poliomyelitis and rabies.

Do Exercise 2.1. Pasteur

The work of Koch

Robert Koch (1843–1910) was a German bacteriologist. Much of his work was done with a microscope and a few basic kitchen utensils, but he isolated bacteria, made pure cultures of them, and made photomicrographs.

Koch’s greatest achievement was the isolation and growth in pure culture of the tubercle bacillus and his invention of the tuberculin test for cattle herds. He also identified that diseases such as anthrax have resting spores that can live for years in the ground.

Koch’s postulates

Koch’s postulates refer to a procedure that identifies the causative organism of a particular infectious disease. The procedure is impressive because of its simplicity and because of the application of logic to solve the problem.

To identify an organism as the cause of a particular disease the following steps must be followed.

Step 1 - The suspect organism must be present in infected organisms.

The organism suspected of causing the disease must be present in all organisms that have the disease.

If the organism that is thought to cause the disease is not present in some or even all of the organisms that have the disease then it is clear that there must be some other cause.
**Step 2 – A pure culture is required.**

A pure culture of the organism suspected of causing the disease must be obtained. This can be a difficult process because all other organisms must be excluded from the sample.

Pure cultures can be obtained by starting with a single organism in a sterile container and allowing it to replicate. Another method is to selectively poison so that only the suspect organism remains living in the sample.

**Step 3 – A healthy organism must be inoculated with the pure culture and the potential host must develop the same symptoms.**

Healthy organisms without the disease must then be inoculated with the suspect organism. The pure culture is used to provide the material for the inoculation.

The pure culture is important because it is used for inoculation. Imagine that you used a culture that was not pure for inoculation. If the healthy organisms became sick after inoculation then you would not be sure which of the organisms in the impure culture caused the healthy organisms to become sick.

Using Koch’s postulates you test just one suspect organism at a time.

If the results are negative then you find another suspect organism and try again.

**Step 4 – The suspect organism must be re–isolated, re–cultured and identified as the organism used for the inoculation.**

The newly diseased organisms must then be sampled with the suspect organism present. The suspect organism must be living within the diseased organisms.

The suspect organism must be re–isolated from one of the inoculated and newly diseased organisms. A pure culture must be developed. The new pure culture is then compared with the previous pure culture to ensure that they both contain exactly the same organism.

Try these past HSC questions related to Koch’s postulates. You do not need to learn Koch’s postulates. The questions relate to a previous Two Unit Biology syllabus. Answer each question in the space provided. Think carefully about your answers before you write.
**Question 1 (3 marks)**

Koch postulated that a specific micro–organism could be said to cause a disease if several conditions were met. List THREE of these conditions.

(Question 18 Part B 1995 HSC 2 Unit Biology Examination Paper. Board of Studies, NSW.)

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**Question 2 (2 marks)**

Individuals in an isolated village become sick. A physician establishes that all the sick individuals are infected with a particular strain of bacteria. A sample of this strain is taken from a sick individual and grown in pure culture away from the sick individual. This strain of bacteria was not found in any healthy individuals.

What TWO other pieces of information are required to establish that the disease was caused by the strain of bacteria?

(Question 28 (a) Part C 1996 HSC 2 Unit Biology Examination Paper. Board of Studies, NSW.)

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**Question 3 (3 marks)**

A biologist took a scraping of a diseased patch on the leaf of a plant. He cultured the scraping and found that a pure culture of bacteria developed. The bacterial culture in the culture dish may be responsible for the disease on the plant leaf. What steps would Koch have followed to determine this?

(Question 19 Part B 1997 HSC 2 Unit Biology Examination Paper. Board of Studies, NSW.)

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Do Exercise 2.2. *The work of Koch*

**A disease causing micro-organism**

If you read the historical note on Koch, you will have noticed that he identified the tubercle bacillus in cattle. This bacterium was responsible for tuberculoses in cattle and could be passed on to humans.

Koch came to the conclusion that the tubercle bacillus was responsible after he noticed that:

- healthy cattle did not have the tubercle bacillus
- cattle with tuberculosis had the tubercle bacillus
- if blood from infected cattle was injected into healthy cattle, the healthy cattle developed the disease
- when a pure culture of the tubercle bacillus was injected into healthy cattle, the healthy cattle developed the disease.

**Summary of the contribution of Pasteur and Koch**

These two scientists laid the foundations of the study of microbiology. Before their work it was commonly believed that disease and decay were caused by spontaneous generation. This meant that nothing could be done to prevent these problems. Once Pasteur discovered micro–organisms it became apparent that there were ways of controlling and preventing disease and decay. This then led to practices that are still used today including:

- controlled fermentation of beer and wine
- pasteurisation of milk
- sterilisation of surgical instruments
- hygienic medical practices
- vaccination.

Koch’s work gave a system of producing a pure culture of disease causing microbes and a procedure for the identification of the pathogen that was causing a disease. Koch also discovered that diseases could be caught from water and set up methods for ensuring safe water supplies. His work has led to the modern practice of epidemiology where the prevention and control of disease over a population is carried out.
A pathogen is a disease–causing organism. Pathogens cause infectious diseases in both plants and animals.

Different pathogens cause different diseases. For example, the protozoan \textit{Plasmodium vivax} is a pathogen that causes malaria, \textit{Mycobacterium tuberculosis} is a pathogen that causes tuberculosis.

### Types of pathogens

You will learn about six different types of pathogens.

- Prions
- Viruses
- Bacteria
- Protozoans
- Fungi
- Macro–parasites

### Prions

The term prion comes from proteinaceous infectious particles–prion for short.

\textbf{Prion diseases} are caused by a protein produced in the brain called prion protein. All adult \textit{vertebrates} have prion protein and the normal form of prion protein causes no harm. However, there is an abnormal form of prion protein which causes the death of brain cells.
The normal and abnormal forms of the prion protein are the same protein. The only difference is in the shape of the protein. How a small difference in the shape of a protein can cause disease is still unknown.

The gene that codes for prion protein is on chromosome number 20 in humans.

**Why are prion diseases so interesting?**

Prions are a naturally occurring protein. Because they are a natural part of the body, the immune system (you will look more closely at immunity later) does not attack the prion. The body’s outer barriers such as skin are also useless in defence because prion protein is made inside the body’s barriers.

Vaccination and antibiotics are also useless in combating prion diseases.

Unlike the other pathogens you will learn about in this section (virus, bacteria, protozoans, fungi and macro–parasites), prion protein contains no genetic material. Prion protein is coded for by a single gene, but prion protein itself does not contain genes.

All known human prion diseases are fatal. Prion disease is often called spongiform encephalopathies. The word spongiform refers to the fact that the brain often becomes riddled with holes (just like a sponge) when infected with a prion disease.

**What does normal prion protein do?**

The function of normal prion protein is unknown. At the time of writing all that was known was that prion protein occurs in the brain and that abnormal prion proteins cause prion disease.

**Examples of human prion diseases**

Prion diseases in humans include Creutzfeldt–Jakob disease (CJD) and Kuru disease.

CJD usually only begins when a person is in their 60s or 70s. The symptoms include memory loss that proceeds to dementia within just a few weeks. Death usually occurs within six months of the first symptoms of the disease. The annual rate of occurrence of CJD is about one in a million for most human populations.

If you like trivia, then Kuru is a more interesting disease. Kuru was first diagnosed in Papua New Guinea and is transmitted by eating human brain. That’s right, unless you are a cannibal you have little fear of catching this disease!
Do other animals have prion diseases?

Yes.

Mad cow disease (bovine spongiform encephalopathy or BSE) is a well known example from cattle. Other examples include scrapie in sheep, transmissible mink encephalopathy and chronic wasting disease in deer, elk and goats.

We will say nothing more about prion diseases in other organisms because our focus here is on the human types of prion disease.

How can you catch a prion disease?

You have already seen that cannibalism can lead to one type of prion disease, now it is time to look at the other ways prion diseases can be contracted.

- Injection or ingestion (eating) of brain extracts from individuals with the disease.
- Genetic susceptibility. Some people have genes that produce a slightly different form of prion protein. This slightly different form of the prion protein is more susceptible to changing into the abnormal form of the prion protein. It is possible to inherit some types of the disease.
- Inadequate sterilisation of instruments used in brain surgery. This can result in CJD being passed from one patient to another.

How common are prion diseases?

You have already seen that prion disease has an annual occurrence rate of around one in a million. One doctor we consulted said that most Australian doctors could work their entire medical career without ever seeing a single prion disease case!

Answer the following questions in the spaces provided then check your answers against those at the end of this unit. Plan your answers and try to answer within the space provided for each question. This is good practice for answering questions in examinations.

1 There are many types of prion diseases. Name two types of prion disease that occur in humans.

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Part 2: The causes of disease
2 Name two features of prion diseases that would make them difficult to treat.

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3 What is the cause of prion disease?

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4 A small city has two million inhabitants. You have been asked to develop a plan for combating prion disease. How many cases of prion disease would there be on an annual basis?

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Check your answers.

Viruses

Viruses are so tiny that they can only be viewed using an electron microscope. They have an outer protein coat that encloses genetic material.
There has been some debate about whether viruses are living or non–living. For the purpose of this module, viruses have been grouped with the pathogens (living things that cause disease). This classification is based upon convenience – when discussing disease, viruses are better considered here than elsewhere.

For the purpose of your HSC you can consider viruses to be either living or non–living. All you need to be able to do is to justify your choice! Below are the common arguments for viruses to be considered living or non–living. You have to make your own choice about which argument you think is best.

**Arguments for viruses to be considered living**

- Viruses have genetic material like other living things and are able to reproduce their own kind.
- Viral genetic material passes on hereditary information and is able to mutate. This is a property of other living things.
- Viruses have a recognisable morphology. This means that they have a distinct recognisable structure. Other living things also have this feature (cats look like cats, fish look like fish and so on).

Those in favour of viruses being living consider them to be parasites. Like other parasites they depend on their host for many of their needs.

The argument that viruses cannot be living because they are not cellular is countered by claims that definitions requiring all living things to be made of cells are too narrow.
Arguments for viruses to be considered non–living

- Viruses are not cellular. There is no cell membrane. By definition living things are made of cells.
- Viruses cannot reproduce independent of their host. In fact, viruses control the DNA of the host cell and cause it to produce new viruses.
- Viruses can be crystallised. No other living thing can be crystallised.

Those supporting the idea that viruses are non–living see them as an interesting group of chemicals. They challenge the idea that they could be living because all the processes of life (reproduction, growth, assimilation, respiration) are dependent upon a host cell. The virus can perform none of the life processes by itself.

Diseases caused by viruses

Viral diseases include Ross River fever, AIDS (acquired immune deficiency syndrome), the common cold, chicken pox, cold sores, cowpox, glandular fever, mumps, German measles, poliomyelitis, Sindbis virus infection, Australian encephalitis, hepatitis B and TMV (tobacco mosaic virus—a virus that attacks plant cells).

Treatment of viral diseases

There are very few treatments for viral diseases. Prevention is the best treatment in the form of vaccination, quarantine or removal of vectors such as mosquitoes.

Ross River fever

Ross River fever is caused by a virus belonging to the genus *Togaviridae*. The virus is known to occur in humans as well as in a variety of domestic and wild animals.

The virus is transmitted to humans by mosquitoes. At least 12 different species of mosquito are known to be capable of transmitting the disease. The major vectors (both mosquitoes) are *Culex annulirostris* and *Aedes vigilax* (Stevenson and Hughes, 1988).


The disease is most common December to May (this corresponds to warm moist weather associated with mosquito breeding) and has spread over much of Australia including parts of Sydney.
Symptoms of the disease include an itchy rash, headache, lethargy, muscle tenderness, nausea and sore joints.

Currently there is no treatment for the disease, although the symptoms are treated with analgesics (headache tablets) and bed rest. Precaution against mosquito bites is recommended. The disease is notifiable in all Australian states and territories.

Zoonoses

The term zoonose refers to any disease that is transmitted from animals to humans by either direct contact or through animal products eg. food. The virus causing Ross River fever and Plasmodium, the cause of malaria, are both zoonoses.

Can you find any other examples of zoonoses in these notes?

Answer the following questions in the spaces provided then check your answers against those at the end of this unit.

1. Name one disease caused by a viral pathogen. What are the symptoms and treatment of this disease?

2. Construct a table in the space provided to summarise the arguments both for and against virus being considered to be living.
Bacteria

Bacteria are procaryotic organisms. Some of the earliest organisms to appear in the fossil record are bacteria – they have been around for a very long time!

Although some bacteria respire aerobically (with oxygen), many respire anaerobically (without oxygen). This has allowed anaerobic forms to live in low oxygen habitats such as the digestive tracts of animals.

Diseases caused by bacteria

Diseases caused by bacteria include boils, tetanus, whooping cough, syphilis, anthrax, brucellosis, listeriosis, Lyme disease, melioidosis, psittacosis, salmonellosis, tuberculosis and crown gall (a plant disease).

Treatment of bacterial diseases

Bacterial diseases are frequently treated with antibiotics and disinfectant which kill bacteria. When antibiotics are prescribed for viral infections, they are given to kill associated bacterial infections. Antibiotics do not kill viruses.
Salmonella

Salmonella (which causes one type of food poisoning) is a disease caused by a number of anaerobic bacteria belonging to the genus *Salmonella*. The disease occurs in humans and other animals.

Salmonella is usually transmitted by ingesting (eating) food contaminated with the bacterium. Symptoms include nausea and diarrhoea. The toxins released by the bacteria can, in extreme cases, be fatal.

Re-cooking food that is contaminated with salmonella kills the bacteria but has no effect on the heat stable toxins that cause the symptoms.

Protozoans

Protozoans are single celled eucaryotes that are probably best classified within their own phylum rather than classifying them as being either plant or animal. Only some protozoa are pathogens. Most protozoa do not cause disease.

Trypanosoma, the protozoan that causes African sleeping sickness.

Diseases caused by protozoans

Some diseases caused by protozoa include African sleeping sickness (caused by the protozoan *Trypanosoma gambiense*), giardiasis and amoebic dysentery. Malaria is caused by *Plasmodium*, a protozoan belonging to the class Sporozoa. You will study malaria in some detail later in this module.
**Fungi**

Fungi are a group of eucaryotes that have cell walls but no chloroplasts. Some fungi are **parasitic** while others are **saprophytic**. Fungi are distinguished from other organisms by the mass of hyphae (threads) that make up the body of multicellular individuals.

Fungi include such things as mushrooms, yeast and tinea (athlete’s foot).

**Diseases caused by fungi**

Diseases caused by fungi are called mycotic diseases. Mycotic diseases include cryptococcosis, histoplasmosis and ringworm. Mycotic diseases of plants include mildews of grapes, apple scab, corn smut, stem rust of wheat and potato blight.

**Treatment of mycotic diseases**

Fungal diseases are usually treated with fungicide. A fungicide is any substance that kills a fungus.

**Tinea**

Tinea is a group of fungal infections of the skin. The common tinea of the foot is caused by a number of fungi such as *Epidermophyton floccosum*. Tinea, like other fungi, reproduce by spores. Contact with tinea or tinea spores eg. by sharing footwear or standing on shower floors used by a tinea sufferer, spread the disease. Tinea occurs worldwide in human populations.

Tinea is commonly found growing in the moist areas between toes or on the soles of feet. The skin is often flaky or reddened in areas affected by tinea.

Tinea is not life threatening and for most is no more than an occasional mild irritation.

**Macro-parasites**

The prefix *macro* means large. When biologists use the prefix *macro* it usually refers to something able to be seen with the naked eye. Macro–parasites are the large parasites such as tapeworm that can be seen with the unaided eye.

Macro–parasites are divided into two groups–endoparasites (internal parasites) and ectoparasites (external parasites).
Examples of macro–parasites

Aphids are well known ectoparasites of plants. They are parasitic (they are sapsuckers). Aphids are commonly found on roses and fruit trees.

Animal macro–parasites include tapeworm (an endoparasite) and lice (an ectoparasite).

Hydatid disease

In Australia, hydatid disease is caused by the tapeworm *Echinococcus granulosus*. The tapeworm is an endoparasite and can be transferred from domestic animals to humans.

The diagram below shows how *E. granulosis* may get from infected cattle and sheep to humans.

When *E. granulosus* eggs enter a human an embryo hatches and burrows into the surrounding tissue. The tapeworm embryo has been found in
many human organs including the liver, lungs and brain. The embryo forms a fluid filled cyst which places pressure on surrounding organs. If the cyst bursts then severe shock can be caused by the sudden release of Echinococcus antigens. The cysts may need to be surgically removed in humans.

Preventative measures include careful meat inspection in abattoirs, proper hygiene when handling dogs and regular doses of anti–worming solutions for dogs. The preventative measures focus on stopping the disease reaching humans from either dogs or meat supplies. There is no direct treatment to kill the tapeworm once it enters a human host.

Do Exercise 2.3 now.
What causes malaria?

Malaria is a disease caused by a parasitic protozoan. There are four different malarial parasites all of which belong to the genus *Plasmodium*. These are:

- *Plasmodium falciparum*
- *Plasmodium malariae*
- *Plasmodium ovale*
- *Plasmodium vivax*

*Plasmodium* spores enter erythrocytes. Over a 48 hour period (for most types of malaria, although one type requires 72 hours) they reproduce asexually within the erythrocytes. At the end of this time they burst the erythrocyte and go to infect others.

Symptoms of the disease

The most notable symptoms are chills, fever, sweating, headache, disorientation and delirium that occur each time the erythrocytes are
burst by the *Plasmodium*. These chills and fever are caused by toxins produced by the *Plasmodium* and released by the bursting of the erythrocytes.

So how often do the chills occur?

If you read the previous section on what *Plasmodium* does to the human body carefully, you would have probably already worked out that these chills happen at 48 hour (in one case 72 hour) intervals.

### How is malaria transmitted?

The parasites that cause malaria were observed by Laveran in 1880.

The identification of the parasite did not solve the major problem—how was malaria transmitted from person to person?

The research concentrated on a search for the method of transmission.

If it was possible to work out how malaria was spread then it was possible to stop people from getting (contracting) the disease.

Preventing a person from contracting the disease was better than treating those that had the disease. If it were possible to stop people getting the disease then the problem of malaria would have been solved.

### The work of Ronald Ross

Over a period of several years in the 1890s Ross researched the transmission of malaria. His discovery of how malaria was transmitted was the result of numerous pieces of research. Each piece of research gave a clue and from that clue he was able to develop his next line of enquiry.

Here is the evidence in the order of collection by Ross.

- Mosquitoes were common in all areas where malaria was present.
- Malaria could not be transmitted by ingestion. Mosquitoes that had bitten a human with malaria were crushed into water and fed to healthy humans. The healthy humans did not contract malaria.
- After biting a bird infected with malaria, the mosquito developed cysts in the wall of its stomach.
• The cysts in the mosquito’s stomach burst releasing tiny threads (the *Plasmodium*). These threads migrated to the salivary glands of the mosquito.

• Mosquitoes transmitted malaria to birds by their bite. Mosquitoes that had bitten a bird with malaria were kept several days (to allow the cysts in the stomach to grow and burst). The mosquitoes were then allowed to bite healthy birds. The healthy birds developed malaria.

When a mosquito bites, saliva enters the blood stream of the organism being bitten. The saliva contains a chemical that prevents coagulation of blood—a very important adaptation for species of blood sucking insects such as the *Anopholes* mosquito. If *Plasmodium* is in the mosquitoes salivary glands then malaria will be transmitted.

Ross’s work was very important, but it did not solve the problem fully. Ross had done most of his research on birds. The next important step was to apply the research to humans.

**The work of Giovanni Grassi**

Grassi showed that human malaria is transmitted in the same manner as malaria in birds. Most importantly he identified the particular mosquito responsible for transmitting the disease to humans.

Grassi got numerous types of mosquitoes and allowed them to bite people with malaria (a group of volunteers). The same mosquitoes were then allowed to bite non–infected volunteers (being a volunteer for medical research has its down days).

Grassi found that only the mosquito *Anopheles claviger* transmitted the disease.

**The life cycle of *Plasmodium***

Much of the work on the *Plasmodium* life cycle comes from the work of Ross. The role of the mosquito in the life cycle is as intermediate host and as a vector.
Life cycle of malaria.

There are a couple of points that may require clarification in the figure above. These are explained below.

**Sporozoites**

A spore is used by plants or animals for asexual reproduction. They are generated by mitosis from the parent organism and have the same number of chromosomes as the parent.

Spores grow into a new individual without the need for fertilisation to occur. An asexual phase is common in many life cycles.

To distinguish between the spores of plants and animals, zoologists use suffixes to show the difference. A sporozoite is an animal spore and a sporophyte is a plant spore.

**Gametes**

Gametes are sex cells. They have half the number of chromosomes of the parent. Fertilisation is required before most gametes can form a zygote (a fertilised egg). Fertilisation results in an individual with the same number of chromosomes as the parents.

**Cyst**

A protective coat formed about an organism.
Treatment and control of malaria

Treatment and control of a disease are two different things. Treatment is aimed at the disease itself. Those with the disease are treated to alleviate symptoms or to kill the pathogen. Control refers to measures that stop the spread of the disease. For example, quarantine is a control measure.

Treatment of malaria

Malaria is treated by administering quinine. Currently visitors to countries that still have malaria take quinine tablets during their visit. They also need to take the tablets for a period of weeks before and after their trip.

Control of malaria

Malaria control removes the vector (the mosquito). This prevents the disease spreading. Measures include draining swamps (mosquito breeding sites) and spraying insecticides. Have another careful look at the malaria life cycle above. You will see that by removing the mosquito that the disease cannot spread.

Let’s see how well you have understood the section on malaria. Here is a past HSC question which you can answer using malaria as your example. Use your own paper.

Extract from 2 Unit Biology HSC Examination Paper 1996, Section C. Question 20. Board of Studies, NSW.

Diseases may be caused by pathogenic micro–organisms.

1 Name such a disease.

2 Describe the route(s) of entry of the pathogenic micro–organism into the host.

3 Describe the role of the environment in the transmission of the pathogenic micro–organism.

4 Describe the effect of the pathogenic micro–organism on the host.

5 Describe any possible methods of control.

Check your answers.

Do Exercise 2.4. Malaria
A large variety and number of micro–organisms live within the human body. About 15% of your body weight consists of bacteria living in your body. The majority of these live in the intestines, colon and mouth. Some of these micro–organisms provide important services such as those that provide vitamins that are used by the human body.

The majority of the micro–organisms living in the human digestive system are bacteria. Collectively we refer to these bacteria as microflora.

Think about the following questions and jot down some answers before reading further. You will probably be able to work out the answers by thinking about material you have already studied elsewhere in this course.

1 Bacteria are currently classified within the procaryotes, yet we refer to the bacteria in the human gut as microflora. The word flora refers to plants, which are eucaryotes. Can you explain this apparent contradiction?

2 After a course of antibiotics, many doctors recommend that patients include a little yoghurt in their diet for a few days after the last antibiotic has been taken. Why?

Check your answers.
Microflora imbalance

Although the presence of bacteria can be beneficial to humans, too many or two few of these bacteria can result in disease symptoms. An imbalance of gut microflora can result in disease.

Microflora imbalance can cause symptoms such as diarrhoea, constipation, malabsorption of nutrients by the intestine and imbalances in the chemicals found in bile salts.

To counter an imbalance of microflora many products containing acidophilus bacteria are available in the form of drinks and yogurts.

Malabsorption

Malabsorption means not absorbed or not absorbed correctly. The intestine absorbs soluble material derived from the digestion of passing food. If this absorption process is disturbed, then some nutrients will not be absorbed and digestive juices will be altered. This can result in disease symptoms eg. Crohn’s disease, radiation enteritis and gastroenteritis.

The proximal part of the small intestine (the section of intestine immediately after the stomach) usually has much lower quantities of bacteria than found further down the intestine. There are three main reasons for such low numbers of bacteria in the proximal part of the intestine.

- Acid, in the stomach, kills many bacteria so the digesting food in the upper intestine is usually very low in bacteria numbers.
- Peristalsis removes most of the bacteria.
- Immunoglobulans (chemicals) secreted in this part of the intestine kill bacteria.

The balance of microflora in the proximal intestine is achieved by very low numbers of bacteria.

How does an imbalance develop?

If peristalsis is reduced or food with higher than normal bacterial levels is consumed then additional bacteria can develop in the proximal intestine. The bacteria can become so large in number that they can interfere with the bile salts (effectively breaking down bile salts and releasing an excess of bile acids). The alteration of the bile salts means that the bile no longer functions correctly.
Can you remember from your previous studies in biology where bile is produced? Better yet can you remember what part bile plays in digestion?

If you have forgotten that bile is produced by the liver and assists the digestion of fats by breaking the fats into smaller droplets then it may be a good time to review your earlier work in this course.

In other cases bacteria use the vitamin B12 in the intestine leading to insufficient B12 being absorbed by the human body.

1 Name one disease that results from an imbalance of microflora in humans. ______________________________________________

2 Briefly outline one way a microflora imbalance can occur.______________________________________________________
______________________________________________________
______________________________________________________
______________________________________________________

Check your answers.

This activity is optional.

If you were studying this subject within a classroom your teacher would probably have asked you to do your own research on diseases caused by microflora imbalance or have had a local doctor as a guest in your lesson. You might like to pursue these diseases further by interviewing your own guest expert.

Make contact with your local doctor. You now have an expert at your disposal (well, for at least 10 minutes) that you can interview to get additional information.

You could ask your doctor to:
- name some of the diseases that she/he has seen locally that result from a microflora imbalance
- outline the causes of one or two of these diseases and explain what treatment is used. For example, when bacteria numbers exceed normal amounts in the proximal intestine antibiotics may be prescribed to kill the bacteria.
- give you any pamphlets they may have about any of these diseases.

If you prefer not to visit your local doctor you could always write to one of the doctors that provide free advice in many of the popular magazines and papers.
Antibiotics

Most people at some time in their life have taken a course of antibiotics to fight infections. When you take them you probably don’t realise how they have revolutionised modern medicine. Before the work of Fleming in 1928, many people died of simple infections.

Antibiotics are drugs that prevent bacterial growth. They are usually secreted by other micro–organisms to destroy competing bacteria. Since Fleming’s time there have been a range of antibiotics developed.

Antibiotics work by several methods including the break down of the membrane of bacteria and interaction with the metabolism of the bacteria. Scientists have been able to synthesise new antibiotic chemicals, some of which are broad spectrum antibiotics that kill a wide range of bacteria.

This story sounds hopeful for the future of fighting disease but unfortunately many bacteria have developed resistance to antibiotics. This has been made possible by the overuse of antibiotics and disinfectants. When an antibiotic kills bacteria there may be one or two individual bacteria that have a natural resistance to the antibiotic.

*Staphylococcus aureus* (golden staph infection). Notice that some of the cells are dividing. © Australian Key Centre for Microscopy.
These individuals will be able to multiply without competing with other bacteria that have been killed by the antibiotic. The result is strains of bacteria that are resistant to antibiotics. These resistant bacteria have been labelled ‘super–bugs’. The strongest antibiotic we have is vancomycin. *Staphylococcus aureus* (golden staph infection) now has a strain that is vancomycin resistant leaving us with no defence against this strain.

The overuse of antibiotics and disinfectants is increasing the chance of producing more ‘super–bugs’. There has been an increase in the use of antibiotics in farm animals especially poultry and in the use of household cleaning products that have an antibiotic effect.

Do Exercise 2.5. *Antibiotics*
Suggested answers

Micro-organisms cause decay
1 No bacteria or moulds were visible when the tin was opened. When the control (the second tin that was only opened at the end of the experiment) was opened there was no sign of bacteria or mould in that tin either.
2 From bacteria and spores in the air.
3 Once opened, bacteria carried in the air can enter the contents of the tin. Decay will begin once opened.

Pasteur
1 The experimental flask stopped micro–organisms and their spores from entering. The control allowed micro–organisms and their spores to enter. All other factors were the same for both flasks.
2 Both flasks allowed air to enter, but only the control allowed both air and micro–organisms (and their spores) to enter. When air alone could enter the broth did not spoil. Only when the air contained micro–organisms and spores did the broth spoil. If micro–organisms were spontaneously generated from air then both flasks should have contained micro–organisms at the end of the experiment.
3 In the baked bean experiment, air and micro–organisms were allowed into the opened tin. Air and micro–organisms were not allowed into the closed tin during the experiment. This is significant because it is not possible to separate any effect of the micro–organisms from any effect of the air.

In Pasteur’s experiment air was allowed into both flasks and the only difference was the presence of micro–organisms and their spores. Our baked bean experiment does not discount the possibility that bacteria spontaneously generate from air.
Past HSC questions on Koch’s postulates

Note
Koch’s postulates was removed from the HSC Biology syllabus in November 2002. These questions were retained because they give you an insight into the importance of Koch’s major work which was his postulates.

1 A good presentation tip is to list your three answers so that it is clear to the examiner that you have answered all three.
   a) The micro–organism must be present in all diseased individuals.
   b) If healthy individuals are inoculated with a pure culture of the micro–organism then they must contract the disease.
   c) The micro–organism must be found living within the newly diseased (inoculated) individuals.

2 You would get one mark for each of the two points you make here.
   a) Healthy individuals inoculated with a pure strain of the bacteria would become sick.
   b) The bacteria would be present in sick individuals after inoculation.

3 Koch would have:
   a) determined if all infected individuals have the bacteria present
   b) inoculated healthy individuals with the pure bacterial culture
   c) determined if inoculated individuals contracted the disease
   d) checked that the bacteria was present in all inoculated individuals that contracted the disease.

Prion disease
1 Two types of prion diseases include Creutzfeldt–Jakob disease (CJD) and Kuru disease.

2 Prions do not respond to antibiotics or vaccination programs.

3 Abnormal prion protein causes prion diseases. The abnormal prion protein destroys brain cells.

4 Statistically you could expect two cases of prion disease in a city of two million as there is a one in a million chance of a prion disease.
Viral disease

1. Ross River fever is caused by a viral pathogen. Symptoms include headache, rash, nausea, sore joints and muscles and lethargy. There is no treatment for the disease, only treatment for the symptoms eg. aspirin for pain/inflammation relief and sore joints.

<table>
<thead>
<tr>
<th>Arguments for virus to be considered living</th>
<th>Arguments for virus to be considered non–living</th>
</tr>
</thead>
<tbody>
<tr>
<td>contain genetic material</td>
<td>are not cellular</td>
</tr>
<tr>
<td>can replicate to make virus identical to parent virus</td>
<td>can be crystallised</td>
</tr>
<tr>
<td>have a recognisable morphology (appearance)</td>
<td>cannot assimilate or reproduce independently of a host cell</td>
</tr>
</tbody>
</table>

Malaria

1. Malaria is a disease caused by a pathogenic micro–organism.
2. The micro–organism enters the blood stream after being injected by a mosquito bite.
3. The environment required for malaria is both mosquitoes and malaria sufferers for the disease to be transmitted.
4. The host may experience both shivering and fever.
5. Draining swamps and insecticides reduces mosquito population numbers. This is a method of control for malaria.

Microflora

1. There have been many different classification schemes over time. Currently there are many different classification schemes accepted by the scientific community. In some classification schemes as late as the mid 1970s, bacteria were classified as plants.
2. As a result, it was common to refer to bacteria as microflora. Even though we no longer recognise bacteria as being plants, it is still common in medical circles to refer to them as microflora. Old habits die hard and it is a feature of scientific study that you will encounter both old and new ideas being expressed at the same point in time.
Antibiotics kill bacteria. Many of the gut bacteria that provide useful products such as vitamins are killed by antibiotics. By eating yoghurt (which is made by bacterial culture) some of these bacterial colonies can be re-established.

**How does an imbalance develop?**

1. Crohn’s disease or Radiation enteritis. You could also have answered gastroenteritis.
2. Reduced peristalsis (the most common cause) or contaminated food.
Exercises 2.1 to 2.5  Name: _________________________________

**Exercise 2.1: Pasteur**

Before the work of Pasteur what was a commonly held belief about the occurrence of disease and decay. Then describe his swan-necked flask experiment and say what it showed.

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

**Exercise 2.2: The work of Koch**

a) Using Koch as an example, describe the circumstances which resulted in a named organism being identified as the cause of a disease.

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________
b) Evaluate the contribution of Pasteur and Koch to our understanding of infectious disease.

Exercise 2.3: Types of infectious diseases

Fill in the table below. The first is done for you.

<table>
<thead>
<tr>
<th>Type of pathogen</th>
<th>Animal disease</th>
<th>Plant disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>prion</td>
<td>CJD, Kuru, mad cow disease</td>
<td>unknown</td>
</tr>
<tr>
<td>virus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bacteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>protozoan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>fungi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>macro–parasites</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Exercise 2.4: Malaria

a) Malaria is a disease transmitted by an insect vector, the *Anopheles* mosquito. Describe the life cycle of the mosquito using a diagram if possible.

_____________________________________________________

_____________________________________________________

_____________________________________________________

_____________________________________________________

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_____________________________________________________

_____________________________________________________


b) Using malaria as your example complete the description as outlined below.

i) Name ____________________________________________

ii) Cause ____________________________________________

iii) Transmission ______________________________________

_________________________________________________

_________________________________________________

_________________________________________________

_________________________________________________
iv) Host response

v) Major symptoms

vi) Treatment

vii) Prevention

viii) Control
Exercise 2.5: Antibiotics

a) What is the role of antibiotics in fighting disease?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________


b) Describe how bacteria have become resistant to antibiotics.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
The search for better health

Part 3: Defence barriers and adaptations
Part 3: The first two lines of defence

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In your daily life your body is continually being bombarded with diseases. Luckily you are unaware of this except when a pathogen gets through your defence systems and you feel the symptoms of a disease.

You may have noticed that not everyone gets a disease in a family and that when you are ‘run down’ you are more likely to pick up an infection. This is because your ability to withstand disease has been reduced.

In this part you will have the opportunity to learn to:

• identify defence barriers to prevent entry of pathogens in humans:
  – skin
  – mucous membranes
  – cilia
  – chemical barriers
  – other body secretions

• identify defence adaptations, including:
  – inflammation response
  – phagocytosis
  – lymph system
  – cell death to seal off pathogen.

The body has an impressive defence system to fight pathogens. This system includes:

• barriers (unbroken skin, mucous membranes, cilia, chemical barriers and other secretions)
• adaptations to fight disease (inflammation response, phagocytosis, macrophage, lymphatic system and cell death to seal off a pathogen
• the immune system.

The first two defences will be covered in this part of the module. The immune system is examined in Part 4 of this unit.

Pathogens are prevented from entering the body by barriers. For most pathogens, if they can not enter the body then they can not cause disease. These barriers include unbroken skin, mucous membranes, cilia, chemical barriers and other body secretions.

**Skin**

Skin is a body organ. It has three main regions—epidermis, dermis and subcutaneous layer.
The epidermis consists of a number of layers. The outer layer is made up of dead cells while the remaining layers are made up of living cells.

The outermost layer of the epidermis is called the stratum corneum. The stratum corneum provides a poor environment for the growth of pathogens because it is dry and the cells present are dead. The dead cells of the stratum corneum are sloughed off and any pathogens on the dead skin cells are lost in the process. Active division in the deeper layers of the epidermis produce cells that eventually take the place of cells that are sloughed off the stratum corneum.

From what you have read about the stratum corneum so far, why do you think bathing is often seen as important for maintaining good health?

Check your answer.
Sebaceous glands

Sebaceous (oil) glands can be found in the dermal layer of the skin. Look at the diagram of the skin and find a sebaceous gland.

Sebaceous glands secrete sebum (oil). Bacteria live off the secreted oil in the hair follicle and on any areas of skin that have sebum. These bacteria have a mutual relationship with their host. They repel many pathogens and produce acids that make the skin an even more unfriendly environment for pathogens.

You have come across the word mutualism in your studies of ecology. Many of the scientific terms you learned as part of your preliminary course are important for the understanding of material in the HSC course.

1 Define mutualism.

________________________________________________________________________

________________________________________________________________________

2 Define host.

________________________________________________________________________

________________________________________________________________________

Check your answers.

Mucous membranes

Epithelium is the general name given to the tissue lining the surface of a body and the organs within the body. There are various types of epithelium. One type of epithelium is responsible for secreting mucus. Epithelium responsible for secreting mucus is called a mucous membrane.

Mucus

Mucus is a sticky and often clear fluid. If you blow your nose you can get a sample of mucus on your handkerchief!

There are many places within the body where mucus is produced. For example, in the nose, lungs, reproductive tract and intestines. Mucus has two main roles, lubrication and defense against pathogens.
As a lubricant, mucus allows substances to pass more easily. In the intestines, for instance, mucus lubricates the intestinal walls to allow better movement of digesting food.

Elsewhere the mucus also has a disease–fighting role eg. in the nasal passages and lungs.

Mucus is a **viscous** substance that is secreted on the interior linings of organs. Pathogens can get caught in the viscous mucus. Once caught they are prevented from reaching the surface of the organ where they could cause infection. This process is assisted by antibodies in the mucus that kill many pathogens. You will discuss the role of antibodies when you look at the third line of defense.

**Cilia**

A cilium (plural cilia) is an extension of the protoplasm from the walls of some cells. They are minute hairs that project from the cells lining the mucous membrane. You have previously seen cilia as parts of unicellular organisms where they were responsible for movement.

**Cilia in multicellular organisms**

Multicellular organisms can also have cilia. The cilia in multicellular organisms are produced by ciliated epithelium. Just as one type of epithelium produces mucus, another type has cilia.

In multicellular organisms cilia are used for the movement of particles within the organism. For example, cilia are used to remove particles of dust that collect in the lungs.

One of the side effects of smoking is damage to the ciliated epithelium of the lungs. This prevents the cilia from removing the small particles that collect in the lungs. A smoker’s cough results from the need to cough up the particles that cannot be removed by the damaged cilia.

**Cilia as a defense against disease**

As you already know, pathogens get trapped in mucus. The cilia in the lungs beat to move mucus out of the lungs. In doing so the cilia remove pathogens. The mucus removed from the lungs is either swallowed or coughed out of the body.
Why do you think that spitting is considered unhealthy?

_________________________________________________________

_________________________________________________________

Check your answers.

**Chemical barriers**

Earlier you learned about acids produced by the bacteria living on fats and oils on the skin. The acid produced by these bacteria is a chemical barrier to pathogens.

The stomach also has an acid chemical barrier. The strong hydrochloric acid released by the stomach to aid the digestion of food provides a formidable barrier to pathogens ingested with food.

The enzyme lysozyme is stored in lysosomes. Lysosomes release the enzyme when they come into contact with pathogens. The enzyme destroys the pathogens with which it comes in contact. Tears, saliva and many other body fluids contain this chemical barrier.

**Other body secretions**

**Tears**

Tears are produced by the lachrymal glands that drain into the eyes. Tears are released when you blink and they wash the surface of the eye to remove bacteria and dust.

**Saliva**

Produced by the salivary glands, saliva washes bacteria from between teeth. Swallowed bacteria are digested and destroyed by the acid in the stomach. Saliva also contains the digestive enzyme, salivary amylase, which is involved in the breakdown of food, but that is another story to be told elsewhere in this course.
Urine

The passing of urine cleanses the urinary tract. You may be surprised that urine produced by a healthy kidney is a sterile acid fluid. If you think about how urine is produced you will realise that it must be sterile (unless the kidney is infected).

The kidney filters blood and the resultant wastes are stored as urine in the bladder. The filtering process in the kidney removes liquids from the blood (mainly water and urea) whole cells are not removed by the filtering process. Bacteria and other unwanted pathogens are removed by other processes. So you can see that only sterile components are removed from the blood.

Bile and hydrochloric acid

Alkaline bile (produced in the duodenum) and hydrochloric acid (released into the stomach) also play a part in the killing of pathogens. The human digestive tract varies in pH along its length. Very few organisms can survive such changes because even if they are able to survive the low stomach pH, it is unlikely that they would survive the alkaline pH of parts of the intestine.

1  What is a secretion?

2  With the aid of examples briefly outline how secretions can assist in the body’s defence against disease.

Check your answers.

Do Exercise 3.1.
Pathogens that manage to get through the defence barriers must face the body’s second defence. The second defence is a group of non–specific responses to fight disease. Because the second line of defence acts so rapidly, most pathogens are killed before major infection of tissues can commence.

The defence adaptations include:
- inflammation response
- phagocytosis
- macrophages
- lymph system
- cell death to seal off a pathogen.

**Inflammation response**

If you have ever cut yourself you may have noticed that the tissues around the wound become hot, red, swollen and painful. This is an example of an inflammation response.

The inflammation response allows the body to optimise disease fighting in areas where injury has occurred to body tissue eg. at the site of a wound in the skin.

Tissue in the area of the injury releases bradykinin. This chemical causes mast cells to release histamines. The combination of bradykinin and histamines cause the capillaries to swell and become more permeable.

The enlarged capillaries cause the skin reddening that you may have noticed about a wound. The increased permeability of the capillaries means that more white cells and macrophages can be released to attack pathogens. You will learn more about macrophages and white cells shortly.
Phagocytosis

A cell that can flow about another cell and engulf it is called a phagocyte. The process of engulfing another cell by a phagocyte is called phagocytosis. Two examples of phagocytes are neutrophils (a type of white blood cell) and macrophages.

Leukocytes

Leukocytes are white blood cells. There are five main types of leukocyte which include phagocytes and lymphocytes. A neutrophil is one of the five types of leukocyte. They are manufactured in the bone marrow.

Neutrophils are phagocytes. They can ingest bacteria. Once ingested, enzymes are added to the bacteria and they are broken down.
Pathogens such as bacteria release chemicals that attract leukocytes. Once attracted to the area the leukocytes can then perform their tasks in the prevention of disease.

Besides neutrophils, other body tissues also have specialised phagocyte cells called macrophages. Macrophages are common in the liver and lymph glands and are able to take up foreign particles, poisons and micro–organisms by phagocytosis.

Macrophages are more commonly involved in fighting long–term infections while neutrophils are more commonly found fighting short–term infections.

**The reticulo-endothelial system**

Macrophages and neutrophils form the reticulo–endothelial system.

Both macrophages and neutrophils engulf pathogens by phagocytosis and both are able to move from place to place to seek our foreign particles.

The reticulo–endothelial system is part of the second line of defense against disease. Pathogens that have managed to get through the first line of defense are sought out and destroyed by macrophages and neutrophils.

1 Pus surrounding a wound contains a greater proportion of white blood cells than blood found in the veins. Explain why this is the case.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

2 Are neutrophils the only type of white blood cell?

________________________________________________________________________
A blood test was returned to a doctor from a pathologist. The result showed that the blood sample contained an unusually high number of macrophages and neutrophils. How would you interpret this result?

______________________________________________________
______________________________________________________
______________________________________________________
______________________________________________________

Check your answers.

Do Exercise 3.2.

The lymph system

You are familiar with the circulatory system for blood from previous studies in biology. However, you may not realise that a second, equally important system exists—the lymphatic system.

Just as blood flows through arteries, veins and capillaries, the fluid in the lymphatic system flows through lymph vessels.

A quick review of the circulatory system

Let’s see how much you can remember about the circulatory system for blood. Each answer requires one word for the answer.

1. Name the blood vessels that carry blood away from the heart.

2. Name the blood vessels that carry blood towards the heart.

3. A blood vessel has muscular walls and blood flowing under high pressure. What type of blood vessel is it?

4. Name the blood vessels that go between veins and arteries.

Check your answers
When blood moves from arteries into capillaries it is under high pressure. Because the pressure is so high blood plasma (less the proteins) is forced through the capillary walls into the surrounding tissue. This forms the intercellular fluid.

Intercellular fluid baths the cells of all tissues. Gases dissolved in the intercellular fluid are exchanged with the cells. This is how waste carbon dioxide is lost from the cells and how oxygen that was collected by the blood in the lungs is delivered to body cells.

Intercellular fluid is eventually returned to the circulatory system by
• re–entering the capillaries close to the veins where pressure is low
• entering the lymphatic system.

What the lymphatic system does

The lymphatic system:
• returns intercellular fluid to the blood circulatory system
• is responsible for providing part of the second line of defense against disease
• collects much of the fat absorbed from the small intestine.

Return of intercellular fluid

There are two types of lymph vessel, lymph capillaries and lymph veins.

The lymph capillaries collect the intracellular fluid and pass it to lymph veins. These pass the fluid to a larger set of lymph veins and eventually into two large lymph ducts which empty into veins of the blood circulatory system near the heart.

Fighting disease

The lymphatic system:
• filters particles such as dead cells, cell fragments and dust from the system
• is responsible for the production of the white cells (a type of leucocyte called a lymphocyte) responsible for the immune response (which you will study later in the third line of defence).
Cell death to seal off pathogens

Granulomas are a cluster of cells that produce a covering to seal off a pathogen from the rest of the body. The internal cells die and are surrounded by layers of macrophages, lymphocytes and a hard outer covering. The cells die to seal off the pathogens and protect the rest of the body from infection.

Do Exercise 3.3: Defence mechanisms
Suggested answers

Skin

Bathing helps to remove any pathogens that are on the skin. It assists the natural process of losing cells from the skin.

Sebaceous glands

1 Mutualism refers to a relationship between two organisms where both organisms benefit from the relationship. In the example above, the bacteria benefit from the secreted oils which are a food source. The host benefits from added protection from pathogens.

2 A host is an organism that provides either a source of food or shelter for another organism.

Cilia

The mucus that is spat contains pathogens that have become trapped. If someone else were to come into contact with the spit they could become infected by the pathogens.

Bile and hydrochloric acid

1 Secretion is the process by which the glands of an animal release chemicals in solution.

2 Secretions can be used to poison and/or flush pathogens from the body. For example tears produced in the lachrymal glands flush bacteria and other pathogens from the eye. Mucus is another secretion that can trap pathogens.
The reticulo-endothelial system

1 Neutrophils are attracted to areas where there are foreign particles. They would be attracted to invading microorganisms at the wound site. You would expect to find a higher than normal number of white cells at the site of a wound.

2 No. There are at least five different types of white blood cells (leukocytes).

3 There is an infection within the body. This is why the phagocytes are so high in the blood.

A quick review of the circulatory system

1 Arteries
2 Veins
3 Artery
4 Capillary
Exercises 3.1 to 3.3  Name: _________________________________

Exercise 3.1: Defence barriers

The first line of defence provides barriers to stop pathogens entering the body. For each defence mechanisms state how the barrier prevents entry of pathogens.

• Skin

• Mucous membranes

• Cilia
• Chemical barriers

• Other body secretions

**Exercise 3.2: Defence adaptations**

a) What is the inflammation response?
b) Below is a diagram of the reaction that is defence against disease. Name the process and in your own words describe what is happening.

![Diagram of the reaction that is defence against disease.]

- Phagocyte (white blood cell) moves to surround bacterium
- Phagocytes destroy bacterium
- Vacuole formed to enclose bacterium

c) Name two phagocytes and describe their action on a pathogen.
# Exercise 3.3: Defence mechanisms

Below is a list of defence mechanisms. Indicate with a tick whether each is an example of a barrier defence or a defence adaptation. The first one is done for you.

<table>
<thead>
<tr>
<th>Defence mechanism</th>
<th>Barrier defence</th>
<th>Defence adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>unbroken skin</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>phagocytosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>body secretions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lymph system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>macrophages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mucous membrane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cell death to seal off pathogen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>cilia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>chemical barriers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>inflammation response</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The search for better health

Part 4: Immune response
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You have looked defence barriers and adaptations in the previous part of
the module. Now you will look at the immune response.

In this part you will have the opportunity to learn to:
• identify antigens as molecules that trigger the immune response
• explain why organ transplants should trigger an immune response
• identify the components of the immune response as:
  – antibodies
  – T–cells
  – B–cells
• 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
• outline the way in which vaccinations prevent infection
• outline the reasons for the suppression of the immune response in
  organ transplant patients.

In this part you will have the opportunity to:
• 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 small
pox, diphtheria and polio.

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issued 1999. The most up-to-date version can be found on the Board's website
This version November 2002.
The immune response

The body is able to recognise the difference between its own cells and cell products from the cells and cell products of other organisms. The body is also able to tell the difference between itself and the cells and cell products of other organisms of the same species.

The recognition of self and non–self is carried out by the immune system. Once non–self particles are recognised the immune system sets about the destruction of the non–self particles.

Components of the immune system

There are three main components of the immune system:

- antibodies
- T–cells
- B–cells.

Antibodies

An antibody is a substance produced by the body when an antigen enters the system. Antibodies are proteins that are able to combine with antigens to deactivate them. They are produced in the lymph nodes by B cells.

Your body produces a different antibody for each antigen it encounters during its life. By life’s end you will have made about one million different types of antibody.
Antigens

An antigen is a foreign substance that triggers an immune response. They are often part of the outer coating of a bacterium or virus.

The antigen is recognised by the body as not being part of itself, and antibodies are released to attach to the antigen.

Antibodies are specific. Particular antibodies attack particular antigens. An antibody for one antigen does not attack a different antigen. Chemically, an antigen is usually a protein or polysaccharide.

B–cells

B–cells (also called B–lymphocytes) are a type of lymphocyte that come directly from the bone marrow (hence B–cell). B–cells are responsible for the production of antibodies.

T-cells

T–cells (also called T–lymphocytes) are a type of lymphocyte that have passed through the thymus (hence T–cell). The thymus gland is large during childhood but shrinks in adults. It is located in the base of the neck.

T–cells do not produce antibodies. T–cells directly attack cells whose antigens they recognise.

Complete the table below to summarise the function of the various components of the immune system.

It is important to have the function of each part of the immune system clear in your mind before you read any further.

<table>
<thead>
<tr>
<th>Component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibody</td>
<td></td>
</tr>
<tr>
<td>B–cell</td>
<td></td>
</tr>
<tr>
<td>T–cell</td>
<td></td>
</tr>
</tbody>
</table>

Check your answers
Immunity

The immune system learns to recognise self at a very early age. In one study, cells from one mouse embryo (A) were placed into a second mouse embryo (B). Once the mice reached adulthood a skin graft was made from the mouse (A) that donated the embryo cells to the mouse (B) that had received the embryo cells. The skin graft was accepted.

An identical twin (this mouse was genetically the same) of mouse (B) was also given a skin graft. This mouse had not received any cells from the donor mouse (A). The skin graft was rejected.

This shows that the immune system learns to recognise self while the organism is still an embryo.

A point of interest about this work is that it was performed by Dr Peter Medawar who shared the Nobel Prize with Australian scientist Sir MacFarlane Burnet. We will hear more of MacFarlane Burnet later in this unit.

Memory

When a new antigen enters your body the immune system produces B–cells that make antibodies and T–cells that specifically deal with that antigen. It takes about one week for your body to produce sufficient antibodies and T–cells to mount a successful attack against a new antigen.
If the same antigen enters the system again, perhaps years later, the response is much quicker. Any antigen to which you have been previously exposed is instantly recognised and antibody and T–cell production commences straight away.

Antibody and T–cell production and build–up is always quicker on the second and subsequent infections.

The immune system has a memory of past infections that allows it to respond more quickly to antigens it has previously encountered than to new antigens.

Over the course of your life your body will encounter about 1 million antigens and your immune system will carry the memory of each to allow a more rapid response if the antigen is encountered again.

**How does this memory work in B-cells?**

The clonal selection theory explains the process of memory. This theory says that the antigen selects the correct B–cell to produce the antibodies that will be used against it. A cloning process replicates the cells that will produce the antibodies. By having many cells producing the antibodies required, sufficient antibody can be made to fight the antigen.

Antigens attach to the receptor sites of the B–cell leading to a clonal response that produces many copies of the B–cells.

Let’s imagine a new antigen enters your body. The antigen will combine with a particular B–cell that has a receptor on its surface that matches the antigen.

Not all B–cells are the same. The antigen only combines with a matching B–cell.
The B–cell then makes plasma cells which are clones of itself. Most of these clones release antibodies to attack the new antigens in the system.

Some of the clones are memory cells and do not release antibodies. For some time after an infection by an antigen, memory cell numbers remain high. If re–infection occurs then high levels of antibody production can be achieved in a very short time by the cloning of the memory cells to produce more plasma cells.

How does memory work for T-cells?

T–cells are not able to recognise an antigen without assistance.

A macrophage engulfs the antigen by phagocytosis. The macrophage breaks down the antigen with enzymes and then displays part of a protein fragment of the antigen on its outer surface. The protein fragment is associated with a major histocompatability complex (MHC).

The T–cell combines with the protein displayed on the surface of the macrophage and begins to clone just as you saw in the B–cells.

Some of the clones produced are memory cells. Memory in T–cells works in much the same way as it does for B–cells.
For some time after the attack, memory cells remain in the system to allow for a rapid response to reinfection.

Cloning of T–cells.

You will look more closely at T–cells shortly.

Now would be a good time to see what you remember about immunity and memory.

1. List each step in the immune response of a B–lymphocyte from the time of first exposure to a new antigen until the cloning process is underway.
2 Briefly explain why your body’s response to a re-infection of an antigen is quicker than its response to a new antigen.

T-lymphocyte types and their differences

There are several types of T–cells and each has a specific role. They are

• killer T–cells or cytotoxic T cells (Tc)
• helper T–cells (Th)
• memory T–cells
• suppressor T–cells.

You have seen that T–cells cannot recognise antigens without help.

So how do they work?

Macrophages engulf antigens and then break them down with enzymes. Killer T–cells attack and destroy the macrophage that has engulfed the antigen. These cells release powerful cytotoxins like perforin which causes holes in the membranes of infecting cells.

These cells are the main destroyer of viruses as they kill the cells that have already been infected by the virus. Thus, preventing the spreading of the virus. They are also the cells that make organ transplants difficult as they attack the donor organ.

There are also two other types of T–cells.

Helper T–cells secrete lymphokines and interleukins, chemicals that stimulate the cloning of both B–cells and T–cells. The disease AIDS caused by the human immunodeficiency virus (HIV) disables helper T–cells. AIDS patients die of opportunistic infections that their normal helper T–cells would help to destroy.
Suppressor T–cells stop the immune response when the antigen is removed. Some suppressor cells remain in the system as memory T–cells (just as you saw for B–cells).

The diagram below summarises the activities of T–cells. Compare this to the diagram of B–cells activities on page 7.

![Diagram of T-cell activities]

Summary of T–cell activities.

**Interaction between B and T lymphocytes**

There is a degree of interaction between B–cells and T–cells. They are both attacking the same problem (antigens) although their action is different.

The helper T–cells assist in the interaction by releasing chemicals to stimulate B–cells and T–cells to clone. Because B–cells and T–cells are in close proximity the release of chemicals (called cytokines) by helper T–cells can coordinate the immune response by both B–cells and T–cells.

Do Exercise 4.1 now.
Immunity from vaccination

Vaccination can produce both active and passive immunity from disease.

Active immunity from vaccination

Active immunity results from the body’s own immune system releasing antibodies and killer T–cells to attack an antigen.

Active immunity can be imparted by injecting the body with a serum that stimulates the B–cells and T–cells to clone. The cloning process will result in many memory cells in the system and so allow the body to respond rapidly to the antigen.

You are probably wondering how you could stimulate the cloning process. An injection of the antigen would do the trick, but of course this would give the organism the disease you are trying to prevent. Not such a great idea!

There are a couple of methods to induce cloning

- injection with a dead antigen. The body still reacts to the antigen even though it is dead and unable to cause harm
- injection with a safe form of the antigen (perhaps a closely related but non–lethal form of the bacterium or virus). This is called attenuation.

Active immunity is by far the preferred method of immunisation. Early childhood immunisations impart active immunity so that if a child does come in contact with particular antigens then the body will be able to respond rapidly.
If you are one of our many parents studying this course you should find this exercise fairly easy. You will probably have all the information you need at home. If you are not a parent, then you will need to contact a community health centre, search the Internet or simply ask a parent with young children for assistance.

What is the recommended schedule of immunisations for children 0–5 years in Australia? For what diseases are Australian children immunised?

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This activity does not have answers provided since immunisation schedules may vary from time to time. Active immunisation is used against measles, tuberculosis, polio, diphtheria and whooping cough.

**Passive immunity from vaccination**

Passive immunity is imparted by injecting the individual with antibodies to combat an antigen. This is done where there is insufficient time for the body to create antibodies to combat an antigen. The antibodies are produced by another organism. This is short-term protection. Passive immunity is used when a person has come in contact with a disease such as hepatitis.

Passive immunity does not impart long-term protection, as does active immunity.

Do Exercise 4.2 now.
Vaccination programs

Vaccination programs have been highly successful. Diseases that were once common such as small pox, diphtheria and polio have either been eradicated or at least reduced so that the occurrence rate is very low.

Eradicating diseases

Polio is expected to be totally eradicated in 2000 yet children in Australia are still vaccinated against the disease. The last recorded case of polio in Australia was 1986 and the disease had been very uncommon in Australia for at least 10 years before that.

Write a few lines to explain why polio vaccination has continued in Australia and then read on to see if you were accurate.

Although polio has been eliminated in Australia, it has not been eliminated elsewhere in the world. It is still possible for polio to enter the country from overseas travellers who have contracted the disease.

Vaccination programs must continue until the disease has been wiped out worldwide.

Successful immunisation programs can result in the total eradication of a disease. Small pox is a disease that has been eradicated because of a concerted worldwide vaccination program.

So what happens when a disease is eradicated? Health authorities stop immunising for a disease once it is eradicated. There is no need to continue to provide protection for a disease that no longer exists.

An important caution

The Australian Commonwealth Department of Health and Family Services in the second edition of their publication *Immunisation myths and realities* list a number of concerns about declining immunisation rates in Australia.

A growing number of Australian parents are not immunising their children against diseases such as measles, whooping cough and diphtheria. The decision not to immunise poses serious risks for the children and greatly increases the chances of exposure for the rest of the population.
Looking at measles

The statistics for measles are very concerning. The Department of Health and Family Services cite figures that show that 99.9% of all those not immunised against measles will contract measles during their life. Measles is a serious disease that hospitalises one in every 70 victims and kills approximately one in every 5000 people that contract the disease.

Looking at polio

In Holland there were two polio epidemics late in the twentieth century (1984 and 1991). All those contracting the disease had not been immunised while none of the immunised population contracted polio. Immunisation clearly works!

Looking at diphtheria

Like polio, the occurrence of diphtheria has been reduced worldwide. Unfortunately, declining vaccination rates has seen a resurgence in the disease. To completely eradicate this disease parents must continue to have children immunised against the disease.

Now it is your turn to analyse the effectiveness of vaccination.

Pertussis is better known as whooping cough and is an extremely infectious disease. In Australia immunisation of children against whooping cough is strongly recommended by health authorities.

Use the graph above to answer the following questions.

1. In what year did vaccination against whooping cough commence?

2. What effect did vaccination have on the incidence of whooping cough?

3. Why do you think the incidence of whooping cough increased in the late 1970s and early 1980s?

4. Deaths from whooping cough began to decrease prior to the introduction of vaccination. Propose a reason why this may be so?

Check your answers

**Suppressing immunity**

You have seen that the immune system provides a powerful third level of defense against disease. However, there are occasions when this third line of defense can lead to problems for doctors and their patients.

In the case of organ transplants the immune system will attack transplanted organs and reject the tissue. This can lead to the death of the transplant recipient. As you saw in the case of the mice receiving skin grafts previously, the transplanted tissue is not recognised as self and so tissue rejection occurs.

**Prevention of tissue rejection**

The first step is to ensure that the donor organ is as close (chemically) to the recipient as possible. The tissue from the donor must be
histo–compatible with the recipient. The MHC (major histocompatibility complex) that you were introduced to earlier plays a big part in tissue rejection. If the MHC of donor and recipient are close then rejection is far less than if these chemicals are very different.

The second step to avoid rejection is to introduce chemicals (immunosuppressants) that reduce the activity of the immune system. For many transplant patients this involves initial high doses immediately after surgery with lesser doses to be taken throughout life.

There are problems with suppressing immunity.

By suppressing the immune system to reduce the chance of organ rejection the immune system is less able to react to antigens encountered during life. This means that the transplant patient is far more susceptible to colds, flu and other diseases.

Do Exercise 4.3 now: *Suppressing immunity*

**MacFarlane Burnet**

Sir MacFarlane Burnet’s work in the middle of the twentieth century led to a better understanding of the immune response and the effectiveness of immunisation programs. He was an Australian scientist who made many important discoveries including the discovery of immunological tolerance for which he shared the Nobel Prize for physiology.

Some other of Burnet’s discoveries include:

- The clonal selection theory (you may like to refer back to the section dealing with the memory of B–cells.).
- The development of influenza vaccine.

Do Exercise 4.4 now.

1 A disease in a human population has been very prevalent. Eventually a vaccine was developed to immunise against the disease. Draw a generalised graph to show what may be expected to happen when the immunisation program commenced. (Hint: remember to label axes.)
2 Briefly outline how tissue rejection in organ transplant patients is managed.

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3 You have done an exercise that asked you to identify the immunisation program for Australian children. Do such immunisation programs give active or passive immunity? Explain your answer.

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4 Terri and Toni retired 10 years ago and decided to take the doctor’s advice to have annual influenza vaccinations. Such vaccinations are recommended for all Australians over the age of 60. Terri had always been healthy and rarely suffered from colds or flu. However, each year when Terri had the annual vaccination there were mild symptoms of headache and a slightly raised temperature for about a day after the injection. Terri continues not to get colds or flu.

Toni, on the other hand, had always seemed to get the flu each year. Terri continued to get an annual dose of the flu even after commencing the vaccination program, but the flu symptoms were mild.

a) What is the most likely reason for Terri’s symptoms of headache and raised temperature after being immunised?

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b) Should Terri continue the annual immunisation given the symptoms following immunisation and also considering Terri’s life long good health? Explain.

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c) Why is it that Toni still gets an annual dose of flu even though immunisation has occurred? Explain your answer.

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Check your answers
## T-cells

<table>
<thead>
<tr>
<th>Component</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibody</td>
<td>Produced in response to antigens. Antibodies attack antigens.</td>
</tr>
<tr>
<td>B–cell</td>
<td>Part of the immune response. Responsible for producing antibodies.</td>
</tr>
<tr>
<td>T–cell</td>
<td>Part of the immune response. T–cells attack antigens directly.</td>
</tr>
</tbody>
</table>

### How does memory work for T-cells

1. a) New antigen enters the body.
   b) Antigen attaches to a particular B–cell. The B–cell has a receptor on its surface that matches the antigen.
   c) B–cell commences cloning of plasma cells. The plasma cells produce the exact antibody required to combat the particular antigen.

2. Some of the plasma cells cloned in the initial infection do not release antibodies. These are the memory cells and they remain in the system long after the infection has gone. If the antigen re–infects the memory cells begin producing the correct antibodies at once. Because there are many memory cells remaining in the system the correct quantity of antibody is generated quickly. The response to re–infection is quicker than the response to the initial infection.
**Whooping cough**

1. Vaccination against whooping cough commenced in 1966.
2. The incidence of whooping cough was greatly reduced after the introduction of vaccination programs.
3. Immunisation rates decreased sharply after 1975. The greater number of non-immunised individuals led to an increase in the disease.
4. Improved nutrition and medical services after 1940 possibly contributed to the decreasing death rate.

**MacFarlane Burnet**

1. Tissue rejection is minimised by first selecting a histo-compatible donor and then introducing drugs to suppress the immune reaction in the organ recipient.
2. Active immunity. These programs are designed to give long-term immunity to diseases such as measles and whooping cough. This is done by exposing the child to a safe form of the antigen. The mild discomfort or fever that follows some of these immunisations is related to the reaction of the immune system to the serum.
3. a) Terri experiences headache and mild fever as the immune system reacts to the serum. Remember the purpose of the serum is to stimulate the immune system and to cause the production of memory B-cells and memory T-cells to the antigen.
b) Terri should continue with the annual immunisations. Although Terri has had few colds and flu, as the body ages the ability to withstand these diseases decreases. The elderly and very young children are more at risk than the rest of the community. The symptoms of the immunisation are a minor inconvenience for Terri if compared to a serious flu infection. Despite the symptoms Terri should continue with the program.

c) Immunisation does not prevent a person from contracting a particular disease. Immunisation provides the body with memory cells that can respond quickly to the antigen if it enters the body system. In Toni’s case the reduced flu symptoms are probably due to the immunisation. The body reacts to the infection more rapidly and so symptoms are milder. It is also likely that the symptoms will persist for a shorter period of time.
The search for better health
**Exercises Part 4**

Exercises 4.1 to 4.4  
Name: _____________________________________________

**Exercise 4.1: The immune response**

a) What is an antigen?

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b) What is the immune response?

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____________________________________________________________________
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b) What is the immune response?

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b) Name the three main components of the immune system.

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c) Name four types of T lymphocytes and describe their different roles.

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d) What are memory cells and what is their role?

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Exercise 4.2: Vaccination

a) What is vaccination?

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b) Some forms of vaccination are active others are called passive. What is the difference between the two types? Give an example of each type of vaccination.

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Exercise 4.3: Suppressing immunity

a) During transplants the natural immunity of the patient is suppressed. Why is this necessary?

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b) What are the side effects of this treatment?

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Exercise 4.4: MacFarlane Burnet

MacFarlane Burnet is a famous Australian scientist. Name two of his discoveries.

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The search for better health

Part 5: Non-infectious disease
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  Nutritional disease ..................................................................................... 5
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Epidemiological studies use careful statistical analysis of large quantities of data to study the population wide causes of non–infectious diseases.

In this part you will have the opportunity to learn to:

• identify causes of non–infectious disease using an example from each of the following categories:
  – inherited diseases
  – nutritional deficiencies
  – environmental diseases.

• identify and describe the main features of epidemiology using lung cancer as an example

In this part you will have the opportunity to:

• gather, process and analyse information to identify the cause and effect relationship of smoking and lung cancer

• 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.

A non–infectious disease cannot be transmitted from one person to another as you have seen with the infectious diseases. Diseases caused by such thing

The causes of non–infectious diseases fall into three main categories:

• genetic (inherited)
• nutritional
• environmental.

Inherited diseases

Inherited diseases are caused by genes that have been inherited from parents. Two of the most well known human inherited diseases are Down syndrome and haemophilia.

Focus on Down syndrome

Look at the diagram following. It shows a human karyotype. From your previous study you should have learnt that a karyotype is an arrangement of chromosomes showing the matching pairs of chromosomes.

What is unusual about the karyotype shown below?

Yes, there is an additional chromosome 21. This condition is known as trisomy 21 and causes the inherited disease called Down syndrome.
In a normal meiotic division each sex cell gets a single strand of each chromosome. Sometimes the division is abnormal and both strands end up in the same sex cell. When fertilisation occurs the embryo receives one strand of chromosome 21 from one parent and two from the other parent. The result is three chromosomes 21.

Down syndrome does not have to involve a whole extra chromosome 21. In milder cases of the disease, only a tiny extra bit of chromosome 21 is involved. The process by which an extra part of a chromosome can be transmitted is covered in the genetics option.

The symptoms vary according to the severity of the disease. Some typical symptoms include:

- prominent forehead
- flattened nasal bridge
- an habitually open mouth
- projecting lower lip
- skin fold at the inner corners of the eye
- mental retardation.

This is a genetic disease caused by chromosomes inherited from parents. The only preventative measure is genetic counselling of couples at risk (it is more prevalent in babies born to older parents than in babies born to younger parents).
Why do you think older couples have a higher risk of having a Down syndrome child?

A woman produces all of her eggs before birth. They stop dividing after the first meiotic division and only complete the second meiotic division just before ovulation. The older the woman, the greater the chance that the egg will be defective. Although men produce sperm all their adult life, it has been shown that male sperm has a higher chance of being defective as the male ages.

In Australia a women who is over 35 can have amniocentesis or chorionic villus sampling. These tests will show whether the foetus has a chromosomal abnormality and a decision can be made whether to continue or terminate the pregnancy.

The management of Down syndrome sufferers depends upon the severity of the disease. There have been a number of education programs for Down syndrome children (such as the one at Macquarie University in Sydney) that have had outstanding success in the education and management of Down sufferers.

You cannot contract Down syndrome from a person with the disease. Even blood transfusions from a pose no risk in catching the disease.

### Nutritional diseases

Inadequate nutrition or malnutrition can also cause disease. The table below lists some nutritional diseases and their cause.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Caused by</th>
</tr>
</thead>
<tbody>
<tr>
<td>scurvy</td>
<td>lack of vitamin C</td>
</tr>
<tr>
<td>obesity</td>
<td>overeating and/ or inadequate exercise</td>
</tr>
<tr>
<td>coronary heart disease</td>
<td>some forms of this disease are related to diet eg. high cholesterol intake.</td>
</tr>
<tr>
<td>rickets</td>
<td>vitamin D deficiency</td>
</tr>
<tr>
<td>pellagra</td>
<td>niacin (nicotinic acid) deficiency</td>
</tr>
</tbody>
</table>
Focus on scurvy

Scurvy is caused by insufficient intake of vitamin C. Scurvy was a common disease on ships prior to the 1850s. The inability to carry fresh fruit and vegetables on long ocean voyages resulted in many nutritional diseases among ship’s crew.

James Cook, a British navigator who mapped the Australian East Coast, carried out a successful experiment to reduce scurvy in his crew. Each day each crewmember was required to drink some lime juice. The vitamin C in the juice reduced the occurrence of scurvy in his crew.

The reference to a ‘scurvy crew’ in pirate movies has some basis in fact. Likewise the colloquial term ‘limey’ to describe those of British decent. This term was derived from the use of lime juice on British ships.

The symptoms of scurvy are bleeding gums and even the loss of teeth.

The only way to acquire scurvy is to have inadequate vitamin C intake. The disease cannot be transmitted from one person to another.

Scurvy can be cured by giving the sufferer regular doses of vitamin C and modifying diet to ensure that the minimum required daily intake of vitamin C is achieved.

Environmental diseases

Environmental diseases are caused by factors in the environment that can cause harm. The table below lists some environmental diseases and their causes.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Caused by</th>
</tr>
</thead>
<tbody>
<tr>
<td>industrial deafness</td>
<td>excessive noise in the workplace.</td>
</tr>
<tr>
<td>skin cancer (melanoma)</td>
<td>some forms of skin cancer are related to overexposure to the sun’s UV rays</td>
</tr>
<tr>
<td>lung cancer</td>
<td>some forms are caused by smoking</td>
</tr>
<tr>
<td>heavy metal poisoning</td>
<td>exposure to heavy metals such as lead (in older types of paint) and mercury</td>
</tr>
</tbody>
</table>
Focus on Melanoma

Melanoma is commonly found as a disease of the skin – it is a type of ‘skin cancer’. Below is a case study of melanoma.

‘History of illness:

A 35 year old Caucasian male gardener from Brisbane presented to his local doctor with a “mole” on his right shoulder that had increased in size over the previous six weeks. The mole had changed colour and had become itchy, and was clinically thought to be a melanoma. He had also notice lumps in his right axilla (armpit), which were enlarged lymph nodes. The tumour and the axillary nodes were removed surgically. The patient remained well for two years, but then presented with increasing headaches. A CT Scan of the head revealed multiple tumour deposits in the brain. He died 3 months later after lapsing into a coma.

Appearance of Disease:

[Image of Melanoma of the skin]

This is an area of hairy skin containing a malignant melanoma (skin cancer) of the superficial spreading type. There are several irregular, black, raised areas which are zones of vertical tumour growth deep into the dermis (skin). There is also a large, flat, whitish (depigmented) area, which may represent destruction of tumour cells by an immune response.

Comment:

Malignant melanoma is a skin cancer derived from melanocytes, the cells in the epidermis that produce melanin pigment. Melanoma is the most deadly form of skin cancer, although much less common than squamous cell carcinoma and basal cell carcinoma. It is strongly related to exposure to ultraviolet light (sunlight), and is more common in lower latitudes in fair–skinned people.
Australia has the highest incidence of melanoma in the world. Any pigmented lesion or “mole” that appears in adulthood, or increases in size, or bleeds, or becomes itchy, or has an irregular contour or irregular edge should be regarded as highly suspicious and removed surgically for examination by a pathologist. If not removed early these tumours can spread to local lymph nodes (as in this case), liver, lung, brain and many other organs.

**Focus on heavy metal poisoning (lead)**

Heavy metals include such things as lead, cadmium and mercury. Most heavy metals are cumulative in organisms. This means that once a heavy metal enters the system it does not leave.

So what’s the fuss you ask? Let’s imagine that each year you are exposed to a tiny, non-lethal quantity of a heavy metal. The amount is so tiny that you show no symptoms. Each year a tiny amount is added to the body and, each year, that adds to what is already in the system. Eventually there is sufficient for you to show signs of heavy metal poisoning. Because the heavy metal cannot leave the body it accumulates.

Lead poisoning is caused by an accumulation of the element lead in the body. There are numerous sources of lead including the older (now banned) lead based paints, lead smelting plants and leaded petrol.

Lead attacks the central nervous system and can cause shaking and psychological problems. There is a metallic taste in the mouth. In mild cases there may be vomiting and diarrhoea, but in more extreme cases, there may be coma and death.

Children who have large levels of lead in their bodies often eat dirt. Those living in the inner city area of Sydney are at high risk of lead poisoning.

Treatment for lead poisoning is EDTA (ethylene diamine tetra-acetic acid). This combines with the lead and is then excreted in the urine.

To control lead the level of lead is monitored regularly, leaded petrol is being progressively removed form sale and educational programs are alerting people to the risk of poisoning from old paints and other sources.

You cannot catch lead poisoning by being exposed to a sufferer. However, you can get the disease if you are exposed to lead. People renovating older houses that still have layers of lead based paint are one particular group at risk.
Research activity

You have just learned about a number of non–infectious diseases. Now it is your turn to do some research in a library or on the Internet. If you do not have access to either a library or the Internet do not panic! You can use one of the diseases described above to answer this question. It would also be good to perform a first hand study yourself if you or someone you know has a non–infectious disease.

Choose a non–infectious disease. For this disease make brief notes under the following headings:

• name of disease
• cause of disease
• symptoms of the disease
• treatment/ management of the disease.

You should restrict your answer to no more than a single A4 page.

Record your information in Exercise 5.1. *Non–infectious diseases*

To get you started on your research visit the site below.

http://www.lmpe.edu.au/science
Epidemiology is the study of a particular disease in a particular place. The study looks at groups of people rather than at individuals.

You would probably be familiar with the term *epidemic* which usually refers to an outbreak of a particular infectious disease in a particular place e.g. the bubonic plague epidemic in the Rocks, Sydney in the early 1900s.

So, from where do these terms originate?

‘Epidemiology is a word derived from another word, epidemic. The “ology” part of the word just means ‘the study of’. So, epidemiology is the study of epidemics.

The Oxford English Dictionary notes the first use of the word epidemic in 1603 by one Thomas Lodge who wrote of the London bubonic plague at that time “…it was epidemic among the population”. The word epidemiology did not appear until 1873 when J P Parkin titled a book ‘Epidemiology or the remote causes of epidemic’.

But let’s return to Thomas Lodge. His use of the term epidemic was hardly original in an era when all formal learning included ancient Greek and Latin. He had simply used a variation of an ancient Greek word “epemios” which roughly translated means “upon a people”. The Greek epi = upon and demios = a people. The Greeks had also used this work for plagues (epidemics).’

You may have noticed there are Latin and Greek derivations of many of our scientific terms and, indeed, names for species.

The first epidemiologists only studied infectious diseases. However, it has been found that many of the statistical techniques of epidemiology have been useful for studying non-infectious diseases as well. The current use of the term epidemiology is very broad. Epidemiologists (people who study epidemics) can study both infectious and non-infectious diseases.
Epidemiology is a science for ‘medical detectives’. It is often regarded as one of the most interesting areas of medical research. Epidemiological studies involve the collection and careful statistical analysis of large quantities of data. Such studies can assist in the causal identification of non–infectious diseases.

With any study of epidemiology there has to be discussion about cause and effect. For example, if you found that every person who suffered from a disease also drove a car could you then claim that a car caused the disease? Obviously not! When any disease is linked to a cause it has to be shown that the cause is the direct reason for the disease. The tobacco lobby has been fighting for years to show that smoking was not the cause of lung cancer. Epidemiology has to show that the relationship is not just by chance and is not the indirect result of another cause.

In this brief introduction to epidemiology you will investigate the link between lung cancer and smoking.

**Lung cancer**

You have already seen, in the case of Ross’s work with malaria or Koch’s work with micro–organisms, that careful study and recording can identify the exact cause of some infectious diseases. However, it is not always that easy to identify some causes of non–infectious diseases. The link between smoking and lung cancer, exposure to the sun and skin cancer and diet and cardiovascular disease are examples of links that have been difficult to establish.

The causes of some diseases are identified by statistics rather than direct observation and identification of the cause.

**The history of lung cancer and smoking**

Lung cancer is the uncontrolled growth of tumours in the lungs. Tobacco smoke contains many carcinogens (cancer causing chemicals) such as benzene. The smoker introduces smoke into her or his environment each time a cigarette is lit (and incidentally into the environment of the passive smokers who have the smoke added to their environment as well). The carcinogens turn proto oncogenes into oncogenes resulting in uncontrolled growth in the form of tumours. As the tumours grow the tissue in the lungs is destroyed and breathing becomes more and more difficult. The lungs may collapse and abscess and the patient may begin coughing up blood.
Going back in time lung cancer was a very rare condition. Then in 1880 the mass production of cigarettes began. During the First World War cigarette companies gave away free cigarettes to the soldiers. There is a lag of about 30 years for the onset of lung cancer and in the 1930s there was a sudden epidemic of lung cancer cases. It was quickly realized that there was a link between the increase in smoking and the increase in lung cancer.

Researchers have been for many years trying to link smoking with lung cancer. At the same time tobacco companies have been fighting against the cause and effect link between their products and lung cancer. Epidemiological studies have been important in showing that smoking does increase the chance of getting lung cancer. The first large studies that showed a link were in the 1950s. These showed a statistical link between smokers and lung cancer but not a causative effect. Their results showed that smokers did not live as long as non-smokers. The cigarette companies brought out a healthier low tar cigarette to
counter the bad publicity. In 1964 the Surgeon General’s Advisory Committee concluded that cigarette smoking was causally responsible for lung cancer. By the 1970s lung cancer had gone from a rare condition to the number one cause of cancer deaths.

Women were slower than men to pick up the smoking habit and were the subject of intense marketing programs from the cigarette companies. In the 1970s lung cancer was still rare amongst women but by the mid 1980s it had become the number one cause of cancer death in women.

Once the link between smoking and cancer became more obvious the rate of smoking has begun to fall. Over time there has been a resultant fall in the number of lung cancer cases.

Today lung cancer is still the leading cause of cancer death in NSW. In 2000 there were 2,627 new cases of lung cancer of which 1,533 were men and 849 were women.

Since 1984 there has been a fall of 2% a year in men diagnosed with lung cancer. However over the same period there has been an increase in the number of women diagnosed with lung cancer.

**Criteria for epidemiology**

There are five criteria for linking cause and effect with evidence from epidemiological studies. These are:

- high relative risk
- consistency
- a graded response to a graded dose
- a time relationship
- a possible mechanism

Looking at lung cancer epidemiological studies the criteria are met for the link between smoking and lung cancer.

**High relative risk**

The risk of death from lung cancer is ten times that for a smoker than a non–smoker. Cigarette death is associated with more than 80% of deaths caused by lung cancer.
**Consistency**

Different researchers using different populations have come up with the same results. Doll and Hill in Britain and Horn in the United States found that lung cancer was higher amongst smokers.

**Graded response**

The death rate increased with the number of cigarettes smoked in a day. The relative death rate among heavy smokers was higher than for light smokers.

**Time relationship**

Smoking must precede lung cancer to be caused by it. The lag time between smoking and the onset of lung cancer may be 30 years. The smoking rate has decreased and this is reflected in a decrease in lung cancer over time.

**Possible mechanism**

Smoke contains a mixture of chemicals including some that are known to be carcinogens. This provides the mechanism for the mutation in the DNA sequence required to begin cancer.

Look at the following graph showing the incidence of lung cancer in NSW.
Answer the following questions about the graph and then check your answers against those given at the end of this unit.

1. What is the general trend shown in the above graph?

Information from the Cancer Council website accessed November 2002.
2 The incidence of death from lung cancer is higher in men or women. What possible reasons can you think of for this?

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______________________________________________________

3 What do you predict will happen in the future?

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Check your answers.

Throughout your studies in biology you have been asked to gather information from first-hand and secondary sources. A first-hand source is one that you have investigated personally. This may be in the form of an experiment or a field trip. It includes the values and attitudes that you possess.

Secondary sources are ones that are external to your experience and consist of information gathered by other people. When using secondary information it is always necessary to check that the information is valid.
The Internet is a wonderful source of information but it comes with a price. Anyone can put information on the Internet and there is no overall check of the information that a webpage contains. When gathering information from secondary sources, check to see who has written the text and also the date. Educational institutions and government departments always have edu or gov in the webpage address. For example:

- http://www.erin.gov.au is a government department
- http://www.lmpc.edu.au is an educational institution.

When using books and scientific journals, check the publisher. Scientific articles are peer reviewed so these are usually a source of reliable information.

In this activity you have to gather, process and analyse information to identify the cause and effect relationship of lung cancer and smoking.

To help you with this task some information on lung cancer is given on the previous page. More information can be gained from the Internet sites given below and your local library. Present your information as a report. Make sure you include the following points in your report.

- Name of the disease
- Effects of the disease
- Cause of the disease
- Statistical information
- The source of your information

Write your report in Exercise 5.2: Epidemiology.
Melanoma

1. On average 46.2 men in every 100 000 men will get a melanoma.
2. Males tend to go topless more so than females. Females are more likely to wear body covering on their trunk and to use sunscreens than men. Women tend to leave the legs exposed and so they get more melanomas on the legs than the trunk.
3. Males tend to use sunscreens less than females and bath at beaches with less clothing than females. The females may wear small swimsuits, but they cover up with a beach shirt more often than the men.
4. Exposure to sun is the risk factor.
5. North of Sydney the sun is closer for longer periods than for areas south of the city. The increased ultraviolet radiation in these areas may be a factor. Also the coastal areas north of Sydney are popular surfing and beach-going areas where people are more likely to be engaged in outdoor activities.
6. Use of sunscreens, covering the skin with cloths, wearing hats. Slip, Slop, Slap!

Lung cancer

1. For men lung cancer reached a peak in the middle of the 1980s and since then has fallen. For women the level has been less than for men but is still increasing
2. Women took up smoking later than men. The lag between the start of smoking and the incidence of lung cancer may be up to 30 years so the women are still catching up to the men’s statistics.
3. In the future both the rate for women and for men will decrease as the percentage of smokers in the population falls.
Exercise 5.1: Non-infectious disease

(a) Define a non–infectious disease.

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(b) Non–infectious diseases can be classified as

– inherited
– nutritional deficiencies
– environmental diseases.

For each of the above categories identity a disease and give its cause.

(i) Inherited

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(ii) Nutritional deficiency

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_____________________________________________________
ii) Environmental

Report on non infectious disease
Exercise 5.2: Epidemiology

What is epidemiology and why is it important to study?

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Report on epidemiological study

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The search for better health

Part 6: Developing strategies to fight disease
# Contents

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You have been looking at the different types of diseases that affect the human body and the natural defence mechanisms that maintain health.

In this last part of the module you will look at how increasing technology has led to the development of a wide range of strategies to prevent and control disease.

In this part you will have the opportunity to learn to:

- discuss the role of quarantine in preventing the spread of disease, plants and animals into Australia or across regions of Australia
- 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

In this part you will have the opportunity to:

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


This version November 2002.
Quarantine

The Concise Macquarie dictionary defines quarantine as:

- a strict isolation designed to prevent the spread of disease.

- a period, originally forty days, of detention or isolation imposed upon ships, persons, etc., on arrival at a port or place, when liable or suspected to be bringing some infectious or contagious disease.

- a system of measures maintained by public authority at ports, on frontiers, for preventing the spread of disease.

Australia has been in an ideal position to use quarantine as a method of preventing the occurrence of diseases. Our isolation from other continents means that all diseases must cross oceans to reach our shores. By controlling the points of entry into the country then diseases can be excluded.

Some quarantine measures

Australia has quarantine measures for both material entering the country and for items crossing state borders or regions within the country. For example animals and plants entering the country from some countries are isolated for a period to ensure that they do not develop diseases after arriving into the country.

Quarantine for the outside world

It is possible that an apparently healthy animal or plant may be incubating a disease so the plant or animal is detained long enough for any potential symptoms to develop. If the organism does not develop symptoms then it can be allowed into the country. At one time all plants
and animals (including humans) were placed into quarantine after arrival in Australia.

Quarantine measures often work hand-in-hand with inoculation programs. Organisms entering the country require certificates to show they have been inoculated and, in the case of plants, sprayed for various diseases.

You may like to visit the Australian Quarantine Information Service on their web site to find the latest details of quarantine measures in Australia. The site lists many diseases and pests quarantined from entering Australia and outlines the industries/species affected.

This site can be accessed at:  http://www.lmpc.edu.au/science

Here are some pests/diseases affecting species/industries that are targeted by the Australian Quarantine Service. The information was obtained from the website, June 2000.

<table>
<thead>
<tr>
<th>Pest/ disease</th>
<th>Species/ industry affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japanese encephalitis</td>
<td>horses, pigs, humans</td>
</tr>
<tr>
<td>foot and mouth disease</td>
<td>cattle, sheep, goats and pigs</td>
</tr>
<tr>
<td>Newcastle disease</td>
<td>birds</td>
</tr>
<tr>
<td>swine influenza</td>
<td>pigs</td>
</tr>
<tr>
<td>tracheal mite</td>
<td>bees</td>
</tr>
</tbody>
</table>

**Quarantine within Australia**

Within Australia, restrictions apply to the transport of fruit, vegetables and livestock.

Fruit and vegetables are not allowed to be carried into the Murrumbidgee Irrigation Area (MIA) to prevent the importation of fruit fly from other areas. Bins are placed at the side of the road for motorists to dispose fruit and vegetables before entering the MIA.

Sugar cane is also a restricted import. Cane may not be taken from Queensland into New South Wales to prevent the distribution of cane diseases.
Grapevines are also restricted to prevent the movement of diseases from one grape growing area to another.

Many diseases are no longer considered a threat as they have been controlled or practically eliminated over the past 100 years. These include bubonic plague, yellow fever, cholera and typhoid.

In the additional resources section of this part there are some fact sheets from AQIS (Australian Quarantine Information Service) reproduced with permission. Read these and then do Exercise 6.1: Quarantine.
Strategies for disease control

There are four strategies for the control of preventable diseases mentioned in your biology syllabus. These are:

- public health programs
- pesticides
- biological control
- genetic engineering to produce disease resistant plants.

Your syllabus requires that you only study one of these, but you will briefly look at each before examining one in detail.

Public health programs

Public health programs provide sanitation, safe drinking water, immunisation programs and even the quarantine of disease sufferers entering the country. These have all played a part in disease control.

You may accept a safe water supply as a fact of life, but that has not always been the case in Australia and certainly is not the case in many other countries. One of the first things aid agencies try to establish when working in these countries is a safe water supply.

A classic epidemiological study was performed by English physician John Snow. He found that people who suffered from cholera in the 1849 London epidemic lived mostly in the area of the Broad Street pump.

You must remember these are the days before running water in houses.

Water was collected daily from village pumps or wells.
Snow found that nearly every person with the disease had consumed water from the Broad street pump. He had the pump closed and no further outbreaks occurred in the area.

**Pesticides**

Pesticides have been important in killing vectors such as mosquitoes. You will remember the earlier section of work on quarantine and the previous Australian policy of spraying insecticide inside every aircraft when it landed. Such spraying was to kill any insect vectors (and insect pests) that may have hitched a ride on the aircraft.

**Genetic engineering**

Genetic engineering (and plant breeding) has been used to develop crops that are resistant to certain diseases. Rust resistance in wheat is an example of breeding being used to develop disease resistance.

The bacteria mentioned above (Bt) has been genetically engineered to eliminate spraying for *Heliothis*. The Bt genes that produce the toxin responsible for caterpillar death has been introduced into tomatoes, corn, potatoes and cotton. In Australia Bt, cotton was the first genetically engineered crop grown.

Insulin is produced by recombinant DNA technology and is an example of a strategy to fight disease by genetic engineering.

Do Exercise 6.2 now.
Your case study

You are required to explain how one of the strategies outlined above has controlled and/or prevented disease. For your study you will use malaria as your example.

You will remember from the earlier section on malaria in Part 2 of this module, that swamps were drained to remove mosquito breeding grounds. Pesticides have also been used to kill the mosquitoes.

We provided all the information you require for your study in some of your earlier notes. Use the information on malaria and then answer the following questions. The questions are designed to focus you on the disease control aspects of using pesticides to kill mosquitoes.

1 Name of the insect vector that transmits malaria.
2 Does the insect vector cause the disease malaria? Explain your answer.

______________________________________________________
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3 Why is the insect vector controlled rather than Plasmodium?

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4 With reference to the life cycle of plasmodium, explain why the use of pesticides against mosquitoes is an effective technique for controlling malaria.

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Check your answers
There has been a shift in the way we deal with diseases. Rather than wait for an organism to become diseased before acting a more proactive approach is being taken for many diseases.

Prevention *is* better than cure.

The proactive approach has been particularly evident in the rural sector where control of breeding is possible. Wheat, for example, can be bred so that it is genetically resistant to various diseases such as rust. Rather than spray a crop when it becomes diseased, the farmer plants a crop that resists the disease.

Quarantine also fits into this approach. Rather than let diseased organisms into the country and then treat the new diseases, it is better to exclude sick organisms to preserve the health of those already within the country.

You will also remember from your work on immunisation in the previous part that active immunity is a preventative measure. By preparing the body’s immune system with memory cells the body is able to deal with antigens rapidly itself. Often this has little effect on the organism exposed to the antigen. When immunisation is combined with quarantine whole diseases can be eradicated on a worldwide basis (eg smallpox).
Investigating plant pathogens

In this activity you will be examining plants for evidence of pathogens (insect pests, viruses and fungus). You should read the following information on plant pathogens and then do the practical titled *Plant pathogen practical*.

Insect pathogens of plants

**Pathogen**

The African black beetle, *Heteronychus arator*, is a pathogen of grasses in Australia. The beetle belongs to the order of insects known as Coleoptera. The lava of this beetle is as destructive as the adult.

Insect pathogens have a number of advantages in their role as pathogens. For example, they have wings which allow them to fly. Wings enable widespread distribution.

**Symptoms**

African black beetle is common in lawns. The major symptom is the browning of patches of lawn. The beetles are *subterranean* for most of their life and eat the roots of grasses. The browning of areas of lawn results from the death of grass caused by root damage by the beetle.
Viral pathogens of plants

Pathogen

Broad bean wilt virus is a virus that causes wilting and necrosis in broad bean (*Vicia faba*). The pathogen uses the weed lamb’s tongue (*Plantago lanceolata*) as an intermediary host. Aphids transfer the disease from the lamb’s tongue to the broad bean.

Symptoms

Necrosis and wilting. Intermediate host has mosaic pattern on leaf when infected.

*Plantago lanceolata* showing mosaic pattern of the virus (left) with *Vicia fabia* showing wilt from the disease (right). Campbell, K O. and Bower, J W. (ed) (1988) *The Scientific basis of Modern Agriculture* Oxford University Press.
Fungal pathogens of plants

Pathogen

Loose smut of wheat is caused by the fungus *Ustilago tritici*.

![Image of wheat heads showing healthy, partially infected, and completely destroyed by smut]

*Ustilago tritici* infection showing healthy head of wheat (left), partially infected head (center) and head completely destroyed by smut (right). Campbell, K O. and Bower, J W. (ed) (1988) *The Scientific basis of Modern Agriculture* Oxford University Press.

Symptoms

Destruction of wheat head. Powdery residue covering wheat head.
Plant pathogen practical

Read the instructions that follow for investigating plant pathogens. You must write an experimental report when you have completed the investigation.

If you are not able to complete this activity using first hand data then you can use the information about plant parasites in the previous section to complete the required report. You will gain more from this exercise if you do the practical rather than relying on the data provided.

What you will need:

You will need access to a variety of plants. A garden, park, crop, potted plants or even plants growing on the roadside will do.

If you can get some help for this practical you will find that it is very easy to do. If you know any keen gardeners nearby then it would be a good time to befriend them. Ask them if they can show you some of the pests currently infesting their plants.

If you live in a rural area then see if you can talk to one of the local landholders–these are the true professionals who will probably know every plant pathogen in your area.

Besides some plants, you will need a pencil and some paper. A hand lens (magrifying glass) would be useful, but not essential.

What you will do:

a) You need to identify three different plant pathogens. Attempt to include a fungus, an insect and a virus. Of course, time of year and availability of material may mean that you end up with three pathogens from the same group eg. three insect pests. If you can only find pathogens from a single group do not worry.

b) For each pathogen you will need to:
   - name the pathogen
   - provide a drawing of the pathogen and/or a drawing of the symptoms the plant may be showing eg. wilting, spots on stem or leaves.
   - name the general group to which the pathogen belongs (virus, fungus or insect pest).

c) You might like to include information on the treatment for each pathogen.
Record your observation in Exercise 6.3: *Plant pathogen practical.*

**More information**

If you are going to ask for help from a local gardener you may find it useful to complete the exercise below first. It outlines an encounter with a local gardener.

Read the following interview with an amateur gardener and then answer the questions that follow.

Chris’s garden has a mixture of fruit trees and annual vegetables in the back yard while the front yard is devoted to an excellent rose garden and a soft dark green lawn of Queensland Blue couch. Chris is familiar with most of the diseases that attack plants in the area.

**Interviewer:** The garden looks great, but do you have any problems with pests?

**Chris:** Yes. Right now I’m fighting African black beetles in the front lawn and black spot on my lemons.

**Interviewer:** Tell me about the African black beetles.

**Chris:** They come in the warmer months each year. They get into the lawn and eat the roots of the grass. If you’re lucky you see one or two walking around on top of the grass and then you know its time to spray. But mostly the first sign of African black beetles are dead patches in the lawn where they have eaten the roots and killed the grass.

**Interviewer:** So, what do you do?

**Chris:** I use this stuff (Chris holds up a bottle of a spray available from the local hardware store). All you do is mix it up according to the directions and spray the lawn.

**Interviewer:** Only one spray?

**Chris:** No. You spray twice about two or three weeks apart. The first spray kills the adults and the second spray kills any juveniles that hatch after the adults are killed. Unfortunately the spray does not kill the eggs.

1 Name the pathogen in Chris’s lawn.

2 To what group does this pathogen belong (virus, fungus, insect)?
3 What effect does the pathogen have on the lawn?

_____________________________________________________
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4 What treatment is possible for this pathogen?

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_____________________________________________________
_____________________________________________________

We now move to the back yard to look at the black spot on the lemon tree. The spots are blackened powdery areas mainly on the underside of leaves. A few leaves are almost totally covered in the black powdery spots, but most have just a few small spots present.

Chris: As you can see the Black spot is not too bad at present, but I need to do something before it gets much worse.

Interviewer: What does it do?

Chris: Black spot will cause the leaves to yellow and then drop. If the leaves start dropping then the plant makes less food and this can reduce the number of lemons I will get off the tree. In really bad cases black spot can kill young plants.

Interviewer: What sort of disease is it?

Chris: Black spot’s a fungus.

Interviewer: What can you do about it?

Chris: I dust my tree with a fungicide powder. It kills the Black spot, although you can not eat the fruit for about 2 weeks after you have dusted the tree.

5 Name the pathogen on Chris’s lemon tree.

_____________________________________________________

6 To what group does this pathogen belong (virus, fungus, insect)?

_____________________________________________________

7 What effect does the pathogen have on the lemon?

_____________________________________________________
_____________________________________________________
_____________________________________________________
8 What treatment is possible for this pathogen?

______________________________________________________

______________________________________________________

______________________________________________________

Check your answers.

You have now completed this module. Take some time to review what you have learnt. Read through the syllabus points at the start of each part and make sure that you have covered each one. If you have time make some summaries based on the syllabus points. This will be useful when you come to study for your HSC exam.

Good health!
Quarantine fact sheets (reproduced with permission of AQIS)

Fruit fly free areas

Fruit flies damage many types of ripe fruit and vegetables by using the fruit or vegetables as a breeding site.

The fruit fly female lays eggs and deposits bacteria in the fruit. The eggs hatch and the developing larvae feed on the fruit.

These are “true” fruit flies and must not be mistaken for the small “Vinegar flies” flies that are often seen around fruit bowls and ripe or rotting fruit.

Fruit flies attack melons, citrus fruit like oranges and lemons, apples, mangoes, tomatoes, capsicums, wild and ornamental fruits. They prefer soft fleshy fruit and vegetables.

There are more than 100 different types of fruit fly in Australia, but only about eight of them cause problems for farmers. There are also many types of fruit fly in other countries around the world, including in neighbouring countries such as Papua New Guinea and Indonesia.

If an area has fruit fly, it is placed under strict quarantine and farmers cannot sell their fruit without treating for fruit flies. Treatments for fruit flies are very expensive and cost the growers a lot of money. The rotten fruit must be destroyed so the pest does not spread.

Overseas countries will not buy our fruit or vegetables unless they are sure there are no live fruit flies in the produce.

There are four farming areas in Australia that have “fruit fly area freedom status.” This means the area has passed a lot of tests and is free from fruit fly.
Other countries will accept fruit and vegetables from farms in these special areas.

This fact sheet will give you some information about fruit flies and tell you how some places are able to get area freedom status. Australian fruit flies

Australia, our main worries are the Queensland fruit fly and the Mediterranean fruit fly. The Queensland fruit fly is found along the east coast of Australia, from the northern tip of Queensland down as far as the East Gippsland area of Victoria. It is native to Australia.

The Mediterranean fruit fly is an exotic species that is known all over the world. The fly was first seen here early in the 20th century in Western Australia. Now it is found in Perth and in summer, it can travel all the way down the south west coast of Western Australia as far as Albany.

**Exotic fruit flies**

The Melon fruit fly is found in Indonesia and Papua New Guinea. It is a very dangerous pest that could destroy our crops. It likes vegetables and fruits such as cucumbers, gourds, pumpkins, squash, beans, watermelon and tomatoes.

The Oriental fruit fly is another very destructive pest found in Indonesia and Papua New Guinea. This fly attacks avocados, mangoes, citrus fruit, guava, paw paw or papaya, bananas, tomatoes, passionfruit, pineapples, peaches, pears, apricots, figs and coffee plants.

The Papaya fruit fly is another dangerous fruit fly. Although it is not native to Australia, it has been found in northern Queensland and the Torres Strait Islands. The most recent outbreak was in Cairns in 1995, but this fly was successfully eradicated by early 1999.

**How do we stop fruit fly from spreading?**

AQIS and the state agricultural departments work very hard to stop fruit fly from spreading around Australia. There are a number of ways to control this problem.

First, you may not bring fresh fruit or vegetables into Australia without a special permit. Even if a piece of fruit seems healthy to you, it may have fruit fly eggs inside. Any fruit or vegetables brought to Australia without the special permit will be taken away at the airport or seaport and destroyed. The AQIS detector dogs have the important job of making sure people obey the quarantine laws.

Some of you may have travelled by car, bus or train across one of our state borders. If fruit fly is a problem in that area, you will be asked to put all fruit and vegetables in the special quarantine bins at the border. This stops fruit flies from hitching a ride with you! Border officers destroy any fruit and vegetables placed in the bins.

Fruit flies are small insects about the size of a house fly and they sometimes manage to sneak into Australia or across state borders. AQIS sets special traps near ports and airports or in areas where fruit flies have been found in the past.
to monitor fruit fly presence. In Australia, AQIS has fruit fly traps throughout all the farming areas including northern Queensland and in the Torres Strait Islands. There are also regular surveys for fruit fly in Papua New Guinea and in Irian Jaya.

The state agricultural departments monitor these traps on behalf of AQIS and these traps and monitoring surveys help AQIS and State agricultural department officers find out very quickly if fruit flies have sneaked into the area.

What happens when fruit flies are found in farming areas?

When fruit flies are found, all the farmers in the area are told immediately. Special baits are laid to attract the flies. The baits attract both male and female flies and kill them. If there is a big area to cover, the baits may be dropped from helicopters.

Flies live for about four weeks, depending on how warm or cold the temperature is. Setting traps for male flies not only kills the flies we can see, it also stops the flies from breeding and spreading across the area.

Setting traps and baiting crops is expensive. But it stops the flies from spreading. If fruit flies attack an orchard or farm, the farmer has to treat the crop before it is allowed to move off the property and that can cost the industry millions of dollars.

An outbreak in Cairns in northern Queensland caused huge problems for farmers in the area and stopped them from sending their crops overseas and interstate.

**What is area freedom status?**

“Area freedom status” means a place declared free from pests under Australian and international laws. The United Nations Food and Agriculture Organisation sets the standards for these areas. Any country that has signed the FAO’s International Plant Protection Convention will consider accepting crops from these areas under the standards. About 90 countries, including Australia, New Zealand, the United States and many countries in Asia have signed this convention.

Before acceptance of area freedom, each potential importing country assesses the fruit fly trapping and monitoring information from the exporting country requesting area freedom. Australia can use area freedom to open up new markets for Australian produce in countries that do not want fruit flies. Australia may also accept fruit and vegetables from places with area freedom status in other countries.

There are many tests and checks before an area is given area freedom status. In Australia, we have four farming areas with this special status for fruit flies.

They are the Riverina area of New South Wales, the Sunraysia area on the NSW and Victorian border, the Riverlands area in South Australia and the island of Tasmania.
Australian areas of freedom from fruit fly.

From time to time, officials from other countries visit Australia to inspect these places with area freedom status. They check our fruit fly trapping and monitoring programs. AQIS and the State agricultural departments can then issue special phytosanitary certificates that show our produce is free from fruit flies for international and interstate trade.

What can you do to help?

You can help keep Australia free from fruit fly and other pests in a number of ways. If you are travelling across a state border or arriving at an Australian airport or seaport, put fruit or vegetables in the special yellow quarantine bins. Don’t carry fruit or vegetables from one country or state to another. Remind your parents and friends too. If you find maggots in your fruit in South Australia, Victoria, New South Wales or Tasmania, get in touch with the nearest office of the state agricultural department.
**Rabies alert!**

‘Rabies is a fatal disease which can kill warm-blooded animals including humans. Australia doesn’t have rabies – if it were to become established in our wildlife it would be practically impossible to eradicate.

All animals imported into Australia are subject to strict quarantine regulations which must be obeyed to keep Australia free of rabies.

If rabies was introduced into Australia, our pets would all have to be vaccinated, they’d have to be walked on a leash and locked up at night so they couldn’t wander and come into contact with stray animals.

Rabies is caused by a lyssavirus which attacks the central nervous system (brain and spinal cord) and then spreads to the salivary glands and other organs of the body.

Rabies is usually spread by the bite of an infected animal such as a dog, cat or fox. The virus can also be spread if one of these body fluids touches broken skin or a mucous membrane (in the mouth, nose, or eyes).

Humans are at risk when saliva from a rabid animal enters the body through a bite or an open wound such as a fresh cut or scratch. Rabies is almost invariably fatal.

Rabies usually causes changes in an animal’s behaviour or temperament. Animals that are normally shy can become very friendly or aggressive.

There are two types of rabies. **Furious** rabies makes the animal foam and drool at the mouth and become unpredictable. Animals with this type of rabies may become vicious and attack without warning.

Dogs with furious rabies become unusually restless, seldom lying or sitting in one place for more a short time, and if confined move around ceaselessly. The pupils dilate and the animal sometimes squints and may snap at imaginary objects.

An important sign of the disease is that the animal assumes a watchful, puzzled or apprehensive look. The animal becomes progressively uncoordinated and eventually paralysed and usually dies within four or five days.

The second type of rabies is **dumb** rabies. In the dumb form, the animal remains quiet, is not irritable and bites only when provoked. The watchful, apprehensive look in the eyes is also present.
Dumb rabies causes paralysis followed by drooling of saliva and death. The animal is unable to eat but tries hard to drink water.

The incubation period is variable in all species and is influenced by such factors as the strain of the virus, the amount of virus injected by the animal bite, and the amount of nerves at the bite site.

Symptoms may appear as early as 10 days or as long as 6 months, or (rarely) even longer.

After the onset of clinical signs, death occurs within 10 days. The only hope for those who are bitten by a rabid animal is a course of vaccinations before symptoms appear.

Treatment for rabies requires prompt scrubbing of the bite site and people who have never had rabies shots are given six shots over the course of a month.

One shot is antibodies to fight the virus, and the rest are vaccinations to ensure long–lasting protection against the disease.

To work best, the shots should begin as soon after the bite or scratch as possible. However, if the animal has been caught and can be tested for rabies, some doctors wait for the test results to see if the shots are really needed.

Although all warm–blooded animals are susceptible to rabies, comparatively few species are good vectors of rabies and even fewer are reservoir hosts. A reservoir host is an animal that is capable of harbouring, without injury to themselves, pathogenic (disease producing) micro–organisms which may at any time be transmitted to another animal and produce the disease.

The main reservoir species are members of the dog family, the skunk family, raccoons and bats.

Dogs and cats may enter Australia from approved countries where rabies is absent or well–controlled and must serve a minimum post–arrival quarantine period of 30 days.

Pets from South Africa where dog–mediated rabies is endemic (present in that country at all times) must serve a minimum post–arrival quarantine period of 120 days.

Before arriving in Australia, all dogs and cats must be properly vaccinated against rabies using an approved inactivated rabies vaccine.

When an animal is given an inactivated or killed vaccine the body develops antibodies to protect it if the animal is later exposed to that disease.

The vaccine does not give the animal the actual rabies disease and it therefore cannot bite another animal and transfer the disease. This vaccination, called the primo–vaccination (first vaccination given), can be given to the animal when it is three months old, with a booster shot being given every 12 months of the animal’s life.
To ensure that the rabies vaccination(s) is effective, blood must be drawn from the animal. That blood sample must undergo a rabies neutralising antibody titre test with satisfactory results.

The level of rabies antibodies must be sufficiently high in the blood to prevent the animal from contracting the rabies infection if exposed to it, and potentially spreading rabies to other animals.

Cats and dogs from South Africa will be subjected to a second (i.e. confirmatory) rabies neutralising antibody titration test while the dog is in post-arrival quarantine in Australia.

If there is insufficient rabies antibody in the dog’s serum it will be required to remain in quarantine for up to one hundred and eighty (180) days at the importer’s expense.

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AQIS HOME
Suggested answers

Your case study

1 Mosquito. In particular it is a mosquito of the genus *Anopheles*.
2 No. The disease is caused by one of four species of protozoan of the genus *Plasmodium*.
3 The insect vector is much easier to control than *Plasmodium*.
4 *Plasmodium* lives, for part of its life cycle, in the salivary glands of the mosquito. The disease can only be obtained by a human from the bite of a mosquito. If the mosquitoes are killed then there are no mosquito bites. No mosquito bites and no *Plasmodium* can be transferred.

3 Prion diseases are caused by a defective chemical made by the body itself. The immune system only attacks non–self and so does not react to the defective chemical because it is manufactured by the body itself.
4 An injection of antibodies is required. It is far too late to immunise against the disease because the patient already has the disease (and will have good levels of protection after the disease has gone from the body). The body requires assistance. At the time you see the patient there are insufficient B–cells and T–cells (they are still cloning to make sufficient numbers) so provision of antibodies is the best solution.

Plant pathogen practical

1 African black beetle.
2 African black beetles are insects.
3 African black beetles kill lawns by eating the roots of grasses.
4 Treatment consists of poisoning the pathogen.
5 Black spot
6 Fungus

7 Leaf drop. This would reduce the amount of photosynthesis going on in the tree. It would reduce the amount of carbohydrate that the plant could produce.

8 Treat the pathogen with fungicide
Exercise 6.1: Quarantine

Australia is an island continent. Quarantine is a method used to prevent the introduction of unwanted diseases. Discuss some of the methods of quarantine:

a) in Australia

b) between the regions of Australia.

c) How effective have these methods been?
Exercise 6.2: Case study of a strategy

Choose one of the following strategies and explain how it has controlled or prevented disease.

- public health programs
- pesticides
- genetic engineering to produce disease resistant plants and animals.

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Exercise 6.3: Plant pathogen practical

a) Name the three plant pathogens that you studied.

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b) Draw or place photographs of pathogens in the space below.

c) Name the general group of each pathogen.

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d) \textbf{(Optional)} Name the treatment for each pathogen.

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Student evaluation of the module

Name: ________________________  Location: ______________________

We need your input! Can you please complete this short evaluation to provide us with information about this module. This information will help us to improve the design of these materials for future publications.

1. Did you find the information in the module clear and easy to understand?
   _______________________________________________________

2. What did you most like learning about? Why?
   _______________________________________________________
   _______________________________________________________

3. Which sort of learning activity did you enjoy the most? Why?
   _______________________________________________________
   _______________________________________________________

4. Did you complete the module within 30 hours? (Please indicate the approximate length of time spent on the module.)
   _______________________________________________________
   _______________________________________________________

5. Do you have access to the appropriate resources? eg. a computer, the Internet, scientific equipment, chemicals, people that can provide information and help with understanding science.
   _______________________________________________________
   _______________________________________________________

Please return this information to your teacher, who will pass it along to the materials developers at OTEN – DE.