

4 The body at war

Lines of defence, soldier cells and chemical weapons all form a part of the amazing array of strategies used by our bodies to keep us healthy.

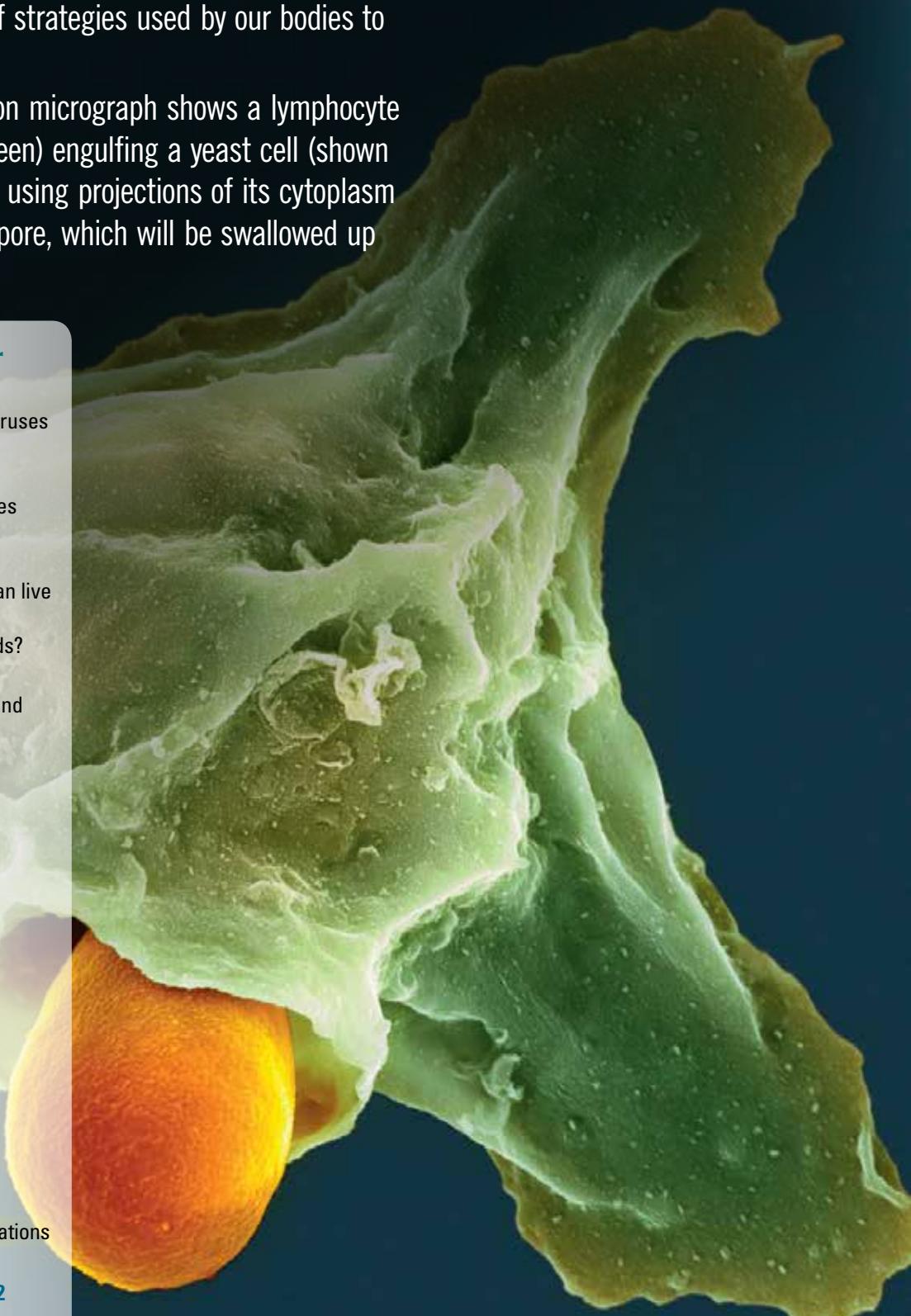
This coloured scanning electron micrograph shows a lymphocyte (white blood cell, shown in green) engulfing a yeast cell (shown as orange). The lymphocyte is using projections of its cytoplasm to extend towards the yeast spore, which will be swallowed up and digested.

Think about the body at war

- What is an infectious disease?
- What are the differences between viruses and bacteria?
- What is a parasite?
- What is the Black Death and how does it spread?
- Is immunisation necessary?
- What animal up to ten metres long can live inside a living human body?
- What does H5N1 have to do with birds?
- Is diabetes contagious?
- Why are anthrax, cholera, botulism and smallpox attractive to terrorists?

In this chapter:

- 4.1 Catch us if you can 154
4.2 Invasion! Alien alert! 158
4.3 SCIENCE AS A HUMAN ENDEAVOUR
Medieval medicine 162
4.4 SCIENCE AS A HUMAN ENDEAVOUR
Zooming in — micro tales 166
4.5 SCIENCE AS A HUMAN ENDEAVOUR
Zooming in — nano news 170
4.6 Outbreak 173
4.7 Putting up defences 177
4.8 SCIENCE AS A HUMAN ENDEAVOUR
Choosing immunisation 181
4.9 Travel bugs 186
4.10 Our noble Nobels 188
4.11 Thinking tools: Cycle maps and relations diagrams  **eBook plus**
ONLINE ONLY
Study checklist/Digital resources 192
Looking back 193



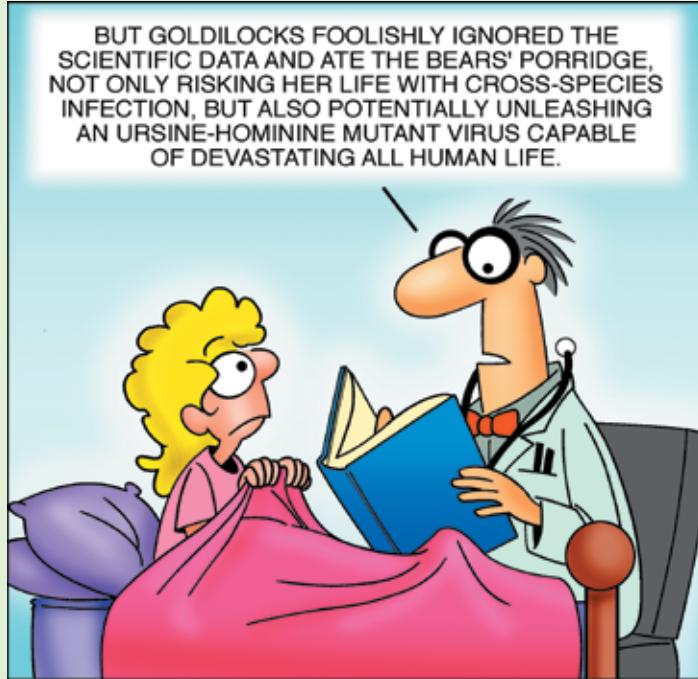
YOUR QUEST

Food warnings

Throughout history, stories and rituals have been used to pass knowledge about food and nutrition from one generation to the next.

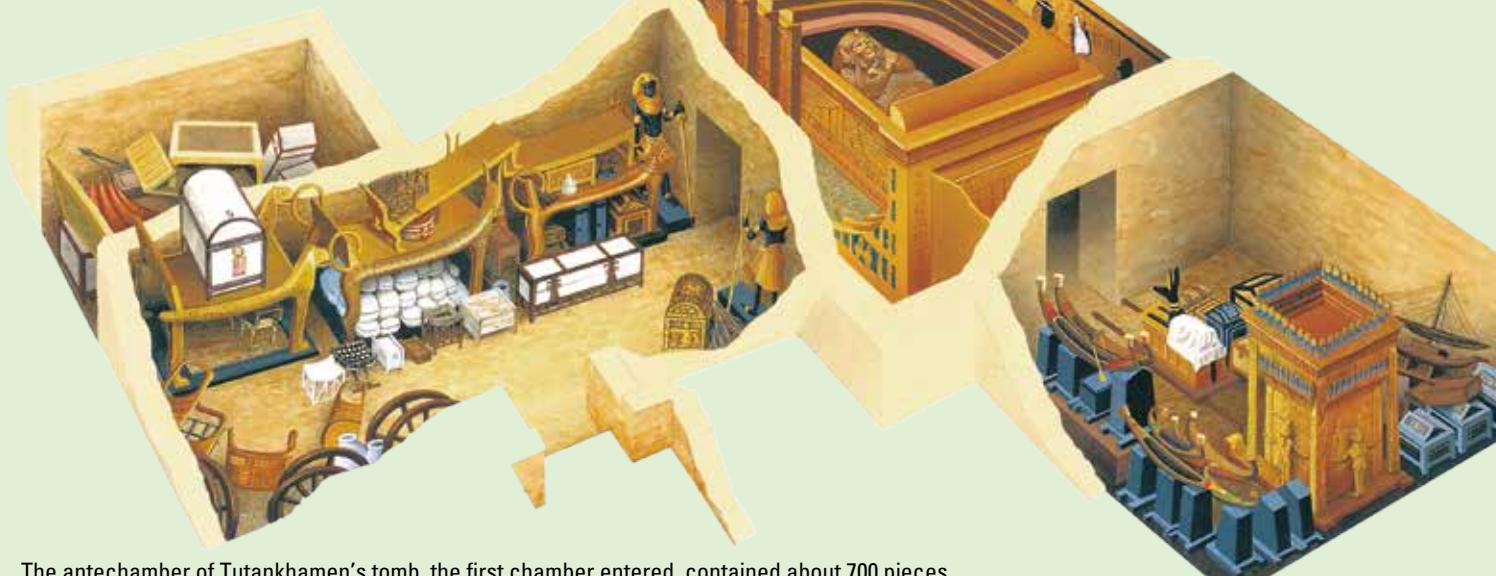
THINK AND INVESTIGATE

- 1 Imagine that Goldilocks got sick after eating the porridge. Suggest some reasons why this may have happened.
- 2 The Three Bears did not cover their porridge while they went for their walk. Was this a good idea or not? Give reasons for your answer.
- 3 How long can porridge stay uncovered at room temperature before it is dangerous to eat? Find out the spoiling time of four other foods.
- 4 Baskets of food, along with jars of wine and oil, were found in Tutankhamen's tomb in Egypt in 1922. Other Egyptian tombs contained honey that was in a well-preserved state; when opened it retained some of its aroma. Today, most foods have a use-by date on the packaging. For three different foods, find out what might happen, and why, if you used it well after its use-by date.
- 5 Sometimes canned food is unsafe to eat. Find out why.



- 6 Find out what strategies humans have to survive eating lots of different foods, some of which may cause food poisoning.
- 7 Create your own fairytale to teach young children about poisonous or spoiled food. Present your story as a PowerPoint presentation, storybook, pantomime or puppet play.

Tutankhamen's tomb in Egypt. This side chamber contained about 600 items, including pieces of wooden furniture, baskets of food, jars of wine and oil.



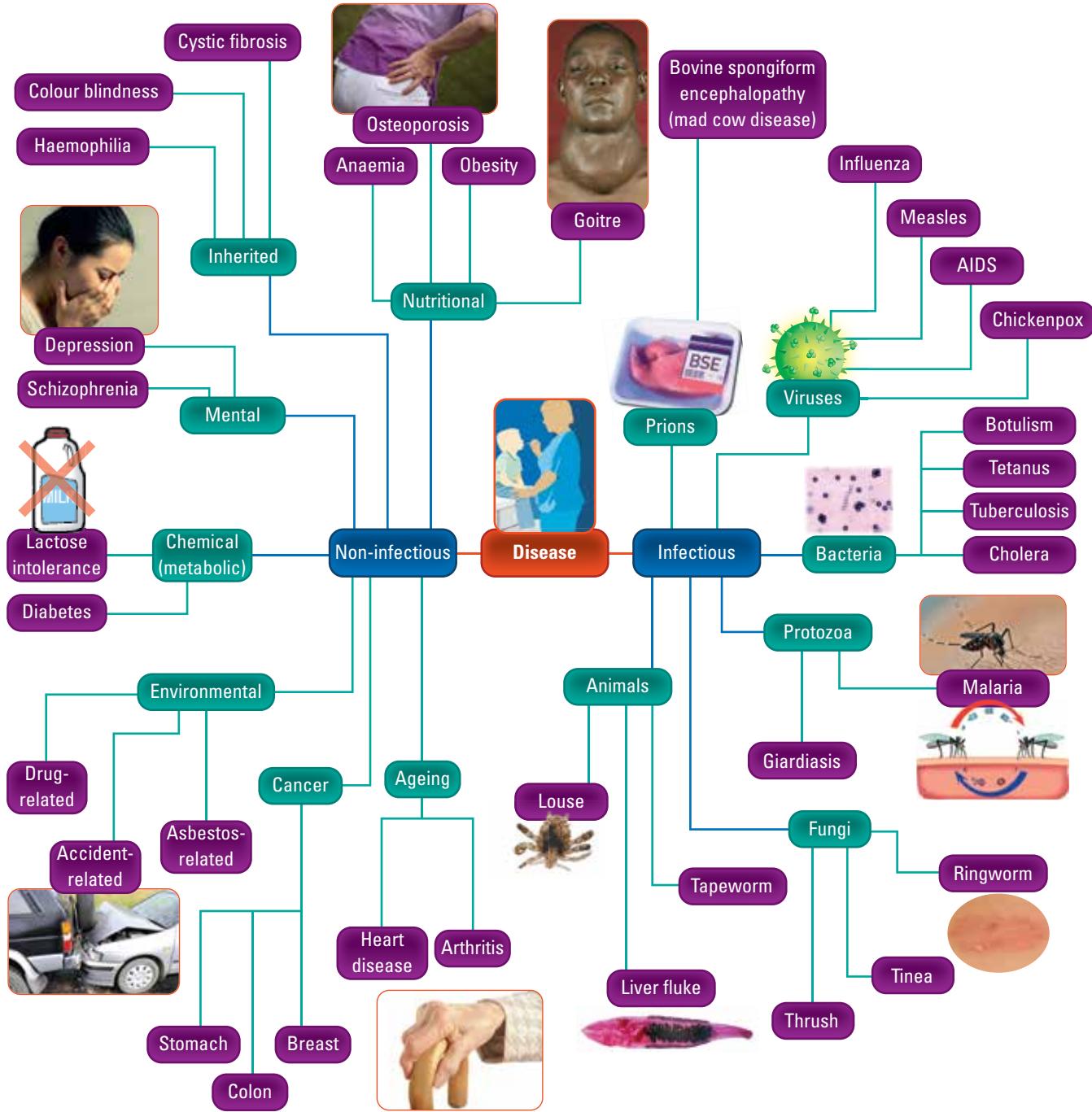
The antechamber of Tutankhamen's tomb, the first chamber entered, contained about 700 pieces of furniture, a chariot (in bits) and two black and gold life-size statues either side of the entrance. There were also jars of oil, lamps, vases, musical instruments, board games and clothing.

Catch us if you can

Something wrong? Not feeling well? You may have a disease! A **disease** can be defined as being any change that impairs the function of an individual in some way — it causes harm to the individual. Diseases can be classified as being infectious or non-infectious.

Can't catch us!

Non-infectious diseases cannot be spread from one person to another — they are not contagious (transferred from one organism to another). Obesity, rickets and scurvy are examples of non-infectious diseases that may be related to unbalanced diets or



nutritional deficiencies. Inherited diseases such as haemophilia and cystic fibrosis and diseases related to exposure to particular poisons or drugs are also non-infectious. Although viruses have been implicated in some cancers (for example, cancer of the cervix), most cancers are considered to be non-infectious diseases.

Can catch us!

Infectious diseases are diseases that are contagious and are caused by a **pathogen**. Tapeworms, head lice, liver flukes, fungi, protozoans and bacteria are examples of pathogens that are made up of cells and can be referred to as **cellular pathogens**. Some other pathogens, such as viruses, prions and viroids, are not made up of cells and for this reason are sometimes referred to as **non-cellular pathogens**.

Spreading it around

Keep out!

Preventing the spread of infectious diseases has been a challenge throughout history. The ancient Hebrews isolated those with disease by keeping them away from others or by sending them beyond the boundaries of the towns. In the Middle Ages, Mediterranean people refused to allow ships to dock for forty days if they carried sick people. The separation of sick people from healthy people to avoid infection was the beginning of **quarantine**. Unfortunately these methods were not enough to stop large outbreaks of disease.

WHAT DOES IT MEAN?

The word **quarantine** is derived from the Latin word *quadrāginta*, meaning 'forty'.

The knowledge of how infectious diseases are transmitted is important if ways to control their spread are to be found. Some key ways in which pathogens may be transmitted include direct contact, vectors, contaminated objects or contaminated water supplies.

Direct contact

Some diseases are spread by direct contact. Touching others or being touched is one way in which pathogens can be directly transferred from one person to another.

Another way is via airborne droplets that are produced when you cough, sneeze or talk. These droplets may contain pathogenic bacteria or viruses and may land on objects or people around you, which may result in disease.

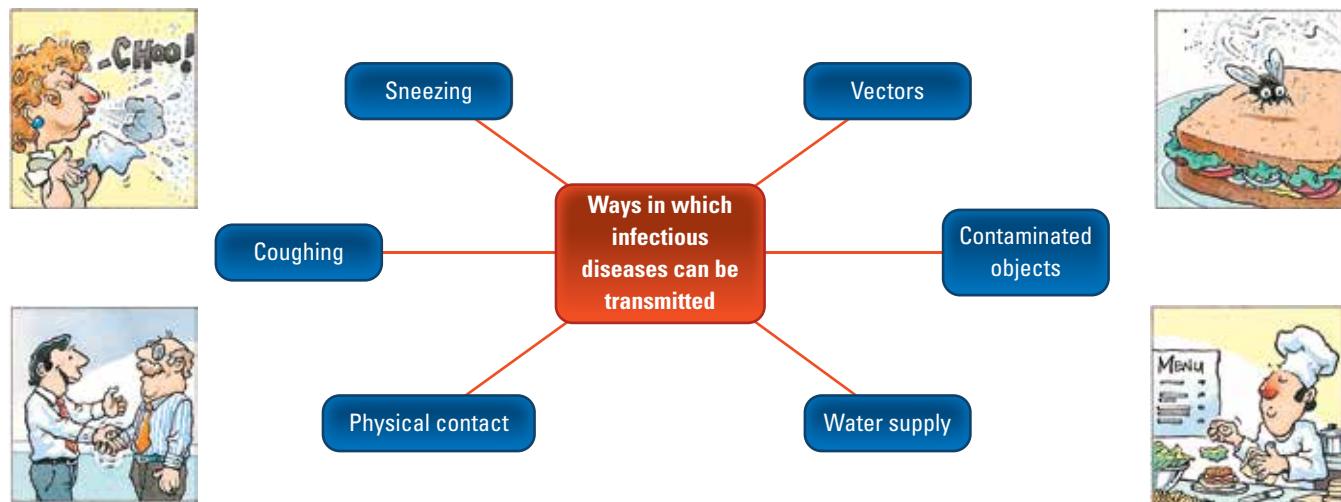
Vectors

Some diseases are spread by vectors. **Vectors** are organisms that carry the disease-causing pathogen between organisms — without being affected by the disease themselves. Mosquitoes, houseflies, rats and mice are examples of organisms that can act as vectors to spread disease.

Contaminated objects

While fungal diseases such as tinea and ringworm can be spread by direct physical contact, they may also be transmitted by towels or surfaces that have been contaminated with skin cells of an infected person.

Food poisoning is often caused by contamination of food (or food utensils) with particular types of pathogenic bacteria. This is why washing your hands is so important after going to the toilet and before touching food or being involved in food preparation.



Contaminated water

Many pathogenic organisms live in water and are carried about in it. Our domestic water supplies are usually chemically treated to kill disease-causing micro-organisms within it. This may not be the case, however, with water drunk directly from water tanks, rivers or creeks. This water may need to be boiled before it is drunk.

During the summer months, the Environment Protection Authority (EPA) measures the levels of *Escherichia coli* (*E. coli*) bacteria in water in coastal beaches. The level of *E. coli* in the water is used as an

indicator of levels of potentially pathogenic bacteria, as it is found in faeces.

Fighting the spread

There are a number of ways in which the spread of disease may be controlled. These include personal hygiene, care with food preparation, proper disposal of sewage and garbage, chemical control of vectors, chemical treatment of clothes, surfaces and water, pasteurisation of milk, public education programs, quarantine laws and the use of drugs such as antibiotics.

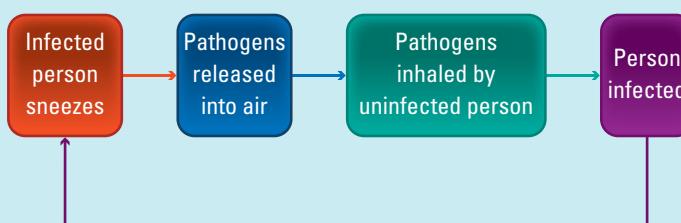
UNDERSTANDING AND INQUIRING

REMEMBER

- 1 Define the following terms: disease, non-infectious disease, infectious disease, pathogen, contagious, vector.
- 2 List three types of (a) non-infectious diseases and (b) infectious diseases.
- 3 Classify the following diseases as either non-infectious or infectious: ringworm, colon cancer, thrush, arthritis, cholera, diabetes, osteoporosis, malaria, measles, depression, anaemia, AIDS.
- 4 Distinguish between:
 - (a) goitre and arthritis
 - (b) haemophilia and anaemia
 - (c) AIDS and malaria
 - (d) tinea and chickenpox.

THINK AND CREATE

- 5 Below is one flowchart that describes how disease can be spread by sneezing. Construct similar flow diagrams or cycles to show three different ways in which diseases can be spread.
- 6 Create a poster or wall chart that can be used to serve one of the following purposes:



- (a) to detail the ways in which salmonella food poisoning could be avoided
- (b) for an advertising campaign designed to promote personal hygiene at home
- (c) to provide information about Louis Pasteur and the development of pasteurisation.

THINK AND INVESTIGATE

- 7 Suggest why nutritional diseases are not classified as infectious diseases.
- 8 Until the middle of the twentieth century, infectious diseases killed many more people than non-infectious diseases. However, since about 1930, in the developed countries of Australia, North America and Europe, more people have died from non-infectious diseases. Account for this change.
- 9 The biggest killer of Australians in 1992 was heart disease. How might conditions of this kind, including heart attacks, be related to nutrition?
- 10 Find examples of at least six different types of diseases. Construct a matrix table with the headings shown below, and use a variety of resources to fill in answers for each disease.
 - 11 How is a chemical or metabolic disease different from an environmental disease?
 - 12 Can ageing be called a disease? What do you think? Explain your response.
 - 13 Choose an antiseptic and a disinfectant found at school or at home and read the directions for use. Explain why they have different directions.
 - 14 Two West Australian doctors, Barry Marshall and Robin Warren, isolated a *Helicobacter pylori* spiral bacillus from gastric biopsies and

| Disease | Symptoms | Pathogen involved | Duration (how long it lasts) | Transmission (how it is spread) | Prevention or treatment | Interesting findings |
|---------|----------|-------------------|------------------------------|---------------------------------|-------------------------|----------------------|
| | | | | | | |

linked its presence to gastric ulcers. Find out more about this discovery and how it changed theories about ulcers and their treatment.

- 15 (a) Research and report on one of the following scientific careers: molecular parasitologist, microbiologist, virologist, bacteriologist, forensic microbiologist.
(b) Use your new knowledge of this field of science to identify two problems that could be investigated.
- 16 Find out about quarantine laws in Australian states and other countries.
- 17 (a) Why did the levels of *Giardia* and *Cryptosporidium* become dangerous in Sydney water in 1998?
(b) Find out how such pathogens are normally controlled.
(c) What measures were taken by authorities to ensure the water was once again safe to drink?
- 18 In a team, find out more about bioterrorism and biological warfare. Each member is to select and research a disease that might be used as a biological weapon. Report to your team and discuss your findings. As a team, construct a visual fact sheet or web page to share your information with the rest of the class.

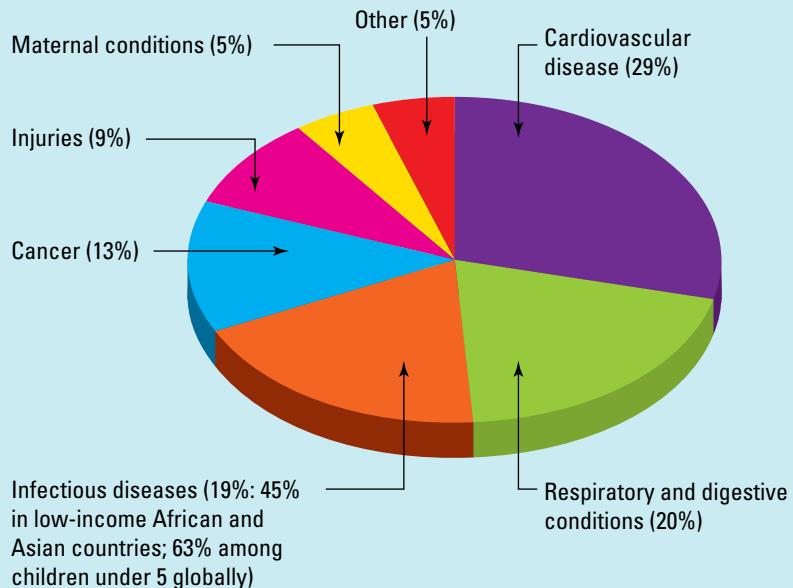
INVESTIGATE AND CREATE

- 19 (a) In a team, find out the cause, symptoms and methods of prevention of one of the following diseases: osteoporosis, schizophrenia, haemophilia, anaemia, arthritis, heart disease, lung cancer, skin cancer.
(b) Report your findings back to your team or class in a PowerPoint presentation, visual thinking tool or poster.
(c) In your team, discuss with others any ways in which the community or government may be involved in reducing the impact or frequency of these diseases.

- 20 Select a disease and research the structure and key features of its pathogen. Create a brochure for your pathogen with information about its life cycle and on the disease that it causes.

ANALYSING DATA

- 21 Study the pie chart below. It shows the main causes of death worldwide in 2002.
 - (a) What percentage of people died from infectious diseases:
 - (i) worldwide
 - (ii) in low-income African and Asian countries?
 - (b) Why do you think there is such a large difference in the percentage of people who died from infectious disease between wealthier countries and poor countries?
 - (c) What percentage of children who died before the age of 5 died of infectious diseases? Why is this figure so high? (*Hint:* Think about the other main causes of death and who they are likely to affect.)
 - (d) Draw a column graph to represent the data shown in the pie chart.
 - (e) If the same data was collected for 2014 and a similar graph drawn, how do you think the two graphs would differ? Give a reason for your answer.



Main causes of death worldwide in 2002



eLesson



Killing Australians

Learn about the leading causes of death in Australia.

eles-0069



4.1 Infectious diseases

4.2 Non-infectious diseases

Invasion! Alien alert!

Feeling hungry? Need shelter? We do not live alone! We need others to survive. Sometimes others need to use us to be able to survive. Sometimes it isn't just about food and shelter — sometimes they even need our help to reproduce.

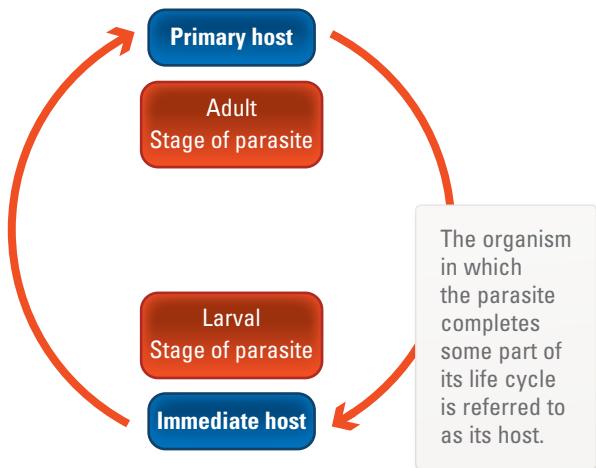
Parasites

Some relationships between organisms may provide one with resources, but not necessarily cause harm to the other. An example of this relationship is that involving a **parasite** and its host.

The organism that a parasite lives in or on is referred to as its **host**. The life cycle of parasites can involve one or more hosts. The **primary host** is the organism used for the adult stage and the **intermediate host** (or **secondary host**) is used for the larval stage.

Parasites can be classified on the basis of the part of your body in which they live. Parasites that live inside your body are called **endoparasites** and those that live outside your body are called **ectoparasites**.

Some parasites can harm their hosts and cause disease; these parasites are also considered to be pathogens. Not all parasites, however, cause harm to their host. It's probably a very good idea if they don't, because they rely on their host for resources.



Pathogens

Infectious diseases are caused by pathogens. Pathogens may be cellular (made up of cells) or non-cellular. Disease-causing bacteria, protists, fungi and animals are examples of cellular pathogens. Viruses, prions and viroids are examples of non-cellular pathogens. Pathogens cause harm to their hosts (the organism that they infect).

Prions

Prions are non-cellular pathogens. The word *prion* is derived from the terms *protein* and *infection*. They are abnormal and infectious proteins that can convert your normal protein into prion protein. When cells containing prions burst, more of these infectious proteins are released to infect other cells. The bursting of these cells can also result in damage to the tissues of which they are a part.

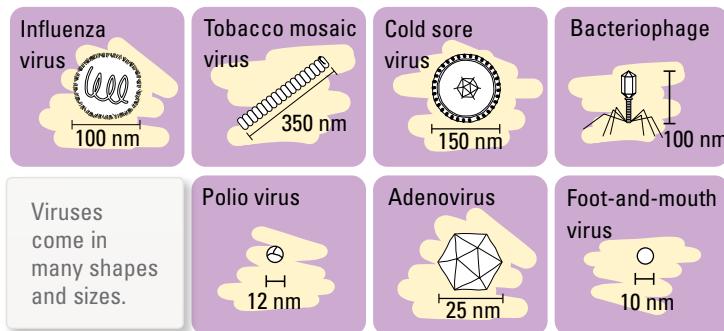
Prions are thought to be responsible for degenerative neurological diseases. These diseases are also called **transmissible spongiform encephalopathies (TSE)**. The term *spongiform* is included because of the tiny holes that result from the bursting of infected cells, giving the brain a spongy appearance. Examples of these diseases include Kuru, Creutzfeldt-Jakob disease (CJD) and bovine spongiform encephalopathy (BSE).

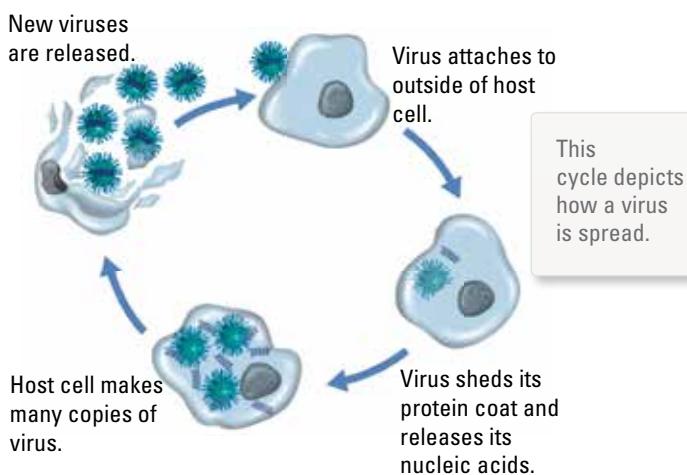
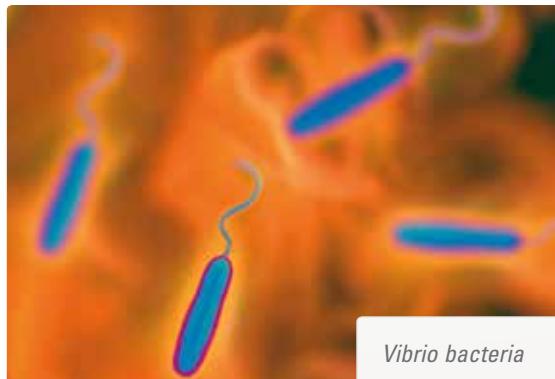
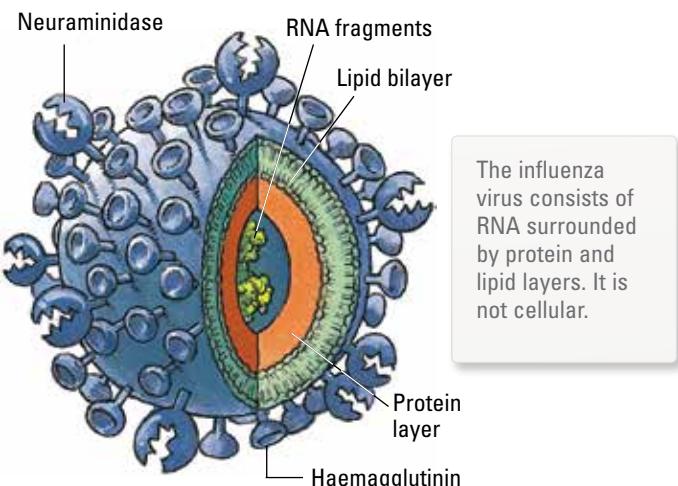
BSE is commonly known as 'mad cow disease' because of the nervous or aggressive behaviour observed in infected cows. Hundreds of thousands of cattle were destroyed when it was discovered that humans could become infected with this disease by eating meat from infected cows.

Viruses

Viruses are another example of non-cellular pathogens. They consist of DNA or RNA enclosed within one or more protein coats. Viruses are so small that they can only be seen with very powerful electron microscopes.

Scientists debate whether viruses should be called living things as they are **obligate intracellular parasites**. This means that they need to infect a host cell before they can reproduce — they cannot do it on their own. As viruses cause damage to their host cell in the process, they are also classified as being pathogens. Examples of infectious diseases caused by viruses include warts, rubella, mumps, poliomyelitis, influenza, AIDS and the common cold.





eBook plus

eLesson



Mystery of the flesh eaters

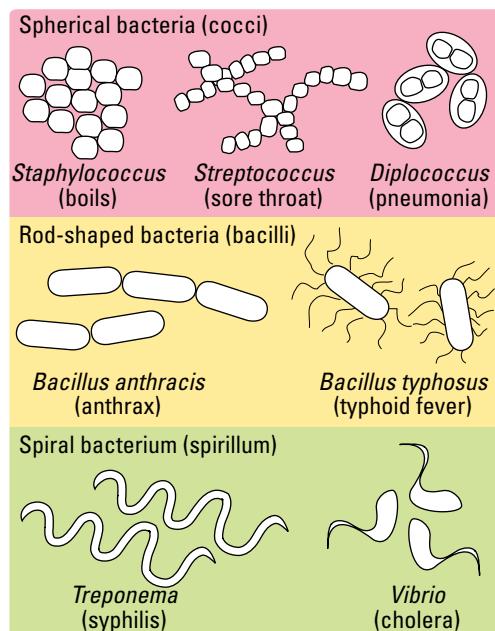
Watch an ABC Catalyst video about flesh-eating bacteria.

eles-1082

Bacteria

Disease-causing bacteria are cellular pathogens that consist of a single cell. They can be classified on the basis of their cell shape, the organisation of colonies of bacteria and the presence or absence of structures (such as a flagellum) or particular chemicals in their cell wall.

A spherical bacterium is referred to as **coccus** (for example, *Staphylococcus*), a rod-shaped bacterium as **bacillus** (for example, *Bacillus*) and a spiral-shaped bacterium as **spirochaete**. Their colonies can be described as being single, in pairs, in chains or clustered together.

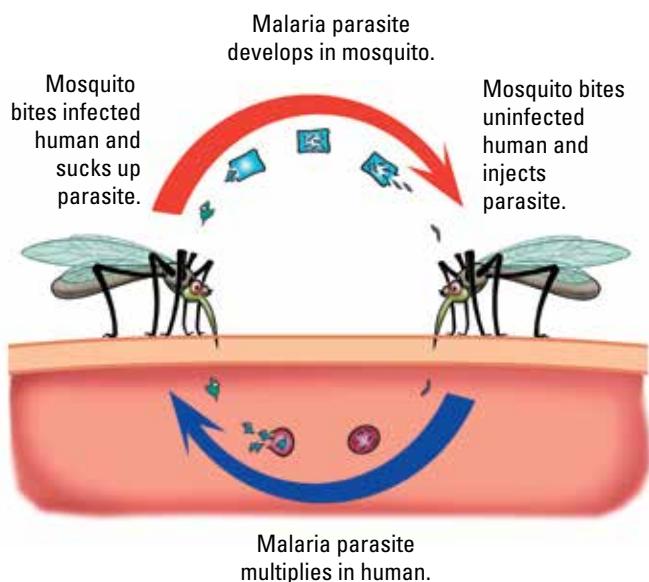


Some types of disease-causing bacteria

Examples of diseases caused by bacteria include strep (short for *Streptococcus*) throat, tetanus, pneumonia, food poisoning, gastroenteritis, cholera, gonorrhoea, leprosy, tetanus, scarlet fever, whooping cough, meningitis, typhoid and even pimples!

Protozoans

A number of infectious diseases are caused by parasitic protozoans. These single-celled organisms are usually found within their host's body. It is a good idea to know more about these diseases if you intend to go to tropical regions, where such diseases are more common. Examples of diseases caused by protozoans include malaria, amoebic dysentery and African sleeping sickness.



Fungi

Fungi belong to one of the biggest groups of organisms. They include some that are large, such as toadstools, and others that are microscopic, such as the **moulds** that grow on bread. Many fungi are parasites, feeding on living plants and animals, including humans. This often results in disease.

Common human diseases caused by fungi are tinea or athlete's foot,



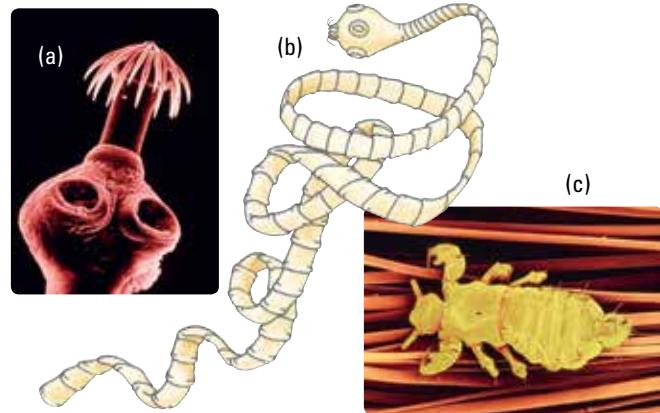
thrush and ringworm. Some fungi live in the mouth, the vagina and the digestive system at all times without causing harm. However, if resistance to disease is low, the fungi in these places can become active and cause problems such as thrush.

Worms and arthropods

Larger parasites include endoparasites such as tapeworms, roundworms and liver flukes, and ectoparasites such as ticks, fleas and lice.

Tapeworms are the largest of the parasites that feed on the human body and can be up to 10 metres long! They have hooks and suckers to keep a firm hold on your intestine. Tapeworms don't have to worry about finding a mate. When they are reproductively mature, their end segment, which is full of eggs, passes out with their host's faeces and on to its next host.

Did you get an itchy bottom at night when you were little? You probably had a roundworm infection such as threadworm or pinworm. Although these worms usually live in the large intestine, when ready to lay her eggs the female worm moves down to lay them on the moist, warm skin of your anus. The sticky material they are covered with irritates your skin so that you scratch it, picking up some eggs in your nails as you do. Better remember to wash your hands before you eat!



(a) The head of a tapeworm, magnified to 15 times its real size, showing its hooks and suckers (b) A pork tapeworm has a flat, ribbonlike body. It can infect humans. (c) A view through a microscope of a head louse crawling on human hair

Some common parasite pathogens

| Parasite | Condition caused | Source of infection |
|-------------------|-------------------|---|
| Amoeba | Amoebic dysentery | Contaminated food and drink |
| Malarial parasite | Malaria | Bite from infested mosquito |
| Tapeworm | Tapeworm | Raw or poorly cooked meats |
| Blood fluke | Schistosomiasis | Contaminated water |
| Tick | Skin infestation | Tick-infested areas |
| Louse | Pediculosis | Contact with human carrier, bedding, clothing |
| Flea | Skin irritation | Animal and human carriers |

INVESTIGATION 4.1

Microbes

AIM To investigate the types of microbes in the air of the laboratory

Materials:

prepared agar plate sticky tape
marking pen

BACKGROUND

Agar is a jelly-like material made from seaweed. It provides a source of nutrients for microbes.

CAUTION Do not open the tape seals after incubation.

METHOD AND RESULTS

- ▶ Take the lid off the agar plate to expose the agar to the air in your laboratory for about five minutes.
- ▶ Seal the lid on the agar plate carefully, using the sticky tape.
- ▶ Give the plate to your teacher to incubate at about 35 °C for 2 days.

- 1 Check the agar plate after it has been incubated, and draw what you see on it.
- ▶ Give the unopened plates back to your teacher for proper disposal.

CAUTION Do not open the tape seals.

DISCUSS AND EXPLAIN

- 2 Describe the general appearance, colour, size and shape of the groups or colonies on the agar plate.
- 3 What can you conclude about the air in your science laboratory?
- 4 Do you think that the air in other parts of your school would be different? Explain.
- 5 Discuss the risks that could be associated with the experiment and ways to reduce these risks.
- 6 Formulate your own question or hypothesis about microbial growth, and design an experiment that could be used to investigate it. Include an explanation of your choice of variables and required specific safety precautions.

UNDERSTANDING AND INQUIRING

REMEMBER

- 1 Outline the differences between:
 - (a) pathogens, antigens and hosts
 - (b) prions, viruses and bacteria
 - (c) allergens and allergies.
- 2 Construct a cycle map to show how prions replicate.
- 3 Why do many biologists consider viruses to be non-living?
- 4 Describe two ways in which bacteria can
 - (a) cause disease
 - (b) be useful.
- 5 Outline the difference between a parasite, an endoparasite and an ectoparasite.
- 6 Suggest why it is a good idea to read up on protozoans before you travel to tropical climates.
- 7 Describe how mosquitoes are related to malaria.

THINK AND CREATE

- 8 Why is the cell invaded by a virus called a host cell?
- 9 Compare the ways in which viruses and bacteria reproduce. Use a visual thinking tool to share your thinking.
- 10 The skin under your armpits contains over two million bacteria per square centimetre. Why don't they cause disease more often?
- 11 Construct a model or play to simulate how viruses infect and replicate.

INVESTIGATE

- 12 Explain how dental caries or tooth decay forms. Why is this related to a study of diseases?
- 13 After taking medicine or being ill, people are often advised to eat yoghurt. Find out what the benefits of this food might be. How is yoghurt made?

INVESTIGATE, REPORT AND CREATE

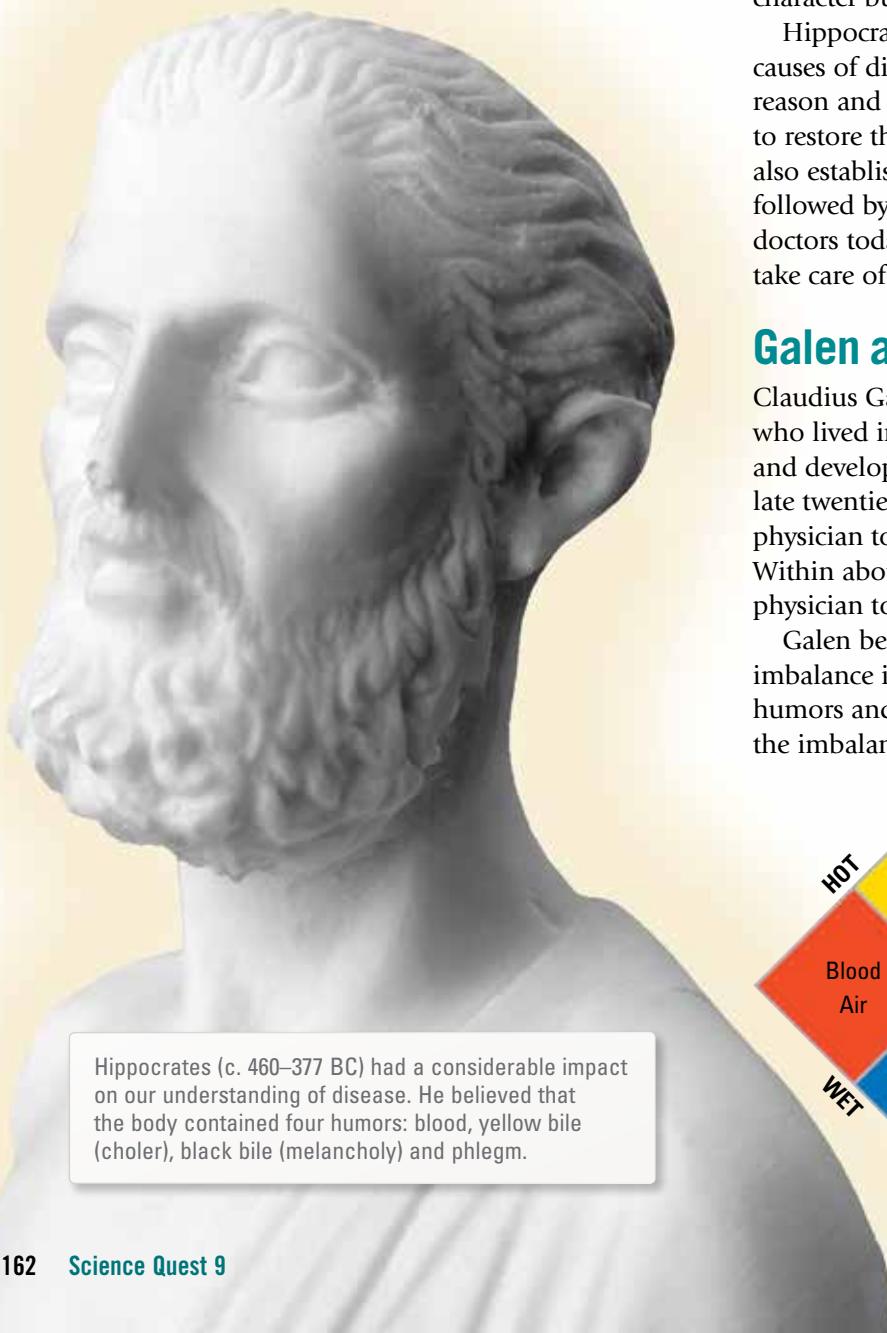
- 14 When neurologist Stanley Prusiner suggested that a rogue protein was the cause of spongiform diseases such as Creutzfeldt-Jakob disease, it was considered so outrageous that he was ridiculed. Find out more about this scientist and his work and why his theory was eventually accepted.
- 15 Research the structure and life cycle of a pathogen. Create models or animations to show activities key to its survival.
- 16 Investigate the link between Kuru and cannibalism.
- 17 Research and report on one of these scientists specialising in research into disease.
 - Dr Carleton Gajdusek — transmissible degenerative disease of the brain
 - Professor Stanley Prusiner — discovery of prions as a new biological principle of infection
 - Associate Professor Robin Gasser — parasitic infections
 - Professor Colin Masters — Alzheimer's disease and neurodegenerative disorders

Medieval medicine

Before the invention of the microscope the causes of many infectious diseases were not only invisible, but also beyond our imagination. Without awareness of cells, other theories were developed to explain what we saw and what could not be seen.

Hippocrates and body humors

Around 430 BC, the Plague of Athens killed one-third of the population of Athens. About thirty years later, a person who would have a considerable effect on our understanding of disease was born. His name was Hippocrates.



Hippocrates (c. 460–377 BC) had a considerable impact on our understanding of disease. He believed that the body contained four humors: blood, yellow bile (choler), black bile (melancholy) and phlegm.

eBookplus eLesson

Leonardo's sketches and anatomy

Watch a video from *The story of science* about anatomy.

eles-1769

Hippocrates (c. 460–377 BC) was a Greek doctor who believed that everything was created from four elements: water, earth, air and fire. He also believed that linked to these elements were four humors within the human body. These were blood, yellow bile (choler), black bile (melancholy) and phlegm. He thought that these humors not only shaped a person's character but also, if unbalanced, could cause disease.

Hippocrates and his disciples looked for natural causes of disease. They based their medical practice on reason and experiment and used diet and medication to restore the body's balance of humors. Hippocrates also established the rules and principles that were followed by medieval doctors and are still followed by doctors today. The **Hippocratic Oath** requires doctors to take care of the ill and not do them harm.

Galen and anatomy

Claudius Galen (c. AD 129–199), a Greek physician who lived in Rome, was influenced by Hippocrates and developed his theories further. When he was in his late twenties (about 157 AD), Galen was appointed physician to gladiators in his home town of Pergamum. Within about ten years he became the personal physician to Emperor Marcus Aurelius in Rome.

Galen believed that all diseases were caused by an imbalance in the elements or their associated body humors and that all cures must be based on correcting the imbalance. He also believed in the importance of



It was thought that body humors not only shaped a person's character but, if they were unbalanced, could cause disease.



Claudius Galen (c. AD 129–199) was influenced by Hippocrates. His published books were used to train doctors for over a thousand years.

anatomical knowledge. Galen wrote hundreds of books about human anatomy, surgery and herbal medicines — books that were to be used by doctors for the next thousand years.

The Middle Ages — times of change

Beginning with the collapse of the Roman Empire, the Middle Ages (AD 500–1500) were a time in which Europe changed dramatically. This was a time of growing populations, developing technology, increased trade and new ideas. It was also a time of hardship, deadly disease and wars in which only about 50 per cent of children reached the age of 15; of those surviving, many died in their twenties and thirties.

Causes of disease

Medieval doctors were influenced by the ideas of Hippocrates and also linked each of the four body humors to the stars and planets. Medieval villagers, however, relied on their own practical knowledge and traditional superstitions to explain causes of diseases, and used natural substances to create potions. There were also those who believed that evil spirits, curses or mysterious magical powers may be the cause of disease.

As the Christian Church grew more powerful, old superstitions were banned and traditional healers were controlled. Church leaders spread their own view of the cause of illness — God's punishment for sins. The church also offered several different methods of spiritual healing, including prayers, charms, relics and pilgrimages.

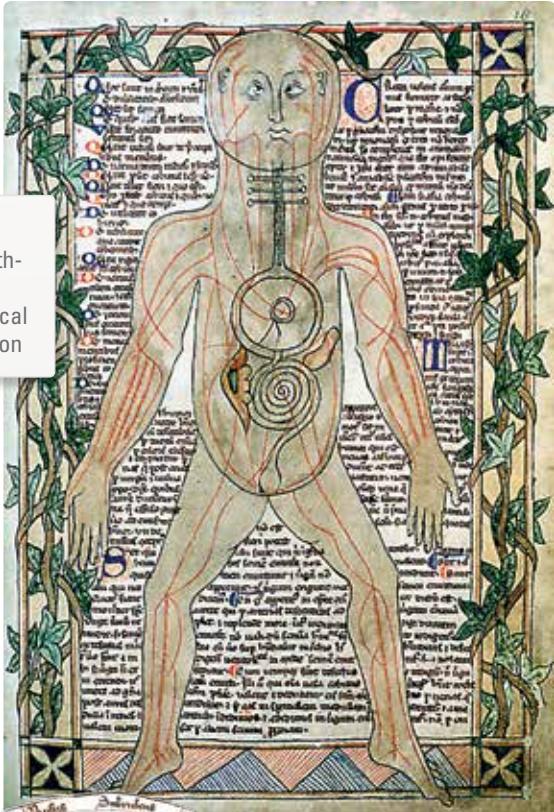


In medieval times, astronomy was linked to body humors and treatment of disease.

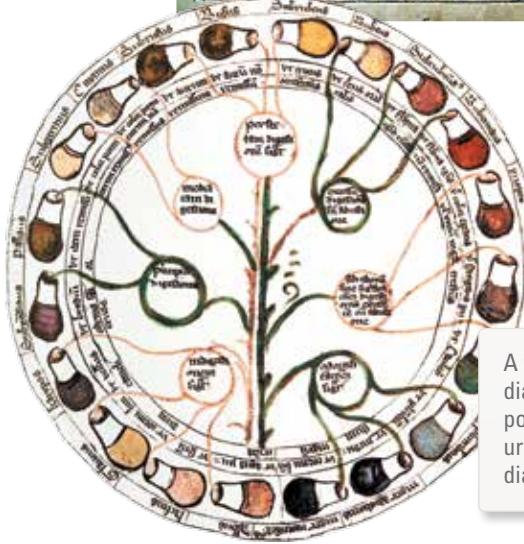
Leprosy was a common disease in medieval Europe. This disease destroys skin, muscle and bones and was thought to be punishment from God. Not only were lepers treated with fear and loathing, but they were also not allowed to marry, had to carry a warning bell and were often driven out of villages.

Medieval medicines

Medieval physicians advised their patients how to live healthy lifestyles, and used their training in mathematics and astronomy to map out healthy and sickly times. They also worked closely with apothecaries, who sold medicinal plants. Sometimes these plants and their knowledge of the four humors, astronomy, chemical sciences and religion were used to create medicines.



A thirteenth- century anatomical illustration



A fifteenth-century diagram showing possible colours of urine to help doctors diagnose diseases

Medieval women made many of their families' medicines. They used seeds, stems and leaves of herbs, trees and flowers. Some medicines even used animals or animal products.

Testing the waters

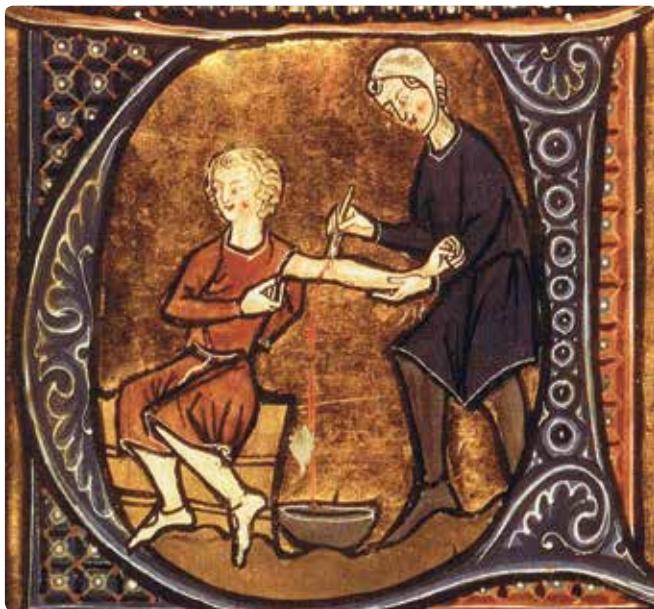
Many medieval physicians considered that testing 'the waters' (urine) was an effective method in the diagnosis of disease. Scribes would note the colour, cloudiness or sediment of the urine and charts were used to match these features to particular diseases. Sometimes blood samples were collected, which may have been tasted to detect a diagnostic sweetness or bitterness.

Balancing humors to treat disease

Medieval barbers not only cut and shaved men's faces but also performed minor surgery, such as removing rotten teeth and bloodletting. The red and white striped pole often associated with barbers was a symbol that they let (released) blood, with the white stripes representing the bandages over the cuts.

Not only barbers were involved in bloodletting — this widespread medieval treatment was also performed by doctors and surgeons and was meant to improve the balance of humors within the body. Medical texts of the time showed which veins to cut to release each humor and cure different illnesses. Leeches were also applied to the skin to suck out poisons or bad blood from wounds.

Surgeons also used cupping and cauterising to treat disease. Cupping involved placing hot metal glasses or



Bloodletting (top) and leeches (bottom) were used to treat disease during medieval times.

cups on a patient's cut skin, in the belief that poisons would be released from the body into the cup. To cauterise wounds or help heal internal disorders, surgeons would burn the tissues with red-hot irons or boiling oil.

Making sense of disease

Our knowledge and understanding of our world is shaped by what we can sense about it. While some of the ideas of those living in early Greece and medieval

times may seem silly or strange to us, they made sense of their world with the tools that were available to them at the time.

The development of new technologies that have enhanced our senses have changed the way in which we see the world. These technologies, that were unavailable to early Greek and medieval humans, provide us with an awareness of our world and the opportunity to explore it that was unavailable to them. Although we shape technology to meet our needs, we are also shaped by it.

UNDERSTANDING AND INQUIRING

REMEMBER

- 1 Who was Hippocrates, and why is he important to our understanding of disease?
- 2 List the four humors of which the body was thought to be made up.
- 3 State Galen's belief about the cause of disease.
- 4 Suggest how Galen was able to influence doctors, hundreds of years after his death.
- 5 What did medieval people think caused disease?
- 6 What were many medieval medicines made up of?
- 7 Describe how medieval doctors used body humors to:
 - (a) diagnose disease
 - (b) treat disease.

INVESTIGATE, THINK AND DISCUSS

- 8 Prior to Hippocrates' theories of disease, what was the belief that early Greeks had about disease? Suggest reasons for these beliefs.
- 9 Suggest why Galen's books were used for a thousand years to train doctors, rather than new books being written and used.
- 10 If you had lived during the Middle Ages, what connections do you think you would have made about the cause and effects of disease? Why?
- 11 Using body chemistry as a key to unlocking health and disease is an idea that has been around for a very long time. Use information on these pages and other resources to investigate this idea. Do you agree with it? Provide reasons for your response.
- 12 Find out more about the life and scientific contributions of either Hippocrates or Galen. Present your findings in a 'This is your life' multimedia, brochure or poster format.
- 13 Research the Hippocratic Oath. What is it? Do all doctors take it? Discuss any issues that are related to it.
- 14 Suggest how scientific theories can be influenced by the period in which you live.

- 15 Many medieval remedies treated the symptoms of the disease rather than the cause. Find examples of at least four different medieval remedies for disease, state their claims of healing and evaluate their effectiveness based on our current medical knowledge. Display your findings as an advertisement or pamphlet, or in a multimedia format.
- 16 Paracelsus (c. 1493–1541) was the pioneer of alchemy in medicine; he challenged some of the Greek and Roman medical ideas and suggested specific remedies for specific diseases. Find out more about his life, theories and contributions.
- 17 Although Galen's texts were used for over a thousand years, some of his ideas were incorrect. Some of this inaccuracy was due to the fact that the ideas were based on his observations of animals rather than humans.
 - (a) Find examples of Galen's inaccuracies.
 - (b) Over a thousand years later another physician, Vesalius (1514–1564), questioned all previous medical theories, dissected human bodies (against the laws of the Church), recorded his detailed observations and published his work — over time, his corrections to some of Galen's theories were accepted. Find out what these corrections were and why Vesalius is so well respected even now.
- 18 Phlebotomy (bloodletting) is still used in the treatment of some diseases. Some of the diseases that are treated in this way include haemochromatosis, polycythemia vera and porphyria cutanea tarda. Find out more about these diseases and why phlebotomy is used to treat them.
- 19 Phlebotomy is also used in blood transfusions and diagnosis of disease. Find out more about what a working day would be like as a phlebotomist.
- 20 While much of our recorded history of science relates to that of Europe, scientific discoveries were being made in other parts of the world. An example is that of the ancient Arabic scientists. The Arabic Golden Age spanned from AD 750–1258. Some of their discoveries later spread through Europe. Select, investigate and report on one of the following ancient Arabic scientists: Ibn Al-Nafis, Ibn-Sina, Al-Zahrawi or Al-Razi.

Zooming in — micro tales

Zooming in ... The invention of the microscope opened a whole new world to explore and led to changes in how we saw and thought about not only the world, but also ourselves!



Hooke's *Micrographia* (1665) and van Leeuwenhoek's *Arcana naturae* (1695)



Robert Hooke observed a sliver of cork under his microscope and noted cells.

Hooke and cells

The microscope was invented in 1609, opening up a whole new world of discovery. Scientists began to develop new ideas rather than relying on those in Greek and Roman texts. In 1665, a bubonic plague epidemic in London killed 75 000 people. It was also during this year that an English physicist, Robert Hooke (1635–1703) observed a sliver of cork under the light microscope and noted a pattern of tiny regular holes that he called **cells**. Later that year, Hooke published his book of microscopic drawings called *Micrographica*. His recorded observations led to many discoveries in related fields.

Leeuwenhoek and cells

In 1674, Anton van Leeuwenhoek (1632–1723) observed 'animacules' in lake water through a ground glass lens. Although this marked the beginning of the formal study of microbiology, little progress was made for over a century. A possible reason for this was because few could equal his skill in grinding lenses to the accuracy required for simple microscopes. It was not until the mid-19th century that technological advances in optics led to the production of compound microscopes that did not produce distorted images.



Anton van Leeuwenhoek

Jenner and vaccination

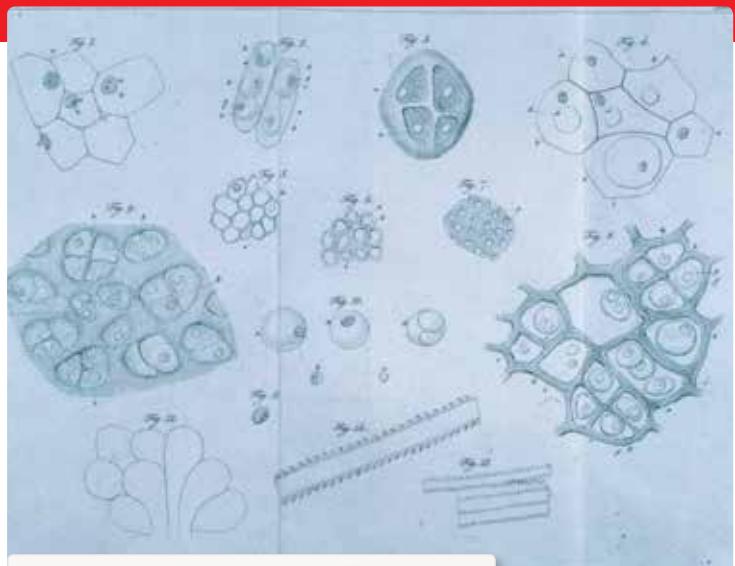
In 1718, Lady Mary Wortley Montagu (1689–1762) introduced **variolation** to England from Turkey to help fight against smallpox. Almost sixty years later in 1774, King Louis XV of France, like many others, died from smallpox. In 1762 Austrian physician Marcus Anton von Plenciz (1705–1786) suggested that infectious diseases were caused by living organisms and that there was a specific organism for each disease. In 1796 Edward Jenner (1749–1823), influenced by the idea of variolation, used cowpox virus to develop a smallpox vaccine. By 1853, Jenner's **vaccination** against smallpox was made compulsory in England. The development and use of many more vaccines was to follow.



Edward Jenner developed the smallpox vaccine, saving many from scarring and death.

Schleiden and Schwann — cell theory

In 1838, Matthias Schleiden suggested that plants were made up of cells and Theodor Schwann recognised that animals were also composed of cells. This led to the establishment of the cell theory — that all living things are made up of cells.



Sketches of cells made by Theodor Schwann



Theodor Schwann and Matthias Schleiden

Pasteur and Koch — germ theory

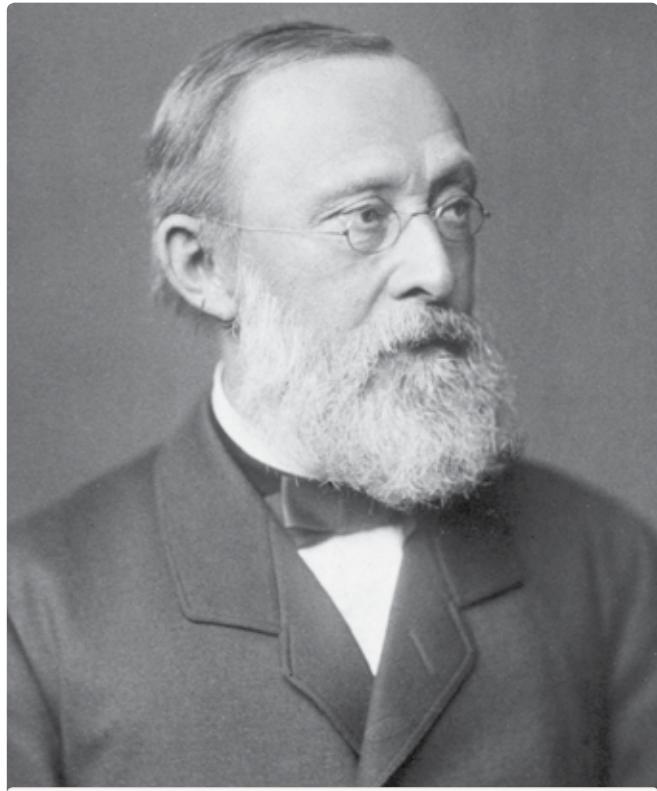
Between 1857 and 1880, Louis Pasteur (1822–1895) performed a series of experiments that disproved the doctrine of spontaneous generation — the notion that life could arise out of non-living matter. Until Pasteur's work, it was thought that microbes were produced only when substances went rotten. Pasteur showed that microbes were around all the time and could cause disease. He also introduced vaccines for fowl cholera, anthrax and rabies that were made from altered or weakened strains of viruses and bacteria.

In 1867, Joseph Lister published a study associating micro-organisms with infection. This led to the use of disinfectants during surgery, reducing post-operative infections and death. In this same year, Robert Koch (1843–1910) established the role of bacteria in anthrax and formulated postulates that could be used to confirm whether the cause of an infection was viral or bacterial. Eight years later, in 1875, his postulates were used for the first time to demonstrate that anthrax was caused by *Bacillus anthracis*. This validated the germ theory of disease.

Virchow — body humors out of favour

In 1858, Rudolf Ludwig Carl Virchow (1821–1902) argued that all cells arose from pre-existing cells and that the cell, rather than body humors, was the ultimate locus of all disease. His paper *Cellular Pathology* established the field of cellular pathology, linking cells and disease.

With the availability of microscopes providing more detailed observations, scientists continued to make many more discoveries. With these observations, new theories were generated. More pathogens were identified as being the cause of infectious diseases and vaccines for specific diseases were developed.



Rudolf Virchow argued that cells rather than body humors were the locus of all disease.

Knowledge of cells leads to discovery of our immune response

In 1884, Elie Metchnikoff (1845–1916) discovered **white blood cells** that showed antibacterial activity and called them **phagocytes**. He then formulated the theory of **phagocytosis** and developed the cellular theory

of vaccination. In 1891, Paul Ehrlich (1854–1915) proposed that **antibodies** were involved in **immunity**. In 1949, Australian Macfarlane Burnet began research that led to the **clonal selection theory** and, in 1961, Noel Warner established the physiological differences between **cellular** and **humoral immune responses**. In 1974, another Australian, Peter Doherty, together with Rolf Zinkernagel, discovered the basis of identifying self and non-self that is necessary for immunity. This was just the beginning of many new discoveries to be made regarding how we fight disease.

Knowledge — a powerful weapon against disease

The development of new technologies has enabled us to expand our senses and magnify the world around and within us. With these new observations came many new discoveries, prompting new ways of thinking and many new theories to identify the causes of disease and how the diseases could be prevented, treated or cured. Often the drive for these discoveries was the devastation and despair associated with the effects of disease within the society in which these scientists lived.

In 1909 Paul Ehrlich introduced the idea of 'magic bullets' — chemicals that could destroy bacteria without harming the host. In 1928 Alexander Fleming (1881–1955) discovered the **antibiotic** penicillin — opening the era of 'wonder drugs'. In 1941, Australian Howard Florey (1881–1955) effectively showed that penicillin killed *Streptococcus* bacteria and persuaded companies to manufacture the antibiotic, saving millions of lives.

New vaccines have been developed against many diseases, saving lives and reducing suffering. Understanding of our body systems and how we fight disease led to new discoveries and technologies. New technologies would often give rise to many other new technologies.

In 1959, Sydney Brenner and Robert Horne developed a method for studying viruses at the molecular level using the electron microscope. Such technologies enhanced our senses and enabled us to observe and be aware of our environment in a way we could never previously have imagined. What future discoveries will new technologies allow us to make? Will our descendants consider our current theories in the same way that we now consider those of Hippocrates, Galen and those who lived in medieval times?

UNDERSTANDING AND INQUIRING

REMEMBER

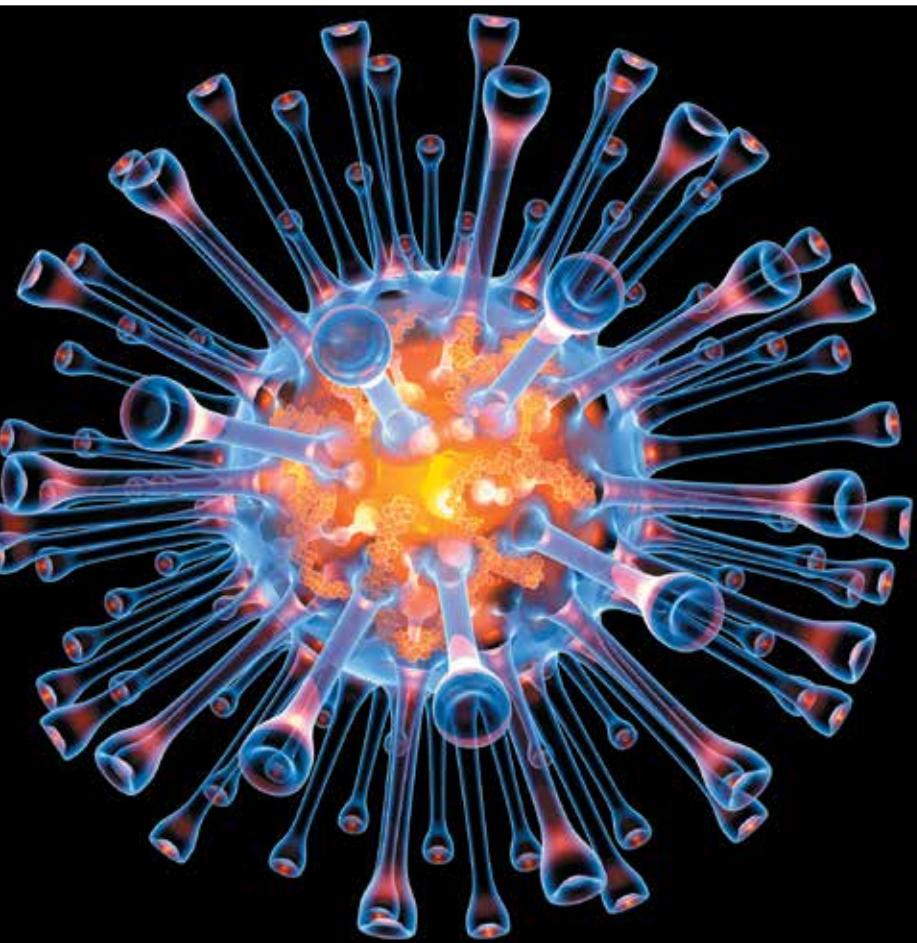
- 1 State a contribution made by each of the following scientists to our knowledge of disease.
- (a) Robert Hooke
 - (b) Anton van Leeuwenhoek
 - (c) Edward Jenner
 - (d) Matthias Schleiden and Theodor Schwann
 - (e) Louis Pasteur
 - (f) Joseph Lister
 - (g) Robert Koch
 - (h) Rudolf Virchow
 - (i) Elie Metchnikov
 - (j) Paul Ehrlich
 - (k) Frank Macfarlane Burnet
 - (l) Peter Doherty
 - (m) Alexander Fleming
 - (n) Howard Florey
 - (o) Sydney Brenner and Robert Horne

INVESTIGATE, THINK AND DISCUSS

- 2 Construct a timeline that shows:
- (a) how our knowledge of disease has changed over time. Include examples of theories or discoveries. Comment on any connections between these.
 - (b) the life dates of scientists mentioned in this section. Comment on any patterns, overlaps or possible influences between these scientists.
 - (c) connections between outbreaks of diseases and discoveries related to disease.
- 3 Select a scientist discussed in this section. Identify the year in which they were the same age as you currently are. Find out what their life may have been like at this time and key events that they may have been influenced by. Construct a paper or electronic diary that describes a week of their life at your age.
- 4 Find out more about the life and scientific contributions of one of the scientists mentioned in this section. Present your findings in a 'This is your life' multimedia, brochure or poster format.
- 5 Find out more about the contributions of one of the following physicians to our knowledge or understanding of disease.
- (a) Samuel Hahnemann
 - (b) Selman Abraham Waksman
 - (c) Hans Christian Gram
 - (d) Jonas Edward Salk
 - (e) Rodney Porter
- 6 Describe how scientific arguments can be used to make decisions regarding personal and community issues.
- 7 The table above right shows some examples of diseases and when the pathogen that caused it was identified. In some cases, the identification was made independently by different researchers around the same time. Select one of the diseases in the table and find out about and report on:
- (a) the pathogen
 - (b) the symptoms, effects, treatment and prevention of the disease
 - (c) the story behind the discovery of the disease and identification of its pathogen.
- | Date discovered | Disease | Pathogen | Discoverer |
|-----------------|------------|------------------------------------|--|
| 1879 | Gonorrhoea | <i>Neisseria gonorrhoeae</i> | Albert Nisser |
| 1881 | Pneumonia | <i>Streptococcus pneumoniae</i> | Louis Pasteur, George Sternberg |
| 1883 | Diphtheria | <i>Corynebacterium diphtheriae</i> | Edwin Theodore Klebs, Frederich Loeffler |
| 1883 | Cholera | <i>Vibrio cholerae</i> | Robert Koch |
- 8 Rational drug design has not only opened up opportunities to help us in our fight against disease, but also enabled scientists from different fields to collaboratively work together. Find out more about this new technology, the types of science involved and examples of its application.
- 9 Our new technologies have enabled us to observe and think at molecular levels. This has led to the development of nanotechnologies. Some of these technologies are being applied in the treatment of disease. Find out about how nanoparticles and nanotechnologies are being used to deliver drugs to cells.
- 10 Some disease research has involved using human subjects without their consent. Other research has put the subject at great risk. Find out about examples of either of these types of research and the consequences or related issues.
- 11 Find out more about the Nuremberg code and the reason for it being developed. Do you agree with these reasons? Justify your response.
- 12 (a) Find out about Australian research and our contribution to knowledge and understanding of disease. Include information on the research methods used.
- (b) Report your findings in part (a) as a newspaper article, podcast or video interview.
- (c) Identify a related problem that could be investigated.

Zooming in — nano news

Just when we thought we knew it all, the development of nanotechnologies has enabled us to see even smaller! With our new vision came another world to explore, another journey of discovery, excitement and questions ... and possible new ways to protect ourselves against disease.



On the flu virus's surface there are only two types of proteins: haemagglutinin and neuraminidase.

From tiny to tinier

When we talk about cells, we usually talk in terms of **micrometres** (a millionth of a metre, or $\frac{1}{1\ 000\ 000}$ m). When we talk about nanotechnology, we need to think in nanometres. A nanometre is one billionth of a metre, or $\frac{1}{1\ 000\ 000\ 000}$ m. To understand nanotechnology and nanoscience, you need to learn to think very, very small.

Tiny but powerful!

While nanotechnology is about the very small, its implications and potential application are enormous. The development of this technology has given us not only super-smart and super-strong materials and medicines, but also the possibility of creating other technologies that are currently not possible for mainstream production.

The race is on

We are in a time of biological revolution. Every day more secrets are unlocked, and with each discovery more questions are generated. One of the current questions for scientists to investigate involves the mysteries of viruses that are a current or potential threat to members of our species or species important to us.

Making models

Scientists often use models to help them visualise the features of their studies. They may even add colour to different parts to emphasise features or chemical composition. These models can be representations of the types and arrangements of atoms or molecules in a virus. Aside from helping scientists visualise their shapes, models also enable them to predict how viruses may interact with other molecules. This may provide clues as to what we can do or create to protect us from attack.

Nanobots

Some suggest that, in the future, nanomedicine may bring about the eradication of disease. This major accomplishment would require combining nanotechnology with biotechnology.

Nanotechnology may make possible the creation and use of materials and devices working at the level of molecules and atoms. Imagine minuscule machinery that could be injected to perform surgery on your cells from the inside. They could be programmed to seek

Neuraminidase, the N in H5N1, is the second main surface protein, and the other main target for the immune system. Neuraminidase helps the new viruses to bud off from cells. By inhibiting the action of neuraminidase, chemicals such as Tamiflu can reduce the severity and spread of these viral infections.

The **lipid envelope** is picked up from the infected cell as a new virus buds off.

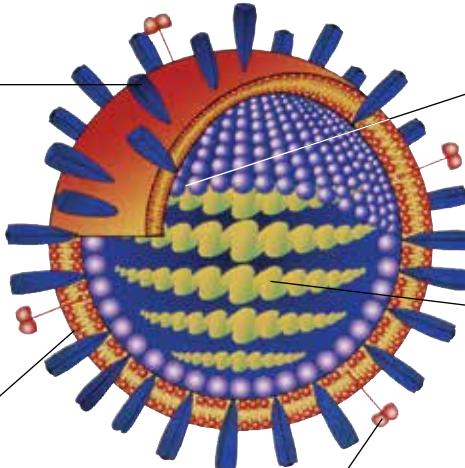
This figure of the avian flu H5N1 virus is an example of a model that scientists may use. Can you suggest the differences between this virus and the swine flu H1N1 virus?

out and destroy invaders such as bacteria, protozoans or viruses, or even cancerous cells. Heart attacks due to the blockage of your arteries may also be a thing of the past. These nanobots may be able to cruise through your bloodstream to clear plaque from your artery walls before it has a chance to build up. Could these nanobots also be programmed to stop us from growing old?

Golden nanoparticles kill brain parasite!

Toxoplasmosis gondii is a parasite that causes cysts in the brain of about a third of the people it infects. Michael Cortie, an Australian scientist, has developed a technique that involves the use of gold nanospheres (about 20 nm in diameter) that are coated with an

This electron micrograph shows a cyst from a human brain that has been infected with the parasite *Toxoplasmosis gondii*.



The **M1 matrix protein** helps put new viral RNAs together and transport them to the cell membrane, where a new virus is formed.

RNA carries the instructions for making new viruses. The RNA strands come packaged along with the enzymes needed to make more copies of the RNA.

Haemagglutinin, the H in H5N1, is one of the two main surface proteins and is a key target for our immune systems. It is responsible for binding the virus to the cell that is being infected. The H protein in H5N1 has a mutation that allows it to bind to both human and bird cells.

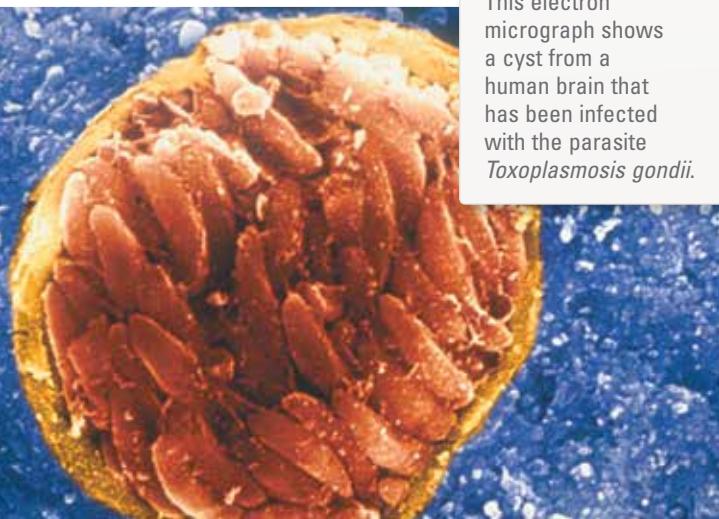
antibody that selectively attaches to the parasite. When a laser is applied, the nanospheres heat up and kill the parasite. This is groundbreaking research and may have further applications related to other parasites.

Delving deeper

Tiny human-made **nanoparticles** (about 0.1–100 nanometres) are small enough to pass through a cell membrane. They are currently being developed to deliver drugs directly to cancer cells. The basic structure of nanoparticles is called a **dendrimer**. Attached to these cancer-fighting dendrimers are methotrexate, folic acid and a fluorescent stain. Methotrexate is a drug that kills the cancer cells and the fluorescent stain allows monitoring of the process. Folic acid acts as the bait to attract the cancer cells. This vitamin is essential in cell reproduction and, as cancer cells are actively multiplying, they have a high need for it. When they accept the nanoparticle, the methotrexate poisons the cell, killing it. These dendrimers are then removed from the bloodstream as they pass through the kidneys.

Rational drug design

Viruses enter the cells of their host to use the cell's machinery to replicate themselves. This makes it difficult to develop drugs to kill them without killing their host's cells as well. Knowledge of the structure of the virus and how it replicates has provided scientists with information enabling them to design and develop drugs that can be used to reduce infection.



Some antiviral drugs inhibit DNA or protein synthesis and hence interfere with the replication of the virus within the cell. Interferon, for example, stops protein synthesis, and idoxuridine interferes with DNA synthesis. Some other antiviral drugs interfere with specific enzymes that are important to the virus.

Relenza is an example of an anti-influenza drug that was researched by Australian CSIRO scientists. Relenza binds to the binding site of neuraminidase, one of the proteins on the protein envelope of the influenza virus. This action prevents new viral particles from being able to leave the infected cell to infect other cells.

Using loaded bugs to target drugs?

Jennifer MacDiarmid and Himanshu Brahmbhatt at EnGeneIC in Sydney have been involved in the development of a new technique that uses fragments

of bacteria (such as *Salmonella enteric* and *E. coli*) called 'EnGeneIC Delivery Vehicles' (EDVs) to carry drugs to tumour cells. Once these little biorobots have unloaded their cargo, the tumour cells are destroyed.

No boundaries

While some see nanotechnology as the technological saviour of the twenty-first century, others are concerned it has a dark side and are watching warily. Nanotechnology operates at the scale of atoms and molecules. It is fundamentally different from current technologies in that it builds from the bottom up. The underlying principle of nanotechnology is both disturbing and mesmerising — if you can control and rearrange atoms, you can literally create anything! What are our boundaries and responsibilities, or don't we need or want any?

UNDERSTANDING AND INQUIRING

INVESTIGATE AND CREATE

- 1 (a) Research one of the current or possible future applications of nanotechnology.
 - Medicines, e.g. drug delivery
 - Artificial cells or body parts
 - Nanobots
 - Cosmetics(b) Construct a model that could be used to communicate information about the use of your nanotechnology application.
 - 2 There is increasing concern about the safety of nanotechnology. Some of these claims are frightening.
 - (a) Find out more about issues surrounding this exciting and powerful new field. Take special note of the types of language being used and the experts or authorities being quoted.
 - (b) Discuss your findings and then construct a PMI chart on nanotechnology.
 - (c) Create a campaign that would communicate your point of view on nanotechnology.
 - (d) Organise a class debate on the applications of nanotechnology.
 - 3 Find out the names and features of at least four different viruses that cause human diseases. In teams of four, write a story that involves these viruses and then create puppets or toys for each type of virus to act out the story.
- 4 Find out more about types of research outlined in this section. Share your findings with others.
- 5 Find out more about the research on H5N1 and how it may be applied in the future.
 - 6 The success of the flu virus is due to tricks that it has evolved to dodge or hijack the defence mechanisms of the cells it invades. Find examples of how it achieves this.
 - 7 (a) What is a pandemic?
(b) How is it different from an epidemic?
(c) Find out more about two pandemics in human history and write up your findings as a news report, diary entry, web page or PowerPoint presentation.
 - 8 (a) What is known about the structure of the human immunodeficiency virus (HIV) that causes AIDS?
(b) How may some of this information be used in the future?
 - 9 (a) Select a virus that is responsible for a human disease and find out what is known about its structure.
(b) Make a model of the virus. Use labels to provide details of the different parts, describing what they are and what they do.
 - 10 Virologists are involved in the study of viruses. Find out more about what these scientists do. Write a science fiction story that includes a virologist as the key character.
 - 11 Suggest dangers that are associated with the study of viruses. Do you think that research on viruses should be allowed? Give reasons for your opinion.
 - 12 What are the differences between viruses, viroids and prions? Give examples of a disease that can be caused by each.

INVESTIGATE, SHARE AND DISCUSS

- 4 Find out more about types of research outlined in this section. Share your findings with others.

Outbreak

Disease has shaped our human history. It could be argued that we are who we are because of and in spite of disease.

Local or global?

Throughout history there have been records of **plagues** — contagious diseases that have spread rapidly through a population and resulted in high death rates. There are also other terms used to describe the spread of disease. **Epidemics** occur when many people in a particular area have the disease in a relatively short time and **pandemics** are diseases that occur worldwide.

The Black Death — bubonic plague

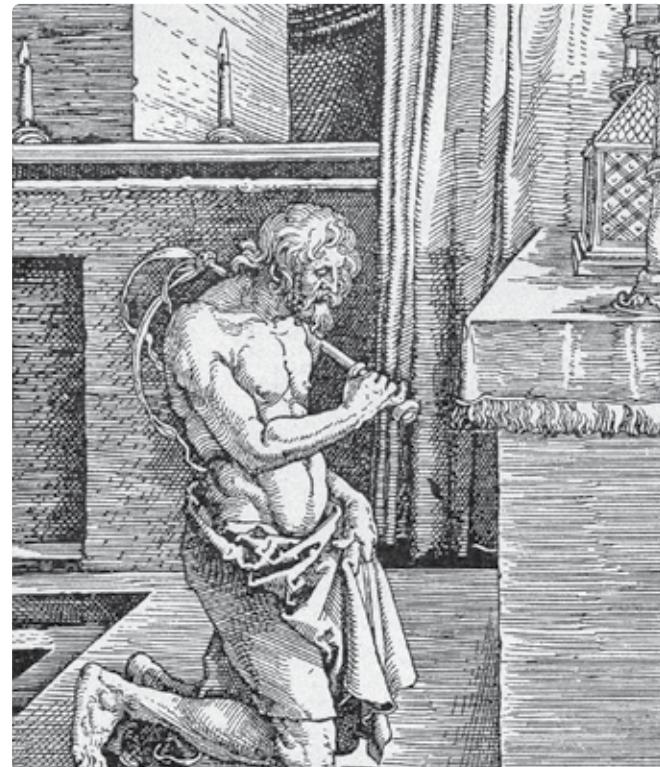
The Plague of Justinian in the sixth century was one of the first recorded pandemics. It is thought to have been the result of **bubonic plague**. Of all of the plagues throughout history, the bubonic plague (known as **Black Death** in Europe) has been the most widespread and feared. Its name is due to the presence of black sores on the skins of victims.

The cause of the disease is the bacteria *Yersinia pestis*. These bacteria were transmitted by fleas that had bitten an infected rat and then bitten a human, infecting the human with the disease.

First recorded in the north-eastern Chinese province of Hopei in 1334, it is thought that bubonic plague was responsible for the death of about 90 per cent of its population (about 2 million people). By 1348, bubonic plague had

reached Europe. Within five years, an outbreak of this disease had resulted in the death of almost one-third of Europe's population. After this time, plague visited England another six times before the end of the century.

Nearly all those infected died within three days of their first symptoms appearing. Lack of medical knowledge and great fear resulted in the development of a diverse range of methods being used to fight the condition. Some people tried special diets or were cut or bled in the hope that the disease would leave their bodies with their bodily fluids. Others (flagellants) whipped themselves to show their love of God, hoping to be forgiven their sins and spared the disease. Most importantly, bodily wastes and the bodies and clothes of those infected with the disease were burned in deep



Plague doctors wore protective clothing that included a long beak filled with antiseptic substances.

Some medieval people believed that self-flagellation would protect them against bubonic plague.

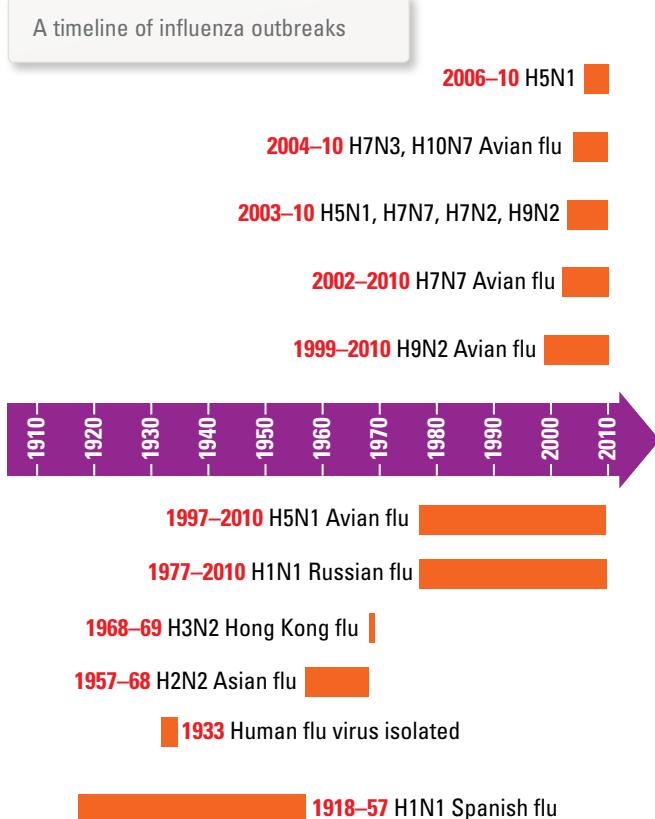
pits. In some areas, improved public sanitation resulted from these outbreaks.

The last recorded epidemic of the Black Death was around 1670. A victim of its own success, it had killed so many so quickly that those remaining had either immunity or genetic resistance. While it could still infect, its hosts were able to fight back and destroy it. Its demise paved the way for another disease, smallpox, to take over as the number one infectious disease.

Crossing boundaries

Recent years have seen not only the discovery of new infectious agents, but also the emergence of some of our old infectious enemies. Some of these new diseases are crossing the species barrier and are now infecting species that they previously did not affect. Increasing resistance of many pathogens to antibiotics or vaccines has also raised concerns about the potential for sudden outbreaks of infectious diseases around the world.

Some of the new diseases and pathogens that have been identified or crossed the species barrier over the last few decades include Lyme disease, rabies, henipavirus, bovine spongiform encephalopathy (mad cow disease), Legionnaire's disease, HIV, Marburg virus, hantavirus, SARS, H5N1 and Ebola virus.



Influenza

Throughout history, there have been numerous outbreaks of influenza. The influenza virus constantly evolves, and pandemics happen every few decades when the flu virus gets new **surface proteins** that people have little immunity to, generally because they come from an animal strain.

By the end of 1918, more than 25 million people had died from a virulent strain of **Spanish influenza** (H1N1). In 1919, The Health Organization of the League of Nations was established with the aim of preventing and controlling disease around the world.

The **Asian influenza** (H2N2) pandemic followed in 1957, followed by a series of others over the next decades. **Avian influenza** (H5N1) made its debut in 1997 in a form that was highly contagious among birds and also infected humans. Since that time, it has devastated East Asian poultry industries. By 2006, a particular strain of H5N1 had been transmitted to humans and had caused a number of fatalities. H5N1 was dangerous because its H5 surface protein was totally new to humans — this is why it has killed more than half of the people who have been infected with it.

Swine flu

In 2009, there was a **swine flu** (H1N1) pandemic. This strain of influenza contained a mixture of genes from the swine flu, human flu and avian flu viruses. It was of particular concern because it was thought that this new strain may have surface proteins that the human immune system may not recognise.

The media was full of headlines expressing fear and concern. This caused global panic and a rush to develop vaccines or treatments for swine flu. Antiviral drugs (such as Tamiflu) that had not been rigorously tested against this new strain of flu were mass produced and supplied to doctors. In Australia, the families of those infected with the disease were quarantined — advised to stay at home, rather than go to work or school. Doctors were advised to have separate areas for those possibly infected (or send them to other surgeries), keeping them away from the general public.

FLU HYSTERIA IF FLU CRISIS HITS

Schools, restaurants, theatres and gyms could be shut and AFL matches cancelled or played in empty stadiums if swine flu grips Australia.

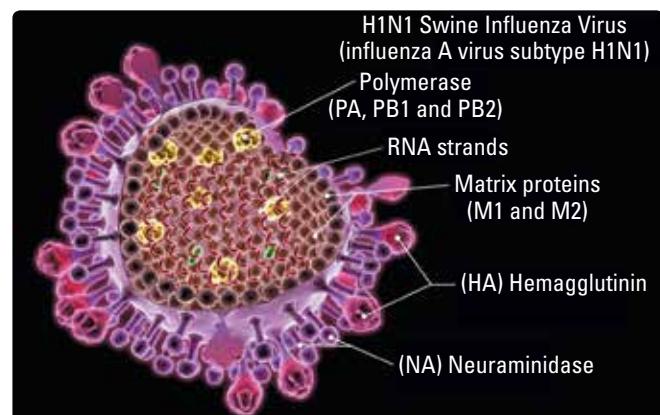
Source: Herald Sun, 1 May 2009.

HOW ABOUT THAT!

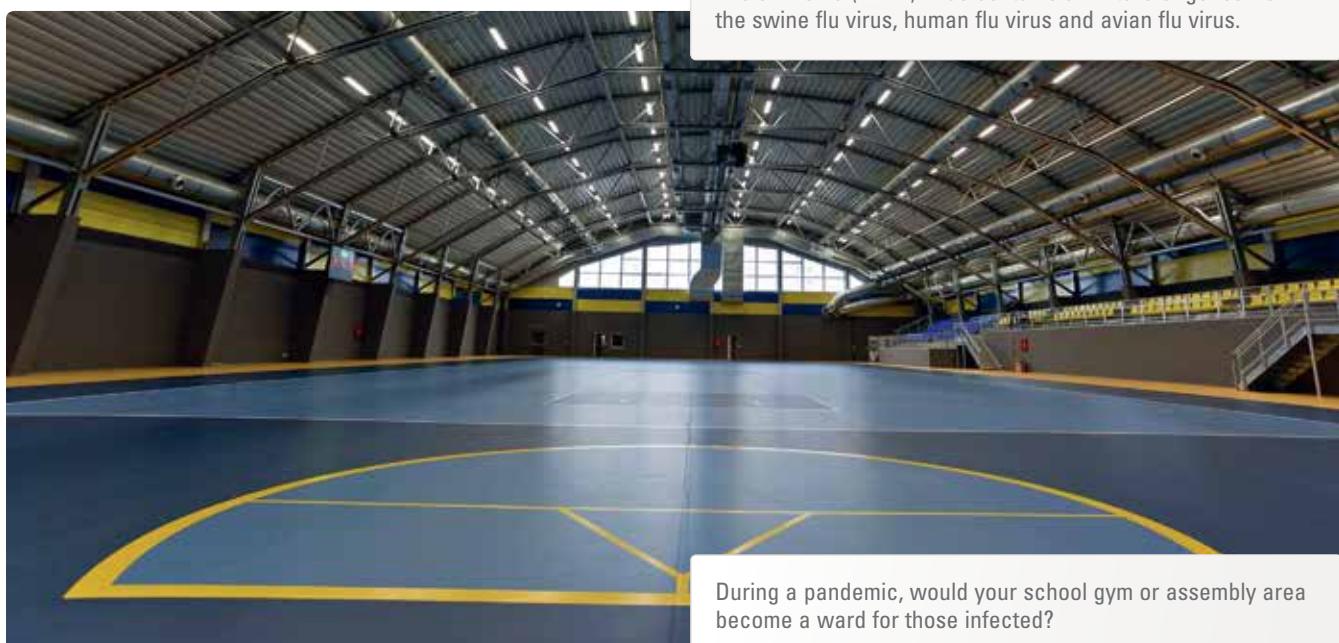
Increased travel between continents brought new knowledge and discoveries. It also brought death. At the turn of the century, around 1500 expeditions by Columbus and other explorers brought venereal diseases, smallpox and influenza to areas that had no prior history of them. This resulted in the deaths of millions of native people, who had no prior exposure to enable them to develop immunity. In some areas, up to 95 per cent of the native population died. If a severe pandemic was to occur, what effect do you think it could have on international travel?



Many claims were made about the dangers and possible consequences of swine flu. There was a rush to create policies and procedures that could be followed if some of the predictions became reality. The community took an interest in the disease and began asking questions. How was it transmitted? What were the symptoms? Could infection be prevented? What treatments were there and how could they be accessed? How many would die? Who would die? Was this a taste of living in the past? What technologies could we use or develop to defend ourselves against this new infectious threat?



The swine flu (H1N1) virus contains a mixture of genes from the swine flu virus, human flu virus and avian flu virus.



During a pandemic, would your school gym or assembly area become a ward for those infected?

UNDERSTANDING AND INQUIRING

REMEMBER

- 1 Define the term *plague* and give an example of one.
- 2 State the difference between an epidemic and a pandemic.
- 3 Suggest why bubonic plague is often referred to as the Black Death.
- 4 Identify the name of the pathogen that causes bubonic plague.
- 5 Describe three ways in which medieval people tried to defend themselves against bubonic plague.
- 6 Construct a flowchart to show the relationship between the bubonic plague pathogen, fleas and rats.
- 7 Suggest why the last recorded epidemic of bubonic plague was around 1670.
- 8 Provide three examples of new infectious diseases that have been identified over the last few decades.
- 9 State the names of three different types of influenza.
- 10 State which Asian industry was most affected by the outbreak of avian influenza.
- 11 In which year was there a swine flu pandemic, and which antiviral drug was used to try to defend us against it?
- 12 Suggest a relationship between international travel and pandemics.

INVESTIGATE, THINK AND DISCUSS

- 13 Doing what science tells us invokes the weight of scientific opinion. Citing scientific evidence as reason can at times lead to different interpretations of truth. How was the data collected and analysed? Were there biases in the methods used to obtain and interpret the results? With this in mind, investigate and discuss aspects of disease that have recently been cited in the media.
- 14 Humans who eat BSE-infected meat can contract Creutzfeldt-Jakob disease. Discuss issues that may result from Australia lifting the blanket ban on beef imports from countries that have recorded cases of bovine spongiform encephalopathy (BSE).
- 15 Find out more about one of the following Australian disease outbreaks: Legionnaire's disease, severe acute respiratory syndrome (SARS), swine flu, whooping cough (pertussis).
 - (a) Present your findings in a brochure or multimedia advertisement to inform others of key points about the disease.
 - (b) Create a model or animation to show how this disease is transmitted and how it causes disease.
- 16 Research the history, cause, symptoms and effects, treatments and relevant issues for one of the following diseases: H5N1 avian flu, anthrax, leprosy, Ebola, hepatitis C, SARS, tuberculosis, HIV/AIDS, syphilis, gonorrhoea, salmonella, cholera, bubonic plague, rabies.

17 Find out more about the sixth-century Plague of Justinian and its importance in history. Imagine you are living in this period; write a letter to a friend living outside Europe to describe what life was like during the time of this plague.

18 *Yersinia pestis* is named in honour of French bacteriologist Alexander Yersin, who successfully isolated the bacteria in Hong Kong in 1894. Find out more about his work and create a virtual Twitter or Facebook page that he may have created if he were alive today.

19 Find out more about the relationship between fleas (*Xenopsylla cheopis*) that fed on infected black rats (*Rattus rattus*) and the transmission of bubonic plague.

20 In 2001, the entire genome (genetic map) for *Yersinia pestis* was mapped. Find out more about this discovery.

21 *Yersinia pestis* was originally a harmless bacterium that lived in the stomachs of rats. About 1500 years ago it mutated in such a way that it was able to enter the rat's bloodstream. Find out what changes occurred that enabled it to do this.

22 Find out what happens once a flea transmits the bubonic plague pathogen into humans. Show your findings in a flowchart.

23 In 1999 in Malaysia more than 100 people died from pig-borne Nipah virus, and over a million pigs were slaughtered to prevent the spread of the disease. Find out more about this disease.

24 Find out more about Typhoid Mary and her involvement with the transmission of typhoid.

25 *Clostridium botulinum* is the pathogen responsible for a type of food poisoning called botulism. Find out more about how this bacteria is transmitted, how it causes paralysis and how chances of infection can be reduced.

26 Find out what cholera and diphtheria have in common and how they are different.

27 Find out more about swine flu and present your information in a creative format to share with others. Consider the following points in your presentation.

- What is a pandemic?
- What causes swine flu?
- Why all the fuss about swine flu?
- What are the symptoms of swine flu?
- How can we prevent or treat swine flu?
- Do we need policies or to take any action to prepare for a possible future pandemic?

28 Click on the **Global Outbreak Alert and Response Network**

weblink in your eBookPLUS

to find out more about GOARN

and their involvement in defence against disease.

eBookplus

Putting up defences

Antigens — you don't belong here!

Pathogens possess specific chemicals that are recognised as being non-self or foreign to your body. These non-self chemicals, referred to as **antigens**, trigger your immune response.

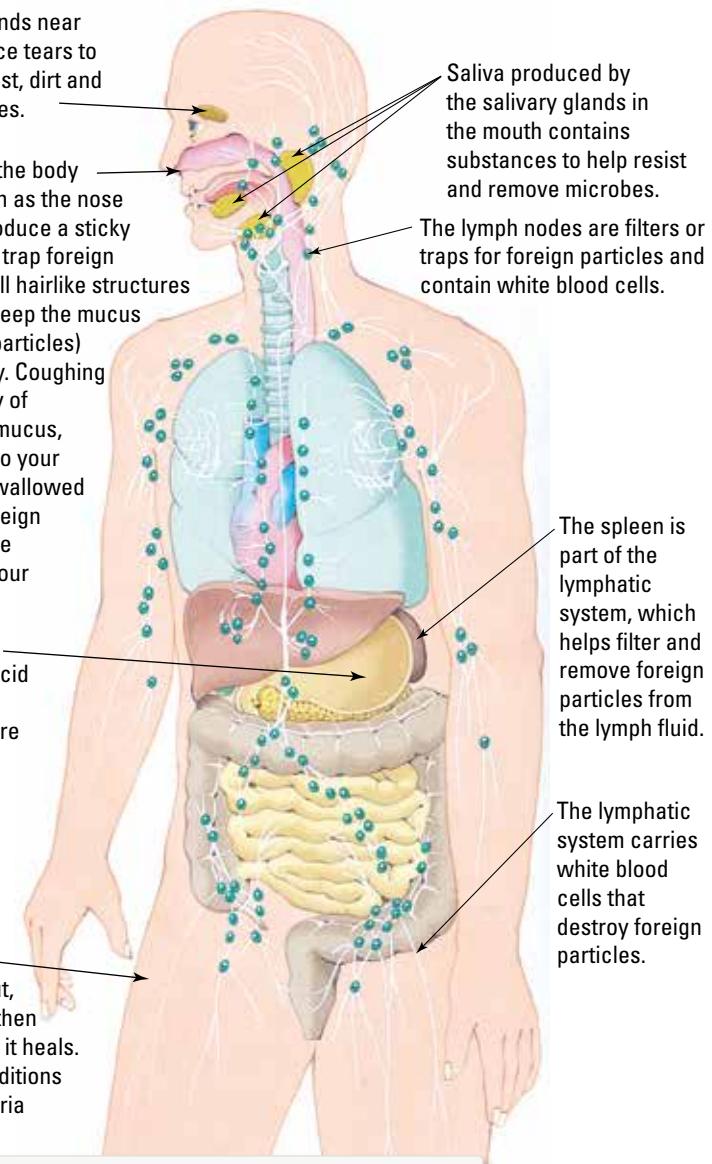
Lines of defence

Pathogens can cause disease, preventing or stopping your body from working well. A healthy body helps you to defend yourself against infectious disease by setting up natural barriers, or lines of defence. The first and second lines of defence are described as being non-specific. They fight the same way for all infections, regardless of whether they have encountered them before. The third line of defence is specific. It fights differently for different types of invaders and may react differently if it has been exposed to them before.

The first line of defence

Your body's first line of defence is designed to prevent the entry of invading pathogens. Some of these defences are physical barriers (such as skin, coughing, sneezing, cilia and nasal hairs) and others are chemical barriers (body fluids such as saliva, tears, stomach acid and acidic vaginal mucus).

The skin is a surface barrier to most diseases. It is waterproof and if it is cut, the hole is sealed by a blood clot that then forms a scab to help protect you while it heals. It is also dry and slightly acidic — conditions that prevent the growth of many bacteria and fungi.



Your first line of defence aims to stop pathogens from entering your body.

eBook plus

eLesson



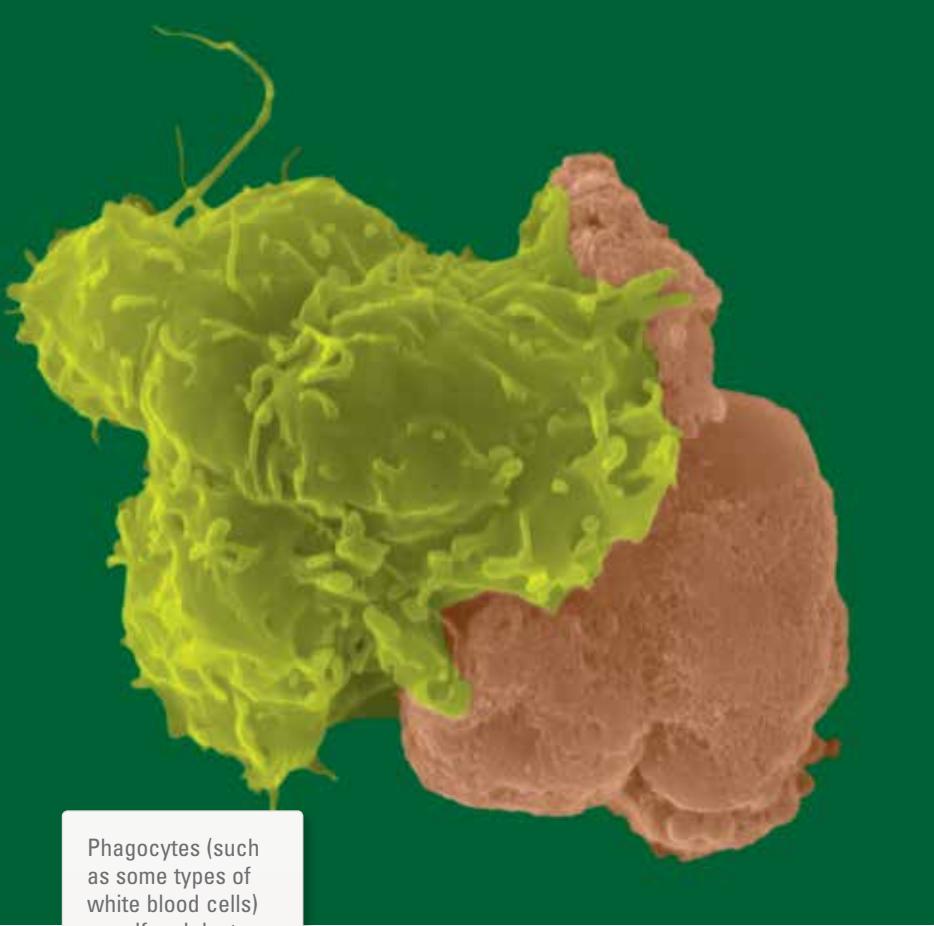
Understanding HIV

Find out what HIV is, how it can be contracted and the ways in which the disease is treated.

eles-0125

The second line of defence

If pathogens manage to get through your first line of defence, the second line of defence comes into play. If you have had a cut that became infected you may have noticed that the area became red, warm and swollen (inflamed). The redness (caused by the increased blood flow to the area) and **inflammation** are signs that your second line of defence has been triggered.



Phagocytes (such as some types of white blood cells) engulf and destroy materials. This action is called phagocytosis.

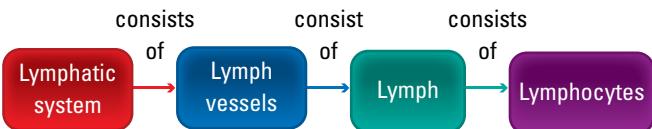
Special types of white blood cells, phagocytes, that engulf and destroy pathogens (and other foreign material) move to the site of the infection. This action of engulfing and destroying materials is called phagocytosis.

The third line of defence

Have you ever felt swollen glands in your neck when you had an infection? These glands are part of a network of fine tubes running throughout your body called your **lymphatic system**. Your lymphatic system contains lymph vessels, lymph nodes, lymph and white blood cells. Some of these white blood cells are lymphocytes.

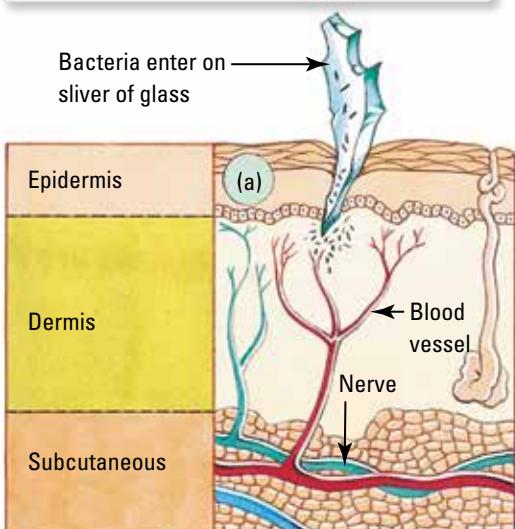
Lymphocytes

Lymphocytes are involved in your specific immune response. When triggered by infection, your **B lymphocytes** divide into **plasma cells**. These cells produce chemicals

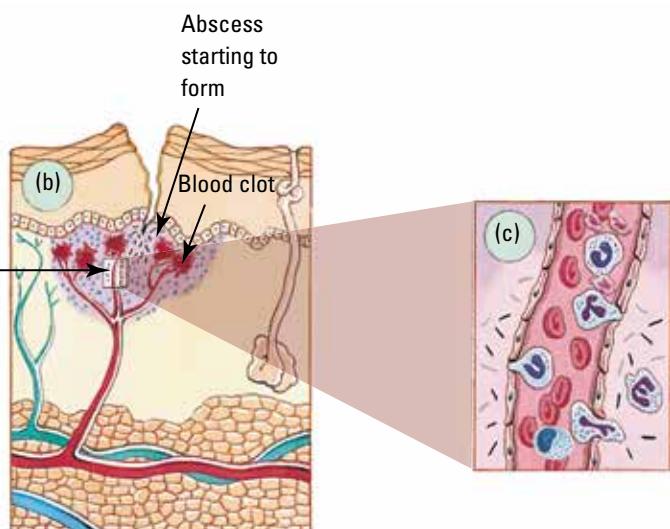


Your lymphatic system is involved in your third line of defence.

Your second line of defence, (b) and (c), is active once the pathogen has breached your first line of defence, your skin (a).



Chemicals released by damaged cells



called antibodies that are specific to the invader's antigens. These antibodies assist in the destruction of the invading pathogen. Your **T lymphocytes** fight at a cellular level. These cells not only attack foreign invading cells, but may also attack your own cells that have been invaded. By destroying these infected cells, they also destroy the cause of infection and reduce the chance that it will be spread to other cells.

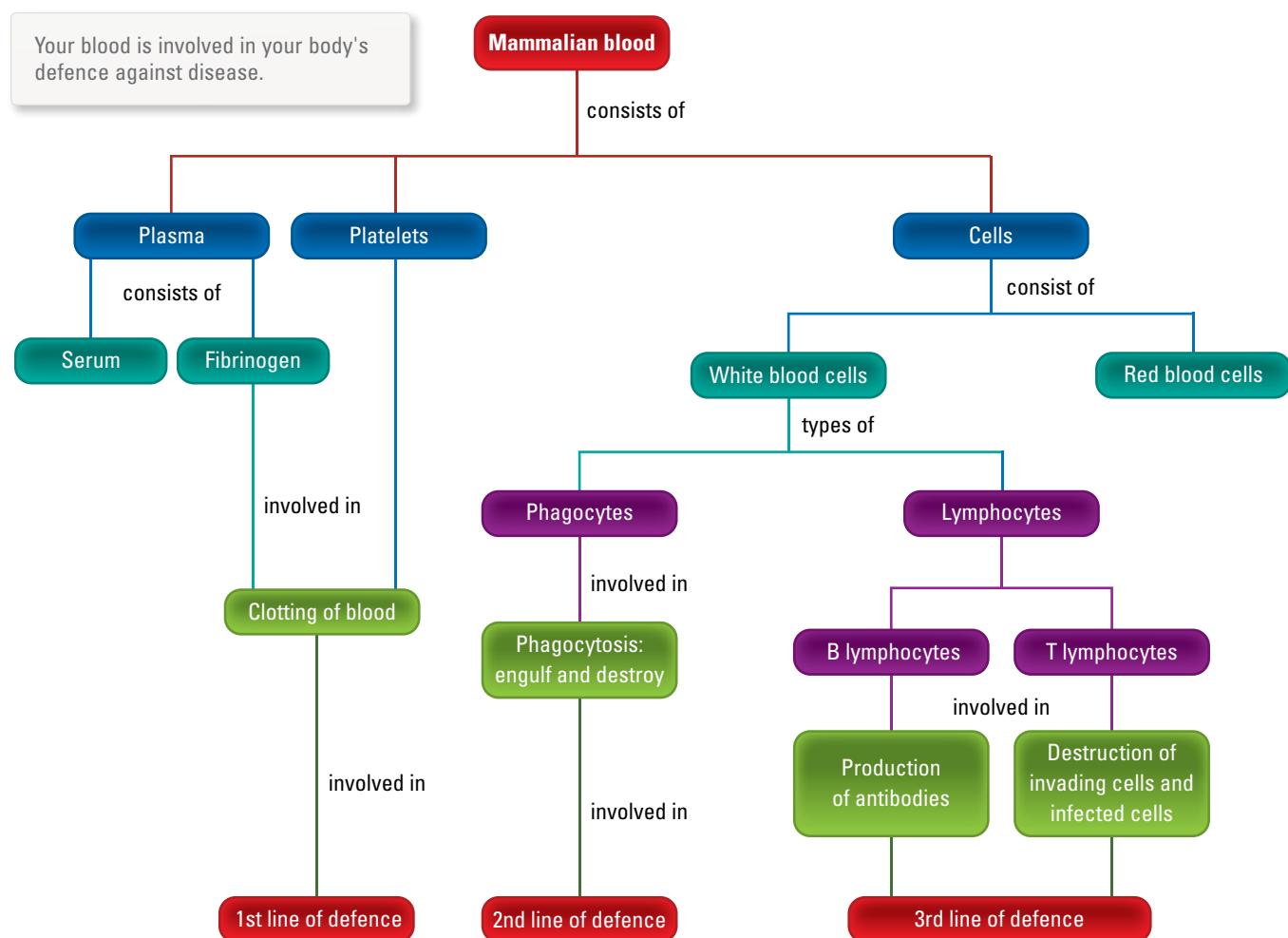
The actions of lymphocytes can assist phagocytes in their duties. For example, some T lymphocytes produce substances that can attract or activate phagocytes. Antibodies (produced by B lymphocytes) can bind to antigens, causing pathogens to clump together. This clumping makes it easier for the phagocytes to engulf them.

Your immune system can be so effective that you can be infected with a pathogen but not develop any symptoms. Lymphocytes can form **memory cells**, so that next time you encounter the same type of invader

your immune response can be faster and stronger. Sometimes it is so fast and strong that, even though you may be infected with the pathogen, you may not show any symptoms of the disease that it could cause.

Systems working together

Defence against disease is another example of how your systems work together. Your respiratory system's lining of mucus and ciliated tubes and your digestive system's enzymes and stomach acids help your fight against invaders. White blood cells produced in your bone marrow include those that will become phagocytes and lymphocytes. These defending cells will be circulated throughout your body in your circulatory system and lymphatic system to areas of infection where they perform their task of destroying invaders. The remnants of these invaders are then excreted from your body via your excretory system.



HOW ABOUT THAT!

A type of T lymphocyte called the *helper T lymphocyte* (helper T cell) can be infected by the human immunodeficiency virus (HIV). This is the virus that causes AIDS (acquired immune deficiency syndrome). HIV destroys the helper T cells, and in doing so

gradually damages the immune system of the infected person — this is why people with AIDS often die from diseases that a healthy immune system could normally defend itself from. HIV can be transmitted through body fluids such as blood, semen, vaginal fluid and breast milk. Currently there is no known cure.

UNDERSTANDING AND INQUIRING

REMEMBER

- 1 (a) How many lines of defence are there?
(b) Describe the key differences between these lines of defence.
- 2 Suggest how cilia, mucus, coughing and stomach acids can work together to help defend you against pathogens.
- 3 Suggest why bacteria and fungi find it difficult to grow on skin.
- 4 Provide two examples of (a) physical barriers and (b) chemical barriers involved in the first line of defence.
- 5 Use labelled flowcharts to show the relationship between:
(a) pathogens, phagocytes and phagocytosis
(b) lymphocytes, lymph, lymphatic system and lymph vessels
(c) antigens, pathogens, antibodies, lymphocytes, phagocytes.
- 6 Suggest how you can be infected with a pathogen but not show any symptoms.
- 7 Outline how your blood is involved in each line of defence against disease.
- 8 Construct connecting flowcharts (or a mind map) to show how systems of your body can work together to fight disease.

THINK AND DISCUSS

- 9 Use Venn diagrams to compare the following.
(a) First and second lines of defence
(b) Second and third lines of defence
(c) Physical and chemical barriers in the first line of defence
(d) Inflammation and phagocytosis
(e) Phagocytes and lymphocytes
(f) T lymphocytes and B lymphocytes
- 10 Use relations diagrams to show why:
(a) some glands feel swollen when there is an infection in your body
(b) the area around an infected cut becomes red and inflamed (swollen).
- 11 Suggest three ways in which foreign particles might be able to enter your body.

INVESTIGATE, IMAGINE AND CREATE

- 12 Find out more about how your body responds to the invasion of a specific invading micro-organism, either a bacterium (e.g. *Bacillus anthracis*, *Bacillus typhosus*, *Treponema*, *Vibrio*) or a prototistian (e.g. malaria, amoebic dysentery). Research and report on the following points about your selected microbe.
(a) Name the disease that it causes.
(b) Outline the symptoms of the disease.
(c) Describe how the microbe enters and infects your body.
(d) Describe how the body defends itself against this microbe.
(e) Describe any consequences of the disease.
(f) Outline possible treatments or cures for the disease.
(g) Describe research and/or issues related to this microbe or the disease that it causes.
(h) Identify a relevant problem that could be investigated further.
- 13 Imagine you are a pathogen attacking a human body. Write an imaginative paragraph about your invasion of the bloodstream. How did you arrive there? What lines of defence did you encounter along the way?
- 14 Find out more about your body's defence systems. In a team or on your own, create a story or play about invaders trying to get through your body's defences. Present your story or play to the class as a puppet play, animation or movie.
- 15 Investigate examples of research about how we defend ourselves from disease. Present your findings as a documentary or newspaper report.
- 16 Find out more about research relating to HIV and AIDS. Present your findings as a poster or in multimedia format.
- 17 Click on the **Phagocytosis** weblink in your eBookPLUS to see an animation of the process in which white blood cells engulf and destroy pathogens. Research examples of animations or simulations that show how your body responds to the threat of invading pathogens. Select the best ones and have a 'Body at war movie' class session. Construct a PMI chart for each that can be collated into a class chart.

eBookplus

Choosing immunisation

Does it make sense, does it have meaning? In your learning, memory and behaviour (and your self-concept), sense and meaning are key elements. If you or a close relative or friend are infected by a disease — it has meaning. Does it make sense if there is nothing that anyone can do to help them survive?

A small start, a giant leap!

Smallpox

Observations that, once infected, a survivor of a disease often did not catch that disease again must have been made throughout history. A long time before vaccination had been created in England, the Chinese used this observation as a basis for a process called variolation.

In the case of smallpox, variolation involved transferring material from the lesions of those infected with smallpox to healthy individuals. The transference was achieved by inserting infected material under the skin or inhaling the infected powder. The relative success of this process in reducing mortality and morbidity rates resulted in its spread to other countries.

It was an English aristocrat and writer, Lady Mary Wortley Montagu (1689–1762) who was responsible

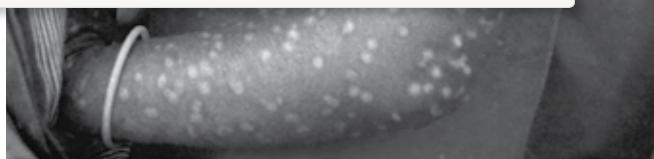


Smallpox leaves the sufferer with scarred skin. In 1980 The WHO announced that smallpox had been eliminated.



Lady Mary Wortley Montagu

for bringing variolation to England from Turkey around 1721. She had been scarred by this disease herself and had also lost close relatives to it. Although variolation was used by some of the aristocracy (including the royal family), it was not until 1797 that Edward Jenner (1749–1823) refined this method into a process we now call **vaccination**. Jenner's vaccination method was able to be used by wider populations and occasionally its use was enforced. By 1980, because of the use of vaccination, the World Health Organization (WHO) was able to announce the elimination of smallpox from our planet.



HOW ABOUT THAT!

In 1796, Edward Jenner found a safe way of developing immunity to the disease smallpox. He noticed that people who had contracted cowpox, a much less serious disease, did not seem to ever develop smallpox. Jenner took some pus from an infected cow and deliberately gave a person cowpox. Some time later he exposed this person to smallpox, but the person never showed signs of the illness. Jenner had successfully produced an immunity to smallpox. He called the method *vaccination*, from the Latin word for cow.



Polio

Poliomyelitis (polio) is an infectious disease caused by the *Picornaviridae* virus. This disease is highly infectious and consequences can include complete recovery, limb and chest muscle paralysis, or death.

A vaccine for polio was developed by Jonas Salk in 1955 using a dead virus. This vaccine, however, required a booster shot about every three years and occasionally a live virus contaminated the vaccine. One batch in 1955 infected 44 children with polio — this resulted in some fear within the population about its use. In 1956, American doctor Albert Sabin announced that his oral live virus polio vaccine was ready for mass testing. Public mistrust in the safety of a vaccine using a live virus resulted in Sabin using Soviet (Russian) school children in his large population tests. His tests indicated that this vaccine was not only safer, but also more effective, providing lifelong immunity — and it was cherry-flavoured and could be taken by mouth! By 1961, Sabin's oral polio vaccine was adopted as the standard in America. In 1966, Australia also introduced this oral vaccine.



Dr Albert Sabin and his vaccine against polio

People suffering with polio may become paralysed.



Patients with polio may be incapable of breathing unassisted. In some cases patients needed to be in an 'iron lung', a machine which provided artificial respiration.

Cervical cancer

Cervical cancer is responsible for the deaths of more than 300 Australian women each year. A significant risk factor associated with this cancer is the common



Ian Frazer developed the HPV vaccine which may assist our fight against cervical cancer.

human papillomavirus (HPV). It is for this reason that every couple of years most Australian women have the **Pap test**, which is used to detect abnormal cervical cells that can lead to cancer.

A vaccine against the papillomavirus was developed by Professor Ian Frazer from the University of Queensland's Centre for Immunology and Cancer Research. He was recognised as Australian of the Year in 2006 for his

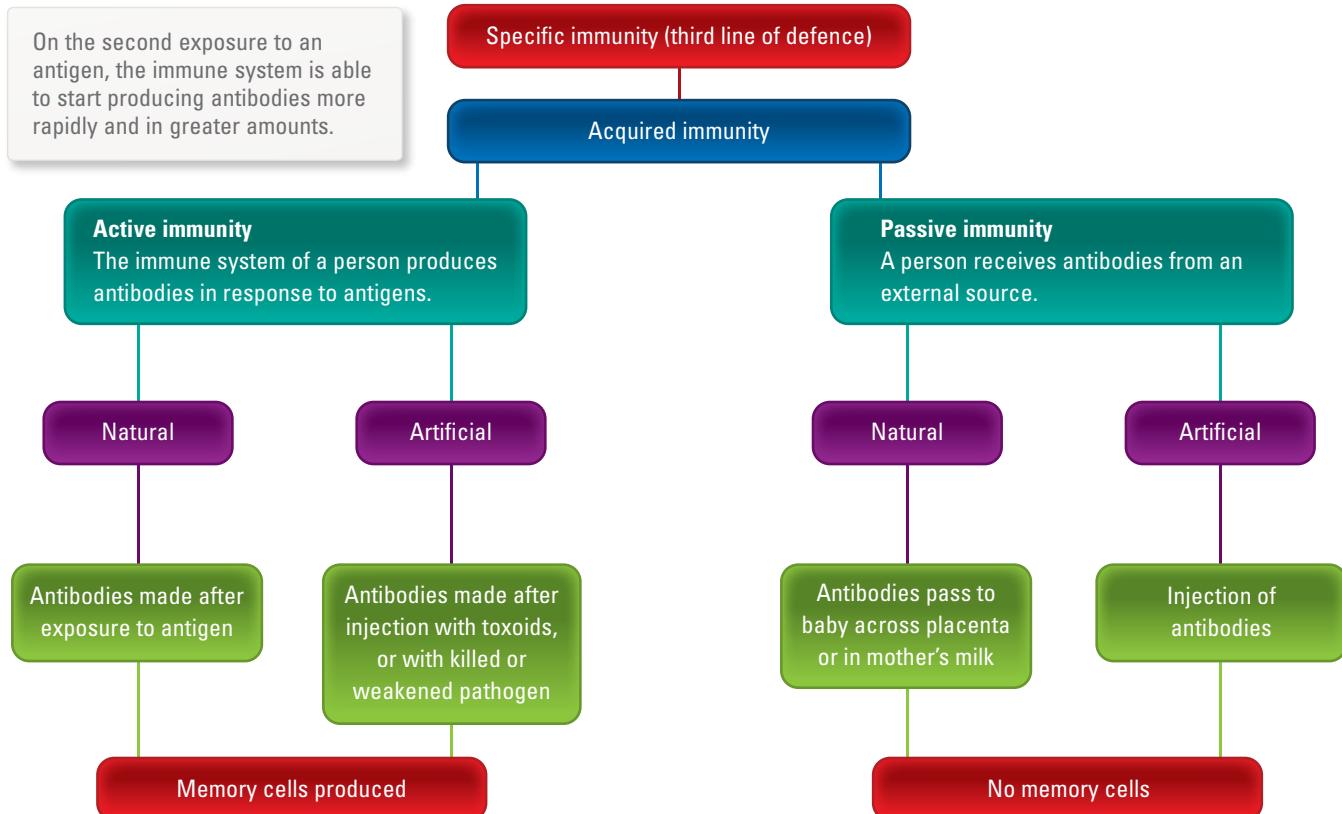
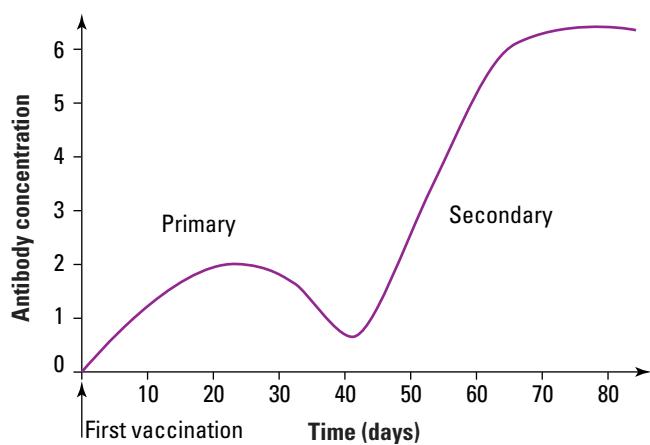
involvement in this development. This vaccine may assist in the prevention of cervical cancer in more than half a million women worldwide each year.

What is immunity?

Immunity is resistance to a particular disease-causing pathogen. A person who is immune does not develop the disease.

If a person is exposed to the antigen of a particular pathogen, or non-self material, they may make specific antibodies against it. The next time they encounter that antigen, their response may be so fast and effective that they can resist infection.

The development of one type of immunity involves the use of a vaccine. Vaccination or **immunisation** is the giving of the vaccine to produce a type of immunity called artificial immunity.



Active or passive?

If your body makes antibodies to a specific antigen, this is described as **active immunity**. Your body has memory cells that remember the antigen and you can make more identical antibodies very quickly. You could also gain artificial (or induced) active immunity by producing antibodies after being injected with a toxoid or a killed or treated pathogen that contains the antigen.

If you receive antibodies from an outside source, this is called **passive immunity**. In this case, you don't have memory cells for this infection so, if you were exposed to it again, your body would react as it did the first time. You could get passive immunity from your mother's milk, across the placenta or through an injection of antibodies.

With just one jab!

Vaccinations have been developed by scientists against many diseases and are available to the majority of Australians. This has meant that many children have not had to experience some of the horrors experienced by previous generations. Community health programs ensure that children are vaccinated to protect them against infectious diseases such as tetanus, rubella, mumps, diphtheria, poliomyelitis and whooping cough. Many of these diseases have now been controlled so are rarely seen in Australia.

Don't jab me!

Alarmingly, there is an increasingly low child immunisation rate in some areas in Australia. This has resulted in the government taking steps to boost the numbers of children immunised. Should they do this and, if so, why? Some people question the safety of such vaccinations. Are there no disadvantages to immunisation? Do we know what may go wrong? How and on whom should we test vaccines?

Guinea pigs

Vaccines are not the only chemicals that require testing. Many cosmetics advertise their products as not having been tested on animals. What does this mean? If they haven't been tested, how do we know that they are safe for us to use? Should we use only humans for testing and, if so, who should we use? Should we pay to test them on people? Should we draft or randomly select members of the population for testing? These are some controversial views for you to think about.

eBook plus eLesson

Immunisation in Australia

Learn how immunisation helps your body to fight disease.

eles-0126

| Vaccine | Diseases vaccinated against | Ages | | | | | | | | | |
|-----------------|--|-------|----------|----------|----------|-----------|---------|-------------|-------------|-------------|--|
| | | Birth | 2 months | 4 months | 6 months | 12 months | 4 years | 10–13 years | 12–13 years | 15–17 years | |
| DTP | Diphtheria, tetanus and pertussis (whooping cough) | | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | |
| IPV | Polio | | ✓ | ✓ | ✓ | | ✓ | | | | |
| Hib | <i>Haemophilus influenzae</i> type b | | ✓ | ✓ | ✓ | ✓ | | | | | |
| MMR | Measles, mumps and rubella | | | | | ✓ | ✓ | | | | |
| Hep B | Hepatitis B | ✓ | ✓ | or ✓ | or ✓ | ✓ | | ✓ | | | |
| Meningococcal C | Meningococcal C | | | | | ✓ | | | | | |
| 7vPCV | Pneumococcal | | ✓ | ✓ | ✓ | | | | | | |
| VZV | Varicella (Chicken pox) | | | | | | | ✓ | | | |
| HPV | Human papillomavirus | | | | | | | | ✓ | | |

Examples of vaccines in the National Immunisation Program Schedule (from 2007)

HOW ABOUT THAT!

Scientists are currently looking at the possibility of inserting genetically modified viruses into the DNA of plants such as bananas and soybeans. These genetically altered plants may

be used as a source of vaccines for injections or simply to be ingested as an oral vaccine. Such vaccines would be cheap to mass-produce and easy to distribute. What are the implications for developing countries? How could this new technology affect food chains in ecosystems?

UNDERSTANDING AND INQUIRING

REMEMBER

- 1 Describe a way in which each of the following people contributed to the fight against disease.
 - (a) Lady Montagu
 - (b) Edward Jenner
 - (c) Jonas Salk
 - (d) Albert Sabin
- 2 Distinguish between the following:
 - (a) immunity and immunisation
 - (b) antigen and antibody
 - (c) active immunity and passive immunity
 - (d) natural passive immunity and artificial passive immunity
 - (e) natural active immunity and artificial active immunity.

THINK AND INVESTIGATE

- 3 (a) Research the cause and effects of the diseases that Australian children are currently vaccinated against, as listed in the table in this section.
- (b) Research reasons parents may not vaccinate their children against any of these diseases. Include examples of claims that are being made and comment on whether these claims are justified.
- (c) Find out the possible consequences to others if children are not vaccinated against these diseases.
- (d) Do you think that vaccination against these diseases should be compulsory? Provide reasons for your opinion.
- (e) Investigate and report on current research related to one of these diseases.
- (f) Provide examples of how the media has influenced or can influence opinions about whether children should be vaccinated. Are there any claims made in these examples that are not scientifically justified? If so, what are they?
- (g) Hold a class debate about whether vaccinations should be compulsory in Australia.
- (h) Write an article for a local newspaper or school newsletter about the importance of vaccination.
- (i) What is the HPV vaccine? Find out more about it and how it may affect you.
- (j) Find out more about the history of vaccination and how various vaccines have been trialled on humans. How do you think vaccines should be trialled? Justify your opinions.

- (k) If there is a pandemic but not enough vaccine for everybody, who should it be given to? Justify your response and share it with others.
- (l) Find out more about the relationship between immunity and babies being breastfed.
- (m) Do you think that immunisation should be compulsory in Australia? Justify your reasons.
- (n) In 1952, the World Health Organization (WHO) set up the Global Influenza Surveillance Network. Find out more about the structure of this network and what it hopes to achieve.
- (o) In the early 1900s, diphtheria caused more deaths in Australia than any other infectious disease. Find out more about this disease and the effect of vaccination on it.
- (p) Use the **WHO** weblink in your eBookPLUS to compare the Australian immunisation schedule with that of other countries.



- 4 Australian scientists Sir Gustav Nossal and Professor Peter Doherty have made significant contributions to science. Find out more about their work and how it relates to the study of viruses.

- 5 Find out why we currently have no vaccine for the common cold. Comment on whether you think there may be one in the future. Discuss this with your team.

- 6 Use the **Interferon** weblink in your eBookPLUS to find out more about the use of nanotechnology in the delivery of drugs.



- 7 Nicotine and alcohol drug abuse can kill millions of people each year. Could a new generation of vaccines stop the explosion of this 'epidemic'? If it were possible to develop vaccines that could target physical addictions would you use them? Trials have already begun on such vaccines. Find out more, share and discuss it with others and react to what you have found out.



- 4.3 Immunity
4.4 Vaccination

Travel bugs

If you are planning an overseas trip, it's recommended that you research the conditions in your holiday destination carefully. Otherwise you may bring back more than you expect!

Pass the toilet paper!

The most common illness suffered by overseas travellers is diarrhoea. While this may cause a little discomfort in the short term, it may be lethal if it continues for a long time. It is responsible for the deaths of almost five million children in tropical regions each year. There are no vaccines to protect you against it, but you can reduce your risk of getting it by following a few simple precautions. These include avoiding locally made ice and ice-cream, lettuce, salads and uncooked foods that may have been washed with contaminated water or handled unhygienically. Only bottled or boiled water may be safe to drink.

A quick jab before you go

Before travelling outside Australia, it is a good idea to check the vaccination requirements for entry into your destination. Vaccines are currently available for some strains of hepatitis, typhoid, yellow fever, Japanese encephalitis, cholera, influenza, rabies and bacterial meningitis.

If you are travelling to a region where malaria is a problem, you are advised to begin a course of antimalarial tablets one week before leaving. This preventative action should be continued for at least a month after your return.

All about malaria

How can I catch malaria?

You catch malaria by being bitten by a female *Anopheles* mosquito that has been infected by the *Plasmodium* parasite. The parasite moves into the salivary glands of the mosquito and is passed into your bloodstream when it bites you.

How do you know if you have malaria?

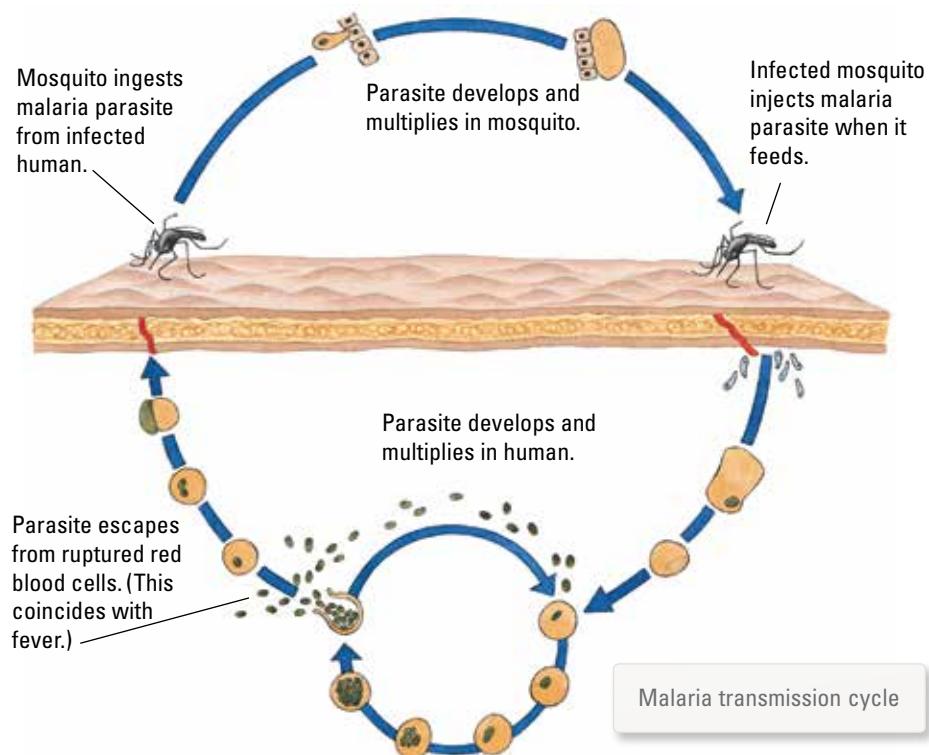
Some people infected with malaria show no symptoms, while most have high fevers, aches, pains, shivering and night sweats. Fatigue, low blood cell counts and yellowing of the skin and whites of eyes (caused by jaundice) may also result. Severe complications include cerebral malaria, anaemia and kidney failure, and can often result in death.

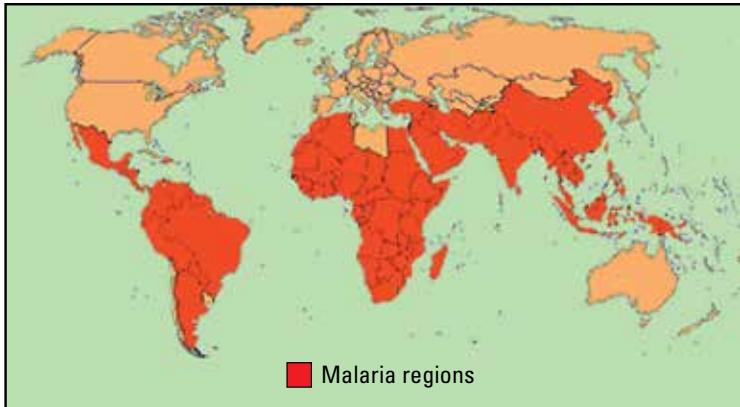
What causes malarial night sweats?

Once inside your body, malaria parasites grow and multiply first in your liver cells and then in your red blood cells. Successive broods of malaria parasites grow inside your cells until your red blood cells burst open and are destroyed. The new malaria parasites (or merozoites) seek other cells to infect and destroy. This causes night sweats.

How dangerous is malaria?

Malaria kills over one million people each year. It is one of the most serious public health problems worldwide. It is also a leading cause of death and disease in many developing countries, in which pregnant women and young children are most affected. An infected mother can transmit the malaria parasite to her unborn child through the placenta.





The malaria hot spots — 41 per cent of the world's population live in areas where malaria is transmitted.



What's new in malaria research?

Mosquitoes, the vectors for malaria, are increasingly resistant to many of the available pesticides. In 2005, British researchers published their findings on two types of fungi that can kill malaria-causing mosquitoes. Their investigations in this field may help reduce the number of malaria victims.

In Australia, teams led by Professor Alan Cowman at the Walter and Eliza Hall Institute of Medical Research

have studied how the malaria parasite uses genetic trickery to evade our immune systems. Their research may lead to the development of drugs that disrupt the malaria parasite's ability to disguise itself. This will increase the chance of detecting and destroying it.

Watch out for the mozzies!

Mosquitoes are not only vectors for the malaria parasite, but can also transmit elephantiasis, dengue fever, yellow fever and Japanese encephalitis.

UNDERSTANDING AND INQUIRING

REMEMBER

- 1 What is the most common illness suffered by overseas travellers?
- 2 Which diseases can you be vaccinated against before travelling overseas?
- 3 Suggest practical methods for avoiding traveller's diarrhoea.
- 4 Construct a cycle map, relations diagram or mind map to summarise what you have learned about malaria.

INVESTIGATE AND DISCUSS

- 5 (a) In a group of four, each team member should select two questions from the following list so that a total of eight questions will be answered.
- (b) Use any resources available to you to research them and then report your findings back to your team.
- (c) As a team, construct a brochure that outlines advice for Australians travelling overseas.
 - (i) Describe how mosquitoes are affected by the malaria parasite.
 - (ii) Explain why only the female mosquito transmits the malaria parasite.
 - (iii) Of the 430 known species of *Anopheles*, how many transmit malaria? Name three.

- (iv) Find out the difference between the gametocyte stage and the sporozoite stage of the malaria parasite. Draw a diagram to summarise your findings.
- (v) Explain how travelling at particular times of the year can affect your chances of getting malaria.
- (vi) In which hours of the day are you at a greater risk of catching malaria? Explain why.
- (vii) Find out six things that you can do to reduce your chances of getting malaria.
- (viii) There have been four Nobel prizes awarded for work on malaria. Who were they awarded to, when and for what?
- (ix) Suggest why travelling to a particular country can reduce your chances of being able to donate blood.
- (x) Malaria, or a disease resembling malaria, was recorded more than 4000 years ago. Research the history of malaria and use a timeline to share your results with your team.
- (xi) Quinine, atebrin, chloroquine, Fansidar, Malarone and artemisinins are examples of drugs used to combat malaria. Find out about their history, effectiveness, similarities and differences.
- (xii) Antimalarial drugs have been found to have reduced effectiveness over time. Explain how this has happened.

Our noble Nobels

Australian scientists have made significant contributions to disease control and to the quality of life that we enjoy today. Sir Howard Florey, Sir Frank Macfarlane Burnet and Professor Peter Doherty each won a Nobel Prize in Medicine.

One hundred years ago, many children died from both infectious diseases and bacterial infections. A small scratch was sometimes enough to allow deadly bacteria to enter the body and cause swelling, the formation of pus and severe pain. Children born today can avoid the harsh consequences of bacterial infections.

Marvellous mould

Howard Florey was born in Adelaide in South Australia in 1898. He was a keen student who loved sport and chemistry. He studied medicine at the University of

Adelaide where he won a Rhodes scholarship to Oxford University, England. While in England he led the team who finally extracted **penicillin** in 1940. In 1945 he shared his Nobel Prize with Alexander Fleming and Ernst Chain. In speaking of his discovery, he modestly stated, 'All we did was to do some experiments and

have the luck to hit on a substance with astonishing properties.'

Penicillin was so successful in saving lives that population control became an issue for medical researchers. Florey later worked on contraception research. In honour of his contribution to medicine, he was knighted in 1944. His likeness appeared on an Australian \$50 banknote and a suburb of Canberra was named after him.

Miracle cure-all

Penicillin is an antibiotic and is a chemical made by the mould (fungus) *Penicillium*. If you leave oranges for too long in the fruit bowl, you will sometimes find them growing a greenish mould. This is *Penicillium*.

Antibiotics destroy bacteria, and they are widely used to treat diseases caused by bacteria.

In the human bloodstream, penicillin works by stopping bacteria from forming cell walls as they try to

divide. Natural penicillin must be given by injection as otherwise it is destroyed by stomach acid. Some people are allergic to penicillin, but luckily there are now several different antibiotics to choose from. There are few people in the community who have not taken antibiotics at some time in their lives.



Howard Florey



Today, we take antibiotics to avoid the harsh consequences of bacterial infections. These photographs of a young patient in 1942 show how serious an infection can be. After being treated with penicillin, the patient's condition improved and she recovered fully.



The father of immunology

Frank Macfarlane Burnet, known as 'Mac', was born in Traralgon, Victoria in 1899 and died in 1985. As a boy, he loved science and spent hours exploring the bush near his home searching for beetles. Charles Darwin was his hero. After graduating from the University of Melbourne as a medical researcher, he started work at the Walter and Eliza Hall Institute (WEHI) in Melbourne. He then worked in England for many years, returning to Australia in 1944 to become director of the WEHI. He was knighted in 1951 and received his Nobel Prize in 1960. In 1961 he was named Australian of the Year, and four years later he was elected President of the Australian Academy of Science.

Immunology, the science that deals with protection from diseases, was Mac's specialty and he spent most of his career studying viruses. His doctorate thesis was on



Mac demonstrates his method of growing viruses by injecting them into eggs to a class of American postgraduate students.

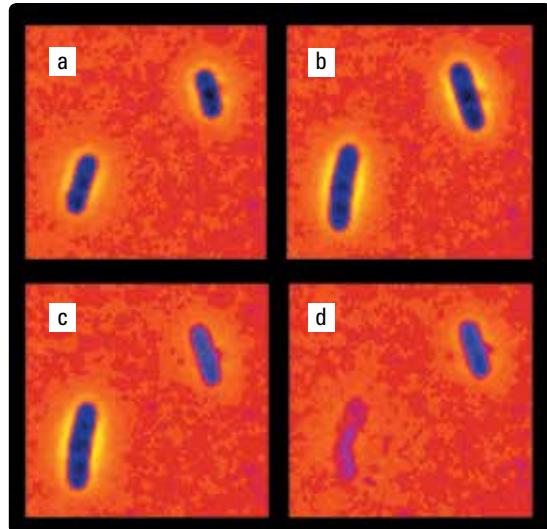
the **phage**, a type of virus that infects and kills bacteria. Scientists of the time thought there was only one species of phage. Mac showed that there are, in fact, several species.

In 1928, there was public hysteria against vaccination when 12 children died after receiving their diphtheria injections. Mac was part of a team that investigated this tragedy. His experiments showed that contamination of the vaccine caused the deaths, rather than the vaccine itself. This no doubt saved many further lives as people regained their confidence in vaccination.

Influenza strains

While in England, Mac worked on the human influenza (flu) virus and developed a successful method of growing high concentrations of the virus using fertilised chickens' eggs. This work led to the development of an influenza vaccine. Mac determined that there were several different strains of influenza. This meant a new vaccine had to be developed each year once the particular strain of influenza had been identified. His work laid the foundation for the discovery by Dr Peter Coleman from CSIRO that all influenza viruses had a common part. Researchers then focused on ways to attack this common part and were able to produce drugs that can kill all strains of influenza virus. Now, people in high-risk categories are encouraged to be vaccinated each autumn to avoid contracting the disease.

Mac was so dedicated to his work that he was willing to risk his life to show others what he knew. In the early 1950s, CSIRO released the myxomatosis virus so



In these photographs, bacteria were grown in penicillin for 30 minutes. The bacteria grow longer as shown at (b), but eventually rupture (d), unable to divide due to the influence of the penicillin.

it would infect and reduce the rabbit population in Australia. At the same time, there was an outbreak of encephalitis that made hundreds of people sick. The public started to blame myxomatosis. Mac knew how the myxoma virus worked and that it could not affect humans. He set up an experiment where he and two colleagues, Professor Frank Fenner and Dr Ian Clunies Ross, injected themselves with live myxoma virus. When it was shown that their health was not affected, the panic died down.

Matching body parts

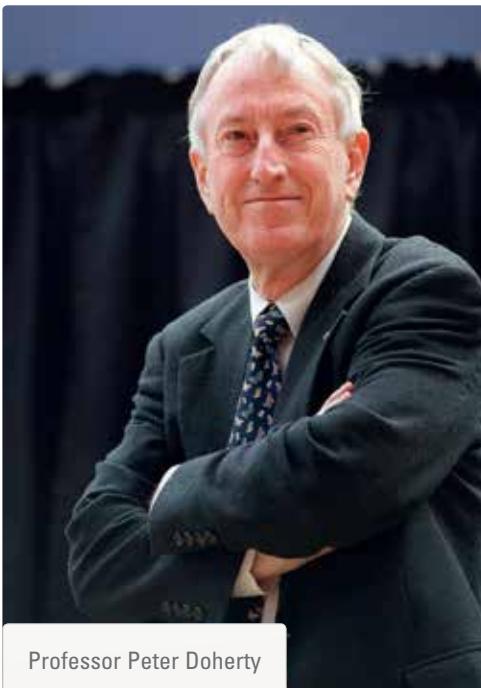
Mac's work inspired other scientists, contributing to our ability to perform transplants. Mac believed that the body learns about immunity at an early age. He suggested that if you could put cells from another body into a fetus at the right time, the fetus would learn not to reject such cells later in life.

Dr Peter Medawar and his team of scientists used this idea when they injected donor tissue from a mouse into the embryo of another mouse. When the mouse was born, the team grafted skin from the donor mouse onto the newborn mouse. No rejection occurred. Now scientists know that they must match the genes carefully when they are looking for possible transplant organs. They use a close genetic match between recipients and donor organs, together with drugs that deaden the immune system, to perform successful transplants. Today organs including heart, lung, kidney, cornea, bone marrow, skin and

pancreas may be transplanted, extending the lives of many people. Immunology is still an important area of scientific research.

Killer cells

Professor Peter Doherty was born in Brisbane in 1940. He received a veterinary science degree from the University of Queensland and a graduate medical degree from the University of Edinburgh. He shared his Nobel Prize in 1996 with Rolf Zinkernagel when they described the way the **immune system** recognises virus-infected cells. In 1997 Peter Doherty was named Australian of the Year. Doherty and Zinkernagel worked at the John Curtin School of Medical Research in Canberra from 1973 to 1975.



The immune system uses special white blood cells called T lymphocytes, or **T cells**, to protect an organism from infection by eliminating invading microbes. T cells have to be smart enough to avoid damaging their own organism. They need a recognition system so that they can identify the parts they must destroy and those they must protect. The body also needs to know when to activate them.

Doherty and Zinkernagel studied mice to learn how their immune systems (particularly their T cells) protect them against the virus that causes meningitis. They discovered that mice can make killer T cells that protect them. However, when these T cells were placed in a test tube with infected cells from another mouse,

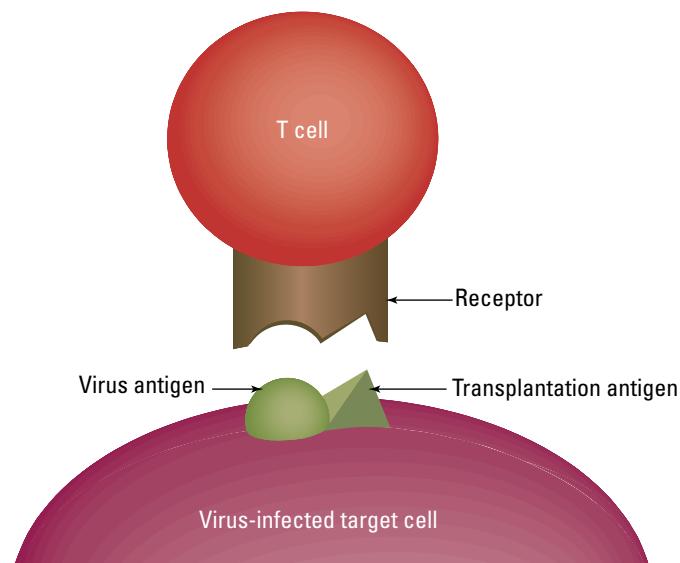
they did not work. Doherty and Zinkernagel developed a model to explain why this happened. They said that each T cell carries a marker that allows it to recognise the cell of the organism it is protecting, as well as the antigen of the invading microbe. At the spot where the antigen attaches itself to the host, the T cell can make a matched fit and destroy the antigen. It works like two interlocking pieces of a jigsaw puzzle.

When your body is exposed to a microbe, it develops T cells that give it immunity. If there are enough of the right type of T cells, these can eliminate the microbes faster than they can reproduce and you remain well. Your body keeps some of these T cells as immunity against future attacks from the same microbe.

This work has had a major impact on our understanding of organ transplantation and vaccines. Scientists now realise they must try to match both tissue and immune system types for a successful transplantation.

From Pasteur to penicillin

Understanding and finding cures for infectious diseases has been a long process involving the efforts of many scientists around the world. Some of the key researchers in the discovery and development of penicillin, and their ideas and breakthroughs, are listed in the tables on the next page. If it were not for their contributions, we may not have the antibiotic medicines that we take for granted today.



Australian Nobel Prize-winning scientists

| Year of Nobel prize | Scientist | Contribution to our understanding of disease |
|---------------------|---|---|
| 1945 | Howard Florey (1898–1968) | Isolation and manufacture of penicillin and discovery of its curative effect in various infectious diseases |
| 1960 | Frank Macfarlane Burnet (1899–1985) | Discovery of acquired immunological tolerance |
| 1996 | Peter Doherty (1940–) | Discoveries about the specificity of the cell-mediated immune defence |
| 2005 | Barry Marshall (1951–) and Robin Warren (1937–) | Discovery of the involvement of the <i>Helicobacter pylori</i> bacterium in stomach ulcers and gastritis |

Other notable Nobel Prize-winning scientists

| Scientist | Field | Contribution to our understanding of disease |
|-------------------------------|-------------------------|---|
| Louis Pasteur (1822–1895) | French chemist | Discovered that infectious diseases are spread by bacteria. Observed that mould stopped the spread of anthrax. |
| Joseph Lister (1827–1912) | British surgeon | Noted that samples of urine contaminated with mould prevented bacterial growth. |
| Alexander Fleming (1881–1955) | Scottish bacteriologist | In 1928, while studying the influenza virus, Fleming went on holiday and left several discarded Petri dishes on his bench. He had been using them to grow bacteria in nutrient jelly. When he returned, he noticed that where some of the mould had fallen, the bacteria had been killed. He called this substance penicillin but was unable to extract it and did not pursue it further. |

UNDERSTANDING AND INQUIRING

REMEMBER

- 1 Sir Howard Florey, Sir Frank Macfarlane Burnet and Professor Peter Doherty are Australians who have received a Nobel Prize.
 - (a) Which Nobel Prize did each win and in what year?
 - (b) In which area of science did each one specialise?
- 2 What would have happened to you if you had a bacterial infection in the time before penicillin was discovered?
- 3 Explain how penicillin works.
- 4 How do T cells protect us from disease?
- 5 Who discovered that infectious disease was spread by bacteria?

THINK

- 6 What precautions must we all take to ensure that antibiotics remain useful to us?
- 7 Click on the **ASAP** weblink in your eBookPLUS to find out more about the important discoveries made by Sir Frank Macfarlane Burnet and Sir Howard Florey. Present your findings as a flowchart.

eBookplus

INVESTIGATE

- 8 Find out how scientists made moulds for their research and then investigate how to produce your own moulds.
- 9 Use the internet to find out more about Nobel Prize winners.

Cycle maps and relations diagrams

1. List actions or steps that are relevant to a particular cycle on small pieces of paper.
2. Order your pieces of paper and then position the steps in a circle.
3. Review your cycle — are any steps in the wrong order, missing or irrelevant? If so make changes.
4. Write your cycle with each step placed in a box and the boxes joined by arrows within your circle.

Helps you to see repeating sequences of events

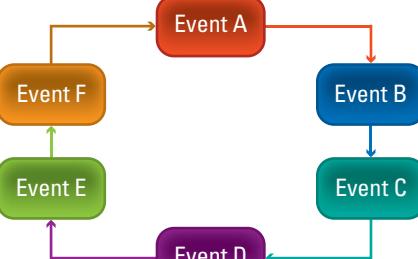
why use?

how to ...?

What patterns can be seen in these events?

question

Cycle map



Cycle chart; cyclical map

also called

comparison

Relations diagram

example

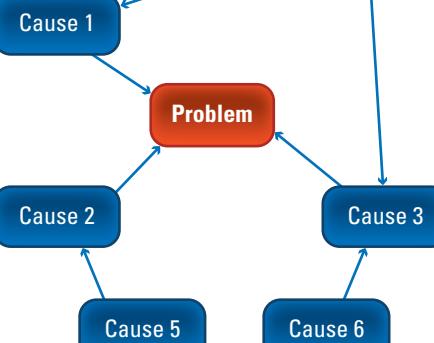
Similarity

Both show the sequence of events.

Difference

Relations diagrams identify and represent relationships between causes of events; cycle maps just sequence them.

Problem



STUDY CHECKLIST

CAUSE OF DISEASE

- compare infectious and non-infectious disease
- define the following terms: pathogen, parasite, cellular pathogen, non-cellular pathogen, host, primary host, secondary host, endoparasite, ectoparasite, plague, epidemic, pandemic
- describe ways in which diseases can be transmitted
- recall examples of disease caused by prions, viruses, bacteria, fungi, protozoa and animal parasites

HISTORY OF DISEASE

- describe how ideas about disease transmission and treatment have changed from medieval times to the present as technology and knowledge have developed
- describe how technology has changed the way in which we view disease

DEFENCE AGAINST DISEASE

- distinguish between the first, second and third lines of defence against disease

- describe the role of the skin, mucous membranes, chemical barriers and other components of the first line of defence against disease in the human body
- outline how inflammation, fever and phagocytosis assist in the maintenance of health
- explain how specific immunity against a particular pathogen is acquired
- distinguish between specific and non-specific defence against disease
- distinguish between antibodies and antigens
- state the relationship between the lymphatic system, lymph, lymph vessels and lymphocytes
- distinguish between T lymphocytes and B lymphocytes
- compare and contrast active and passive immunity

HUMAN ENDEAVOUR AND DISEASE

- evaluate issues relevant to vaccination
- recognise aspects of science, engineering and technology within careers associated with disease
- comment on the use of nanotechnology in medicine
- consider how the values and needs of contemporary society can influence the focus of scientific research

eBookplus

DIGITAL RESOURCES



ANSWERS for this chapter can be found online in your eBookPLUS.

Online section

This section of the chapter can be found online in your eBookPLUS.

4.11 Thinking tools: Cycle maps and relations diagrams

eBookplus
ONLINE ONLY

Individual pathways

Activity 4.1
Revising the body at war
doc-8440

Activity 4.2
Investigating the body at war
doc-8441

Activity 4.3
Investigating the body at war further
doc-8442

FOCUS activity

Access more details about focus activities for this chapter in your eBookPLUS.
doc-10634

eLessons

Killing Australians

Learn about the leading causes of death in Australia.

Searchlight ID: eles-0069

Mystery of the flesh eaters

Watch an ABC *Catalyst* video about flesh-eating bacteria.

Searchlight ID: eles-1082

Understanding HIV

In this eLesson, you will find out what HIV is, how it can be contracted and the ways in which the disease is treated.

Searchlight ID: eles-0125

Immunisation in Australia

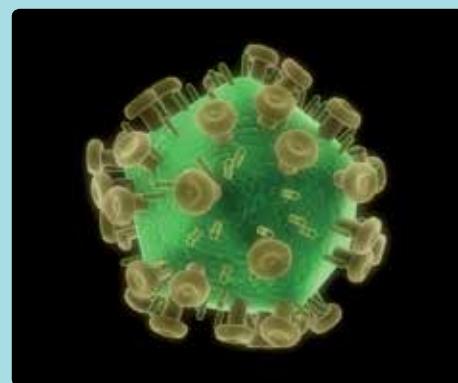
Not just a shot in the arm! Here you will see how immunisation helps your body to fight diseases and the vital part that it plays in the public health of the entire community.

Searchlight ID: eles-0126

Leonardo's sketches and anatomy

Watch a video from *The story of science* about anatomy.

Searchlight ID: eles-1769



LOOKING BACK

- 1 Construct your own summary mind maps or concept maps on the following topics, using the terms suggested below (as well as any others that may be relevant).
- Infectious disease: contagious, infected, pathogen, cellular pathogens, non-cellular pathogens, quarantine, direct contact, vectors, contaminated objects, contaminated water, sneezing, coughing, physical contact, antibiotics, personal hygiene, tapeworms, head lice, fungi, protozoans, bacteria, viruses, prions
 - Pathogens and parasites: parasite, host, primary host, intermediate host, endoparasite, ectoparasite, pathogen, non-cellular pathogen, cellular pathogen, prions, Kuru, mad cow disease, viruses, obligate intracellular parasites, mumps, AIDS, warts, influenza, bacteria, coccus, bacillus, *Streptococcus*, cholera, pneumonia, typhoid, whooping cough, Gram stain, protozoans, malaria, amoebic dysentery, fungi, tinea, ringworm, thrush, worms and arthropods, tapeworm, liver fluke
 - Putting up defences: lines of defence, first line of defence, second line of defence, third line of defence, antigen, non-self, specific, non-specific, physical barriers, chemical barriers, inflammation, phagocytosis, phagocytes, white blood cells, inflammation, cilia, skin, acid, enzymes, nasal hairs, sneezing, coughing, lymphocytes, B lymphocytes, plasma cells, antibodies, T lymphocytes, lymphatic system, lymph, lymph vessels, memory cells
 - Immunity: vaccine, vaccination, immunisation, active immunity, passive immunity, artificial immunity, natural immunity, antibodies, active natural immunity, active artificial immunity, passive natural immunity, passive artificial immunity
- 2 Anthrax, cholera, botulism, smallpox and Ebola are examples of diseases with potential as biological weapons. Although these infectious agents have been used as weapons for centuries, advances in technology have accelerated their threat to large populations.
- Find out more about one of these diseases.
 - In your group, discuss and identify specific problems or threats relevant to your disease.
 - Discuss what you would do to minimise the impact of a possible bioterrorist threat using this disease.

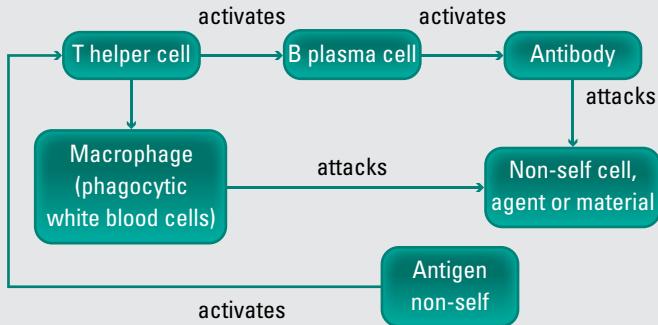


Sores develop 1–3 days after anthrax infection through the skin. These sores start as small red swellings and develop into black depressions.

Link to assessON for questions to test your readiness **FOR** learning, your progress **AS** you learn and your levels **OF** achievement. www.assesson.com.au

- Design equipment and protective clothing that may help protect you from this disease, and make a model of these.
- Create a training video showing the procedures you would use in the event of such an attack.
- Write a story that describes the history and consequences of an imaginary bioterrorist attack.

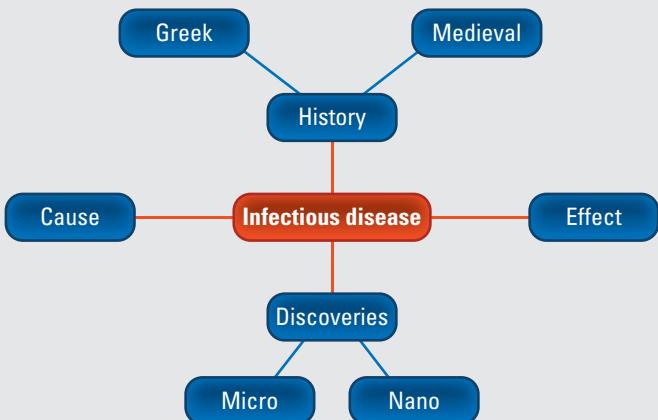
- 3 Write a story about how non-self material passes through the first line of defence and then how the second and third lines of defence work together against attack. Use the diagram below to help develop some of the characters in your story.



- 4 Imagine that you are employed as a member of a team with the responsibility of public health in your community. Either on your own or in your team, design a plan of attack for each of the scenarios below, including how you would communicate to others what you were doing and why, and how you would implement it.

- About a third of the parents in your community refuse to get their children immunised against whooping cough.
- Five families living in different areas of your community have severe food poisoning.
- A child in one of your schools (who has just returned from an overseas holiday) has been diagnosed with swine flu.
- One of your colleagues has broken out in a red rash, but refuses to go home.

- 5 Use the figure below as a framework to construct a summary of this chapter.



- 6 Design an experiment that would show which disinfectants and antiseptics are most effective against the growth of bacteria in your kitchen.
- 7 Select your favourite scientist from the past. Find out more about them and then write and perform a speech that they might have given to their colleagues or scientific community. If possible, make a recording of your speech to share with others.
- 8 Claims that the MMR vaccine resulted in autism in some children led to a measles epidemic. Follow this story and discuss your opinion with others. Organise a class debate about whether there is evidence to support this claim.
- 9 Examine the cluster map below. Find out where the words in the top box fit in the map. Then create your own Venn diagrams, relations diagrams, cycle maps, concept maps or mind maps of what you have learned in this chapter.

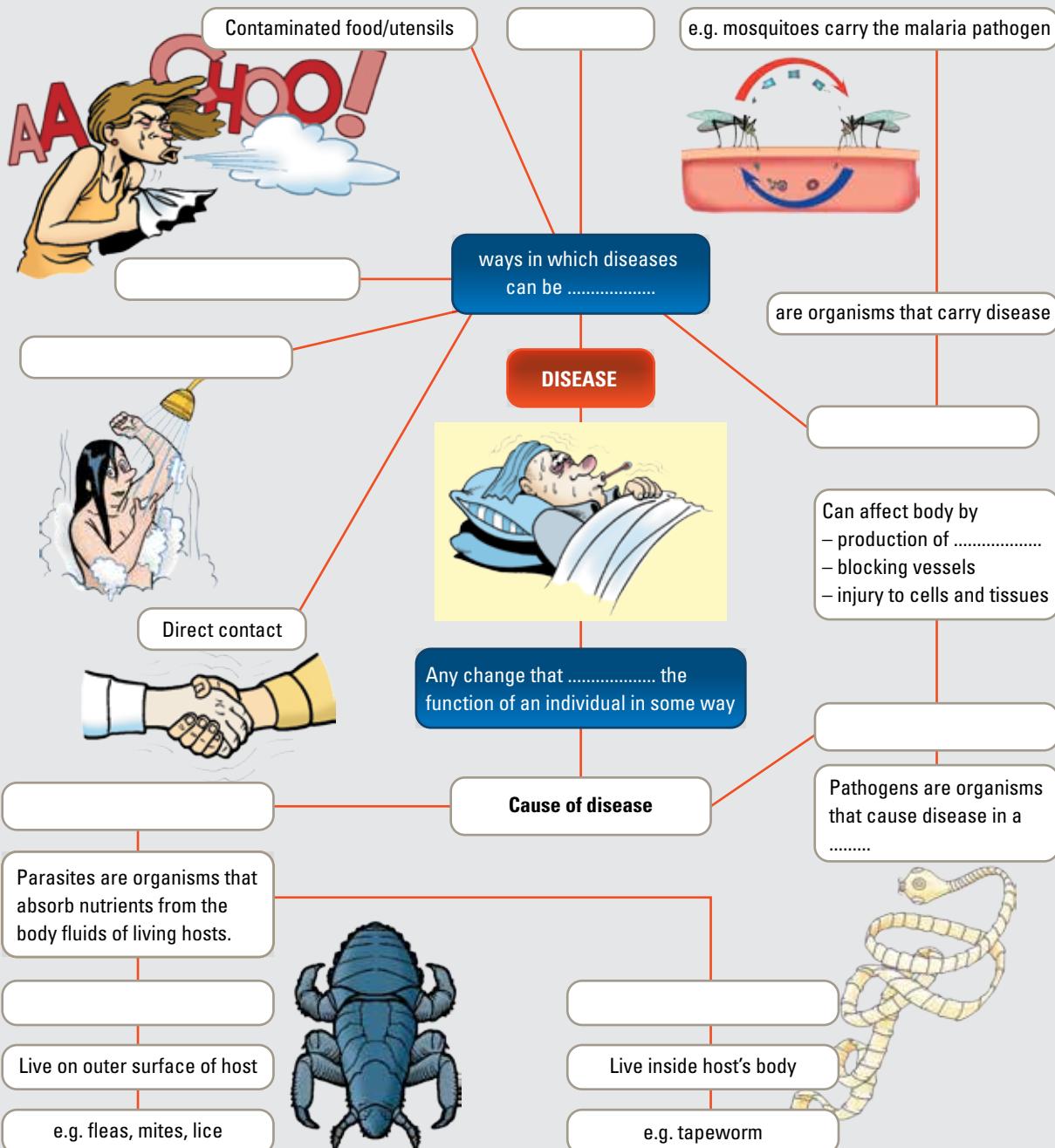
| | | |
|---------------|---------------|----------|
| water | endoparasites | toxins |
| ectoparasites | transmitted | pathogen |
| air | impairs | blood |
| vectors | parasites | host |

work
sheets

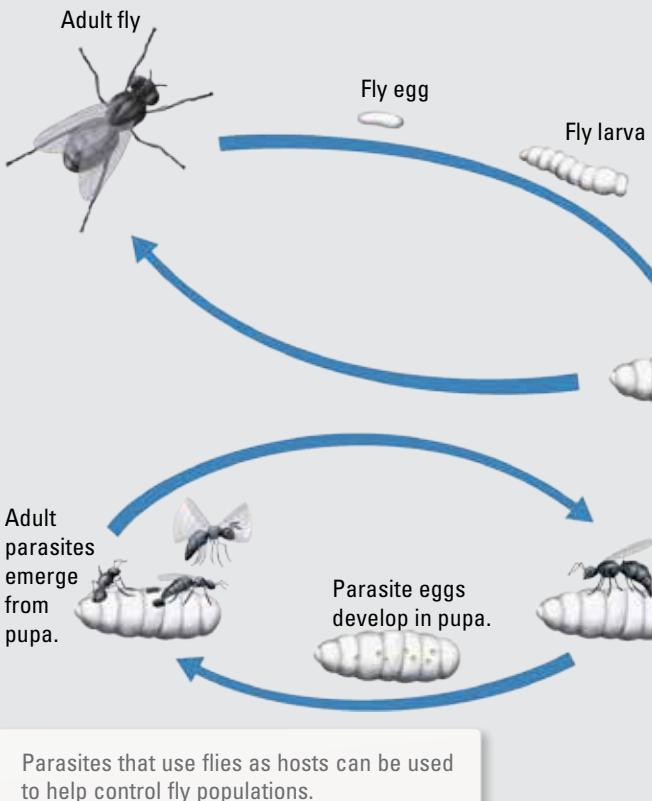
4.5 The body at war: Puzzle

4.6 The body at war:
Summary

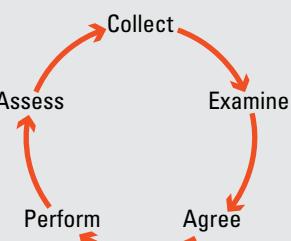
eBookplus



- 10** Use a cycle map or a relations diagram to outline how:
- infection can be spread within a community
 - you can become infected by a pathogen or parasite
 - your body fights disease
 - the spread of disease can be prevented.
- 11** In a team, construct relations diagrams for the following problems and situations.
- In one week, 80 per cent of the Australian population develops a rash and flulike symptoms.
 - Within one month, all cats in Australia die.
 - Over a 48-hour period, all people within 10 km of Melbourne lose their hair.
 - In a six-month period, no-one dies in Australia.
- 12** Biological control is a method of using one living organism to control another by interfering with its life cycle in some way. An example of this is using parasites to control fly populations. Use the diagram below to answer the following questions.
- At which stage in the life cycle of the fly do the parasites invade?
 - Suggest how the use of this method may control the fly population.
 - Find out more about the use of biological control to reduce fly populations.
 - Research two other types of biological control and find out which stage of the pest's life cycle they affect.

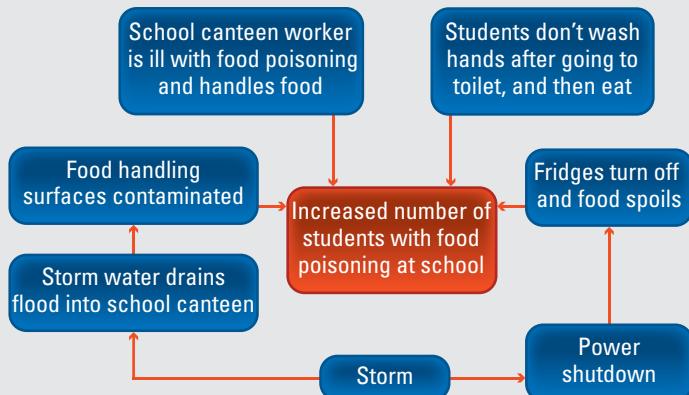


- 13** Cycle maps can also help you to organise your tasks and project time. Examine the cycle map at right and discuss with your team-mates how this could help you develop your team skills.



Team meeting cycle map

- 14** (a) Observe the relations diagram below.
 (b) Suggest other causes that could lead to the problem of increased numbers of students with food poisoning.
 (c) Suggest actions that could be taken to reduce or prevent these causes resulting in an increase of student illness.



- 15** Read the paragraph below on Gram stains and bacteria. Summarise the information as either a cycle map or a relations diagram.

HOW ABOUT THAT!

In 1884, Joachim Gram (a Danish bacteriologist) developed the Gram stain. This stain divides bacteria into two groups on the basis of the chemical composition of their cell wall. Gram-positive bacteria take up the purple colour of the stain, whereas Gram-negative bacteria don't take up the stain, and therefore stain pink. This information can be used to determine which antibiotics would be most effective in killing them. Gram-positive bacteria are generally more susceptible to penicillin and sulphonamide drugs and Gram-negative bacteria are more susceptible to other types of antibiotics such as streptomycin and tetracycline.