4 Systems — living connections

Inside your body is a very busy place. The many complex processes need energy. To convert energy into a form you can use requires transport highways to take nutrients to where they are needed and to carry wastes away. Different parts of your body have different jobs to do — they may work together and rely on each other. It is because of the curiosity, imagination, passion and persistence of humans throughout history that we know today what we do about our bodies and how they function. What sort of questions do you have about what is inside your body and how it works? What exciting new discoveries will scientists make about our bodies in the future?

OVERARCHING IDEAS

- Patterns, order and organisation
- Form and function
- Stability and change
- Systems

SCIENCE UNDERSTANDING

Multicellular organisms contain systems of organs that carry out specialised functions that enable them to survive and reproduce.

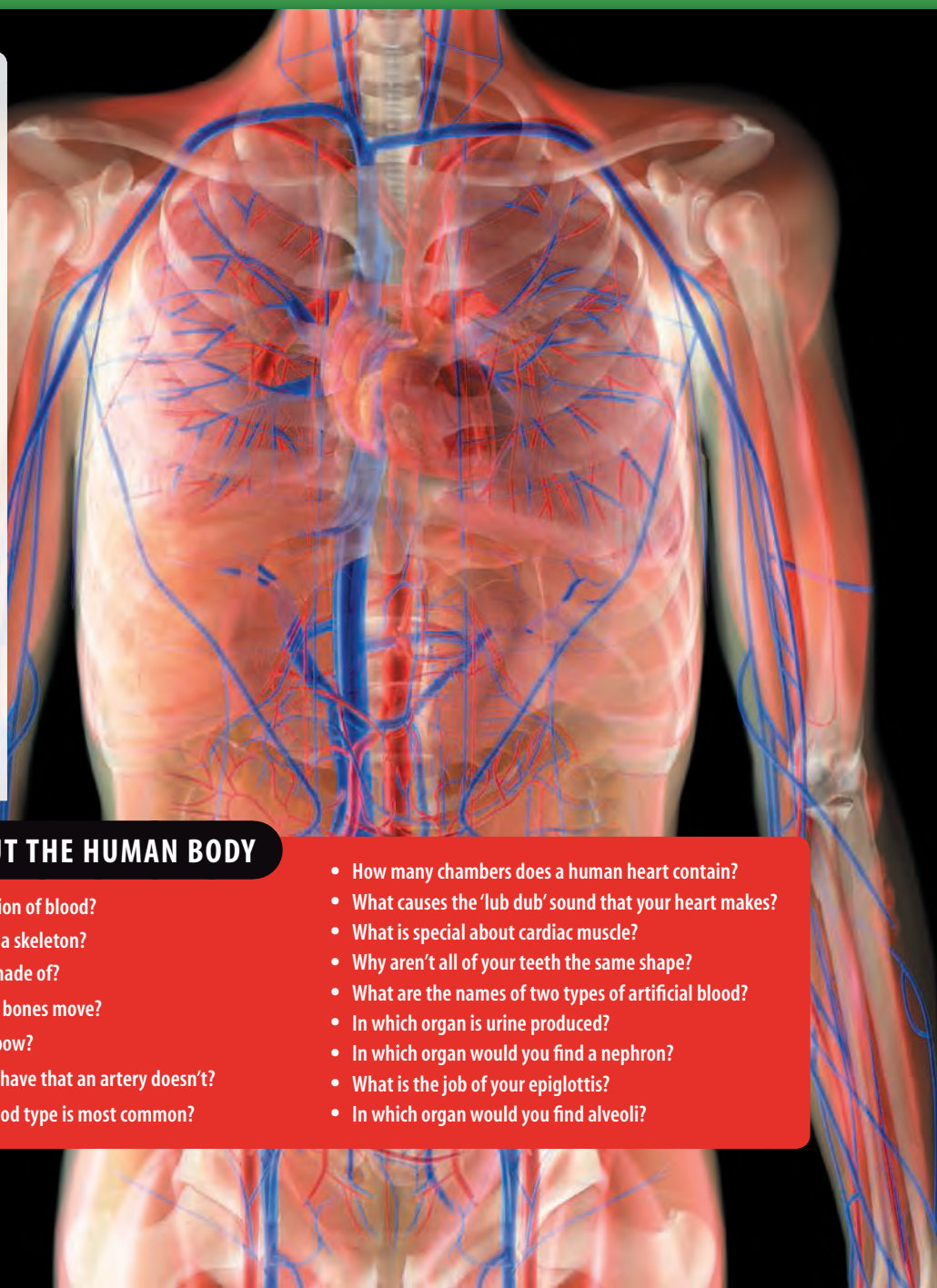
Elaborations

Identifying the organs and overall function of a system of a multicellular organism in supporting the life processes

Describing the structure of each organ in a system and relating its function to the overall function of the system

Examining the specialised cells and tissues involved in structure and function of particular organs

Comparing similar systems in different organisms such as digestive systems in herbivores and carnivores, respiratory systems in fish and mammals



Outside looking in — the human body

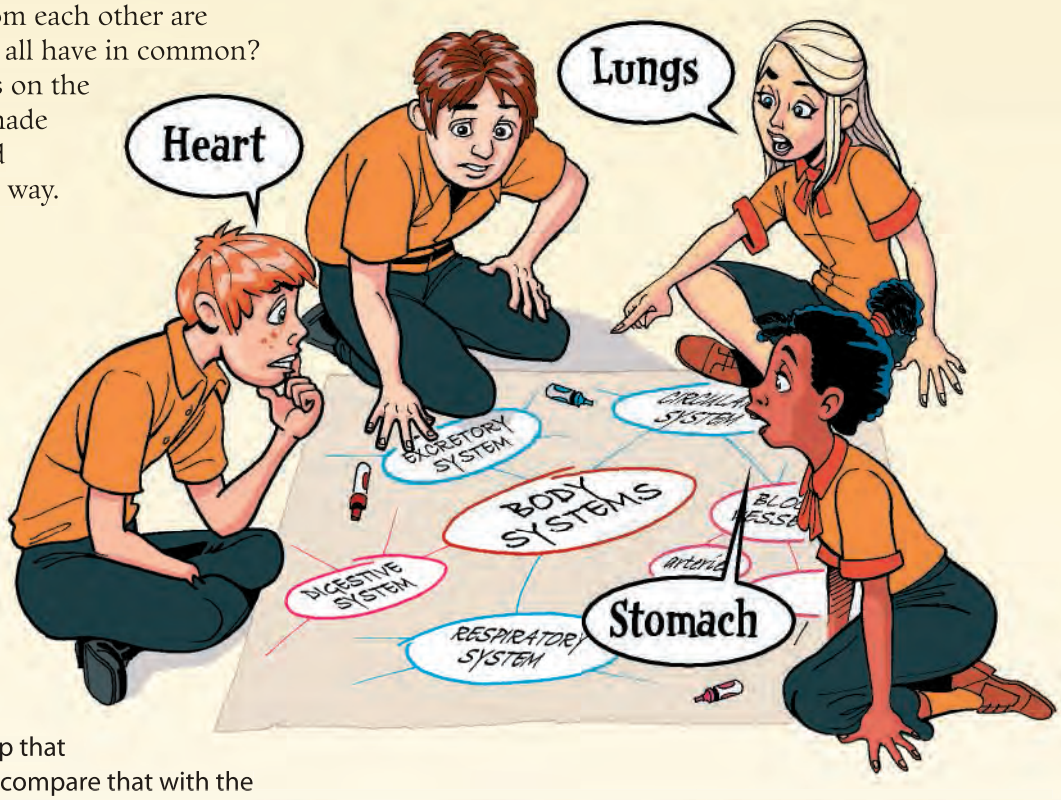
THINK ABOUT THE HUMAN BODY

- What is the function of blood?
- Why do you need a skeleton?
- What are bones made of?
- What makes your bones move?
- What is tennis elbow?
- What does a vein have that an artery doesn't?
- Which human blood type is most common?
- How many chambers does a human heart contain?
- What causes the 'lub dub' sound that your heart makes?
- What is special about cardiac muscle?
- Why aren't all of your teeth the same shape?
- What are the names of two types of artificial blood?
- In which organ is urine produced?
- In which organ would you find a nephron?
- What is the job of your epiglottis?
- In which organ would you find alveoli?

YOUR QUEST

Getting below the surface

Have a look at the other students in your classroom. How different from each other are you? Which features do you all have in common? Perhaps there are differences on the outside, but inside you are made up of all of the same bits and pieces organised in the same way.



THINK AND CREATE

Some of the things that you have in common with your other classmates are your body systems.

1 Use a mind map to summarise all that you know about human body systems.

2 Compare your mind map with those of at least three team members.

3 Create a new team mind map that combines all your ideas and compare that with the mind map of another team. Add any comments that you think help you learn more about human body systems.

THINK AND INVESTIGATE

4 In your team, make a list of ten questions about human body systems. Select four questions and place these on the class noticeboard with those of other teams to make a 'class question gallery'. Arrange these questions into groups or themes.

5 Browse the class question gallery and select one question that interests you most. Research your selected question and report back to the class on your findings in an interesting and creative way.

Driven by curiosity?

Imagine if your curiosity was so intense that you spent hour upon hour painstakingly exploring, sketching and recording layer upon layer of a rotting dead body among other decaying and quartered corpses in the 'dead of night'.

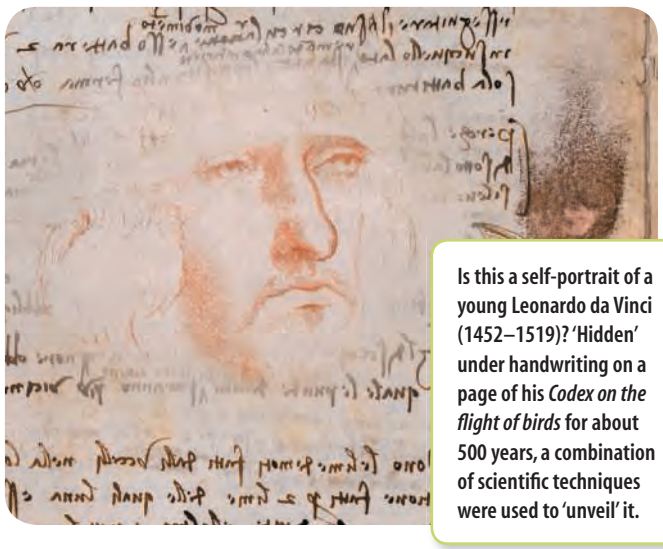
Leonardo da Vinci spent hours amid rotting corpses to draw amazingly detailed observations of body structures.

Intensely curious . . .

> . . . in the medical faculty he learned to dissect the cadavers of criminals under inhuman, disgusting conditions . . . because he wanted [to examine and] to draw the different deflections and reflections of limbs and their dependence upon the nerves and the joints. This is why he paid attention to the forms of even very small organs, capillaries and hidden parts of the skeleton.
>
> Paolo (the first biographer of Leonardo da Vinci), 1520

Leonardo da Vinci was arguably one of the best scientific minds of his time. He was intensely curious and painstaking in his observations. He used close observation, repeated testing and precise illustrations with explanatory notes. Using pen, chalk and brush, his scientific illustrations offered visual answers to mysteries that had escaped others for centuries. His volumes of amazing notes of scientific and technical observations in his handwritten scripts led to the birth of a new systematic and descriptive method of scientific study.

Leonardo da Vinci questioned everything. He may have been the most relentlessly curious man in history. He asked questions such as: Why do birds fly? Why can seashells be found in mountains? What is the origin of the wind and clouds? Why do people die? Where is the human soul found?



Is this a self-portrait of a young Leonardo da Vinci (1452–1519)? 'Hidden' under handwriting on a page of his *Codex on the flight of birds* for about 500 years, a combination of scientific techniques were used to 'unveil' it.

Dissecting, details and drawing

Leonardo's anatomical studies of human muscles and bones began around 1490. His exploration of embryology and cardiology came later, with his astonishingly detailed image of a fetus within the womb (around 1505) providing details for obstetric surgery hundreds of years later. His observations were not just of bodies — later generations have been in awe of his sketches of inventions that were centuries ahead of their time.

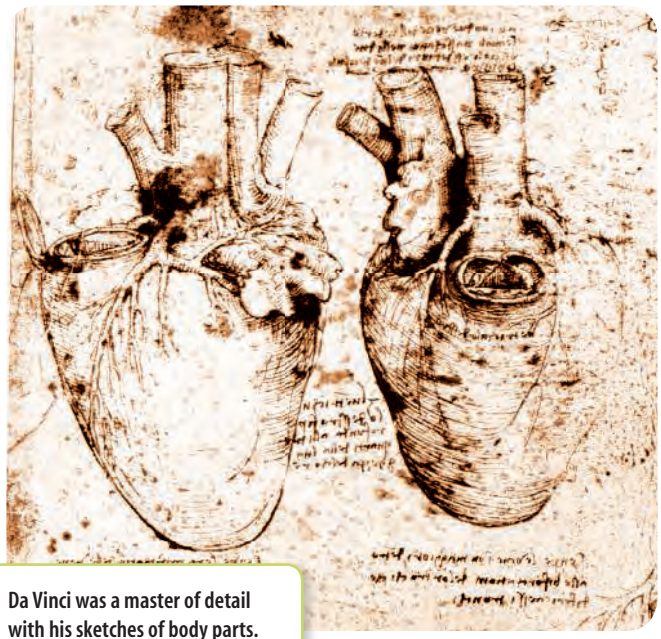
Challenging 'knowledge'

Knowledge of the human body was very different in Leonardo's day from what we accept today. The heart was thought to be made up of two chambers and its function to warm the blood, which was thought to be made in the liver. It was also thought that sperm were produced in the marrow of the spinal column and that the human soul may be located in the spine. Leonardo had questions he wanted to answer. He wanted to find out more. His investigations challenged the accepted knowledge of his day.

Visions and models

Leonardo also emphasised the significance of visual observations and model making — he believed that reality needed to be reconstructed before it could be represented. His models of hands or legs were used to reveal the structural relationships between different layers of arteries, muscles and bones. Leonardo also made a glass model of the heart and used

Leonardo drew this diagram around 1510 — can you see his secretive, reversed form of handwriting?



Da Vinci was a master of detail with his sketches of body parts.

water with different coloured dyes to trace its flow through the heart. His investigations linked anatomy (structure) and physiology (function).

Analogies are sometimes used to help people to connect new learning to previous knowledge. Leonardo used analogies to compare arteries in human bodies to 'underground rivers in the earth' and described the bursting of blood from a vein like 'water rushing out a burst vein of the earth'.

Leonardo's dissections led to changes in the knowledge and understanding about the structure and function of the heart, including that:

- the heart was a muscle
- the heart did not warm the blood
- the heart had four chambers
- left ventricle contractions were connected to the pulse in the wrist.

To locate cavities around the brain and cranium Leonardo used innovative techniques, such as injecting molten wax into them. Although Leonardo did not find the location of the human soul, his studies led him to the discovery that the brain and spine were connected.

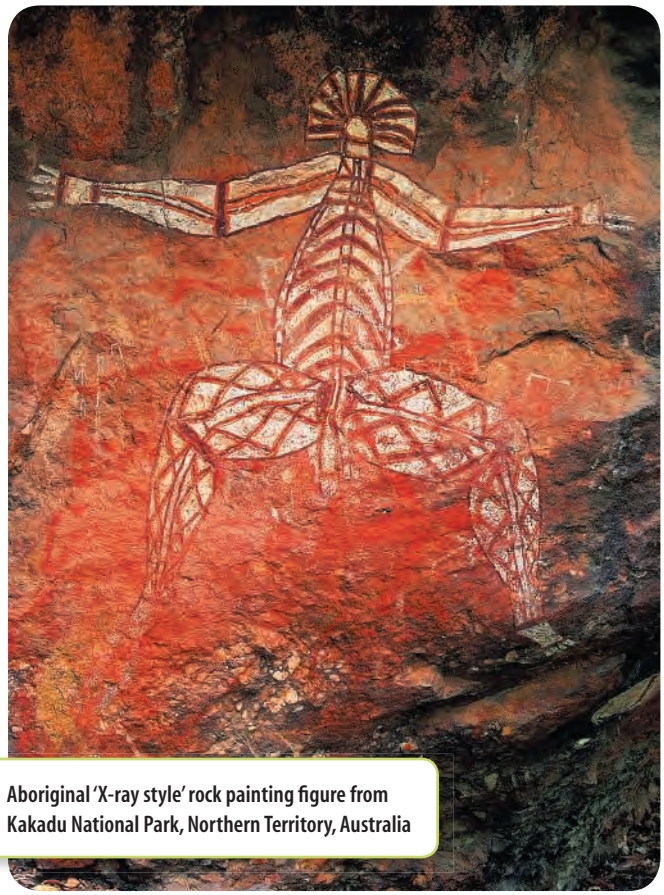
Leonardo's curiosity, determination, creativity and persistence did more than make an amazing contribution to our current scientific knowledge of our bodies. These features also helped mould the way in which scientific frameworks were developed to structure our investigations to explore our questions.

Curiosity throughout time and space

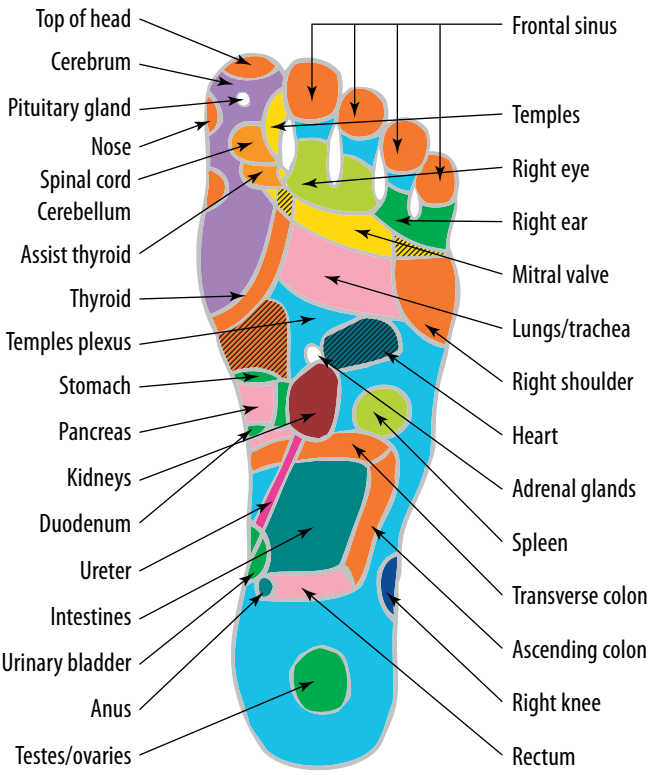
Curiosity is one of the features of humans that have contributed to our survival. Some of this curiosity has been about the structure and function of our own bodies. Evidence of this curiosity is woven throughout history and is often found in art. While Leonardo da Vinci provides one example of curiosity driving a search to find out more, it is not the only example. Nor is human curiosity limited to the place or time in which you live.

Knowledge of the internal biology and physiological process in art appears in rock paintings in caves in Australia that are thousands of years old. Examples of Aboriginal X-ray art also provide evidence that this type of knowledge dates back to more than 6000 years ago.

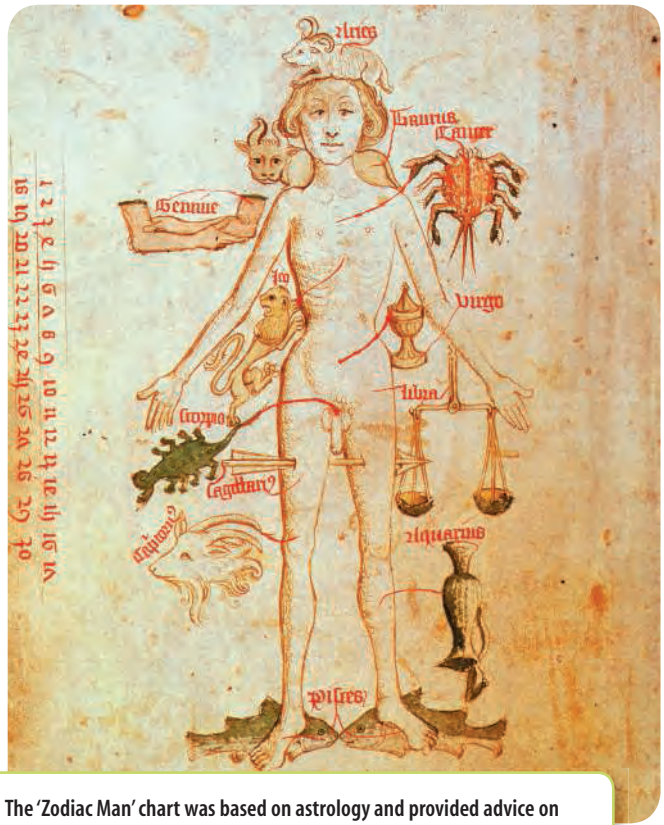
The culture and scientific knowledge of the times often determines the types of treatment given for various diseases of the human body. In medieval times, astrology played a key role in medicine and medical prognosis. It was believed that the 'movement of the heavens' could influence human physiology, with each part of the body being associated with a different astrological sign. An image of the 'Zodiac Man' in the medical texts of the time was used to assist practitioners in their medical treatments.



Aboriginal 'X-ray style' rock painting figure from Kakadu National Park, Northern Territory, Australia



An example of an acupressure reflexology chart



The 'Zodiac Man' chart was based on astrology and provided advice on when, for example, to 'bloodlet' (a medical treatment involving bleeding the patient), regulated by the position of the moon.

Chinese traditional medicine is an ancient medical system that has been practised for over five thousand years and applies understanding of the laws and patterns of nature to the human body. It views health as the changing flow throughout the body of vital energy (*qi*) that, if hindered, can lead to illness. Acupressure is an application of this practice that aims to release blocked energy by stimulating specific points along the body's energy channels.

Scientists are curious

Scientists are also often driven by the thirst to find answers to their questions. With increased technology and knowledge, the answers to these questions often result in even more questions.

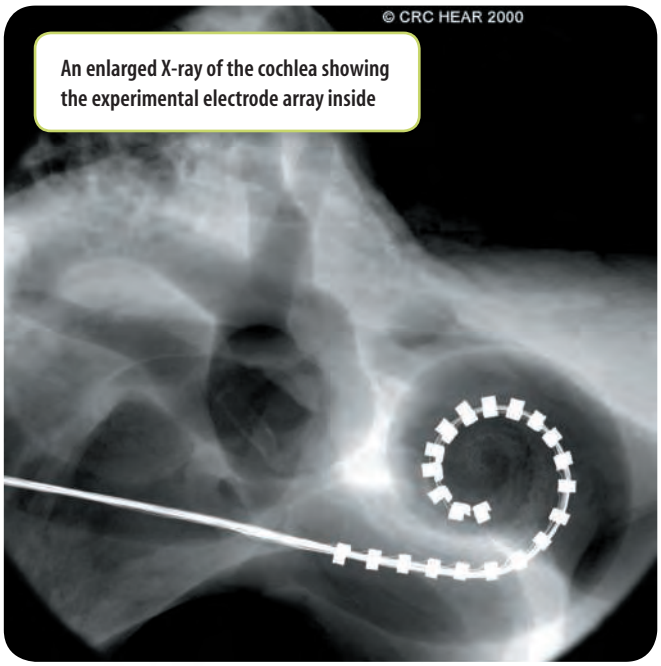
Compared with the situation in Leonardo's day, there are now an amazing number of different types of careers that involve investigations, explorations and applications of science to the human body. Australian scientists are involved in medical research and intervention. They are also involved in the invention and development of medical equipment that assists in the development and understanding of our body systems.

Australian scientists: creative inventors and explorers

Australian scientists have made significant contributions to medical discoveries and inventions. Howard Florey and his team discovered how penicillin could be extracted, purified and produced to be used as an antibiotic to help fight bacterial infections. Barry Marshall and Robin Warren showed that a certain type of bacteria caused stomach ulcers that could be treated with antibiotics. Professor Graeme Clark and his team were involved in the invention of an effective 'bionic ear'. Dr Fiona Wood pioneered a new treatment for burns in her development of spray-on skin that used the patient's own skin cells. Professor Ian Frazer developed the world's first vaccine against cervical cancer.

THE BIONIC EAR

The cochlear implant, also known as the bionic ear, has allowed some people with inner-ear problems to hear sound for the first time. When deafness results from serious inner-ear damage, no sounds are heard at all. Normal hearing aids, which make sound louder, do not help in these cases because the cochlea cannot detect the vibrations. However, the cochlear implant can often help by changing sound energy from outside the ear into electrical signals that can be sent to the brain.



An enlarged X-ray of the cochlea showing the experimental electrode array inside

Dr Jin Xu

DAVID UNAIPON

David Unaipon (1872 –1967) has been described as 'Australia's Leonardo'. He was born in South Australia, the fourth of nine children of James Ngunaitponi and his wife Nymbulda. Both of David's parents were Yaraldi speakers from the lower Murray River region.

Interested in Aboriginal mythology, philosophy and science, David was a preacher, author and inventor. He compiled his own versions of Aboriginal legends such as *Hungarrda* (1927), *Kinie Ger — The Native Cat* (1928) and *Native Legends* (1929). David's published poetry and legends pre-dated the work of other Aboriginal writers by over thirty years.

Obsessed with discovering the secret of perpetual motion, David made ten patent applications between 1909 and 1944 for inventions including a modified handpiece for shearing, a centrifugal motor, a multiradial wheel and a mechanical propulsion device.

David Unaipon

UNDERSTANDING AND INQUIRING

INVESTIGATE

1 Research and construct a model of an invention from one of Leonardo da Vinci's sketches.

2 Research examples of Leonardo da Vinci's inventions and make your own variation of one of them, presenting it as a series of annotated sketches.

3 Research an invention sketch by Leonardo da Vinci that is related to something that we use today. Use a tree diagram to show how it may be linked.

4 Find out what the *da Vinci*® Mitral Valve Repair is and suggest why it is named after da Vinci.

5 Find out about the history behind *Treatise on painting* and how it relates to science.

6 Find out more about *Codex on the flight of birds* and summarise your findings in a newspaper article.

7 Research three Australian scientists involved in medical research and intervention and present your findings as curricula vitae.

8 Find an example of how Australian scientists have been involved in the development of medical equipment. Produce a brochure to advertise this equipment to prospective buyers.

9 Suggest how scientific understanding of human body systems can determine how we respond to public health issues such as the 2009 swine flu pandemic.

10 Research traditional Chinese medicine and find out about the knowledge of the structure and function of human body systems. Present your findings in a scroll with wooden sticks at each end.

11 Research two of the following applications of traditional Chinese medicine:
- Qigong
- herbal therapy
- acupressure
- healing foods
- Chinese psychology.

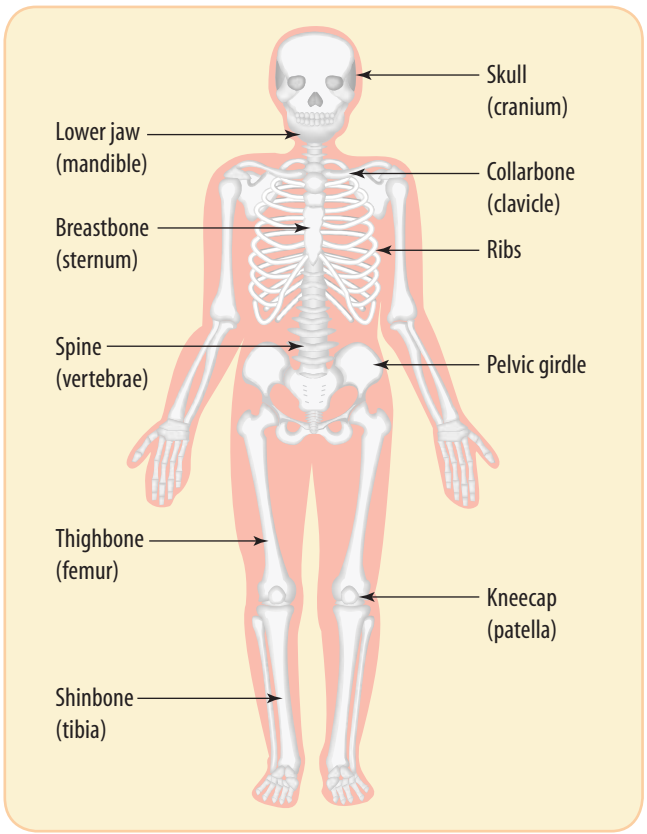
12 Research Aboriginal X-ray art to investigate examples of Aboriginal knowledge of the internal biology and physiological processes of animals.

13 The Warlpiri are one of the largest Aboriginal groups in the Northern Territory. Research and report on their traditional health system and the involvement of ngangkayikirili (or ngangkari or ngangkayi) and Yawulyu ceremonies of the Warlpiri.

14 Research and report on the processes involved in the preparation of mummies in ancient Egypt. Include what happened to specific body organs and why.

Keeping in shape

Without your skeleton you would resemble a jelly-like blob! Your **skeleton** provides support and forms a frame that gives your body shape. It also protects the organs inside your body and with the help of muscles allows you to move.



What's in a bone?

The **bones** that make up your skeleton are alive. They contain living cells and need a blood supply to provide oxygen and other nutrients. If bones were not alive, how would you grow taller? How would a broken arm or leg mend?

The soft **cartilage** that made up your skeleton when you were born is gradually replaced over the first twenty years of your life. Cartilage is very soft and rubbery — it is not as hard or solid as bone. Not all cartilage changes into bone. The ends of your bones remain covered in cartilage, and your trachea (windpipe), nose and ears are made mostly of cartilage.

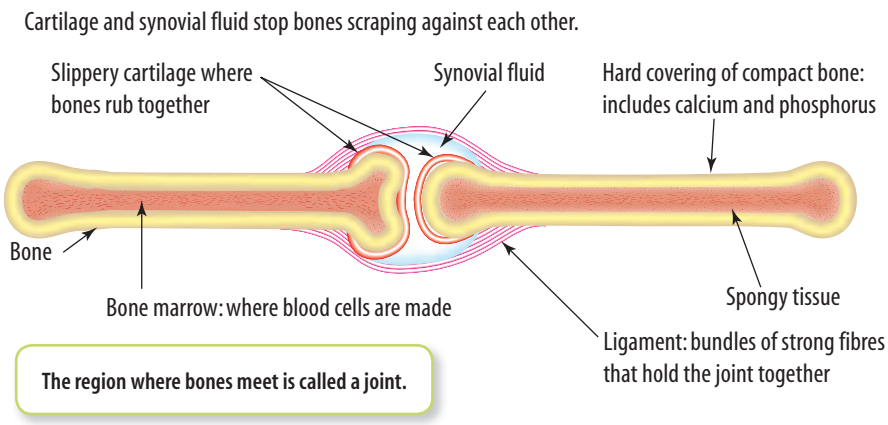
To remain hard, your bones need an adequate supply of two important **minerals**: **calcium** and **phosphorus**. Vitamin D is also important for healthy bone development and strength. Investigation 4.1 on the next page shows what could happen to your bones without a supply of these important minerals.

The hardening of your bones as you get older is called **ossification**. After ossification, the bone is made up of about 70 per cent non-living matter and 30 per cent living matter. As you get even older, your bones may get dry and **brittle**. That is why older people break their bones more easily.

Broken bones

When a bone breaks, the ends of the bone need to be put back into place (set) so that they can grow together. If a bone is shattered into several pieces, it is sometimes possible to use pins or wire to hold the pieces in place while the bone heals. A **greenstick fracture** occurs when the bone cracks but does not break. This type of **fracture** is common in children because their bones are more flexible.

New technologies are being researched and developed to help fix broken bones. Some of these involve special cells called **stem cells**, while others involve the use of special 'glues' that hold the bones together and aid the healing process. Scientists at CSIRO are currently working on a liquid gel called NovoSorb that glues the fractured bone together so



that it is supported while it heals. As this gel degrades naturally, it does not require follow-up surgery to remove pins as is needed with older technologies.

Osteoporosis

Osteoporosis is a loss of bone mass that causes bones to become lighter, more fragile and easily broken. It occurs in middle-aged or elderly men and women. In Australia, about 60 per cent of women and about 30 per cent of men are affected by osteoporosis. It is believed to be caused by lack of calcium in the diet.

In your teenage years, you can help protect yourself from getting osteoporosis later in life by having a healthy diet and exercising. Your diet should include dairy products such as milk, cheese and yoghurt and other foods high in calcium. Such a diet will help ensure that your bone mass is adequate as an adult.

Joints

The bones in your skeleton must be able to move so that your body can move. Bundles of strong fibres called **ligaments** hold your bones together. The region where two or more bones meet is called a joint. Most joints allow your bones to move. The amount and direction of movement allowed depends on the type of joint.

Some joints, such as those that join the plates in your skull, do not move. Such joints are called **immovable joints**. While not allowing movement, these joints provide a thin layer of soft tissue between bones. Their job is to absorb enough energy from a severe knock to prevent the bone from breaking.

INQUIRY: INVESTIGATION 4.1

Rubbery bones

KEY INQUIRY SKILLS:

- planning and conducting
- processing and analysing data and information

Equipment:

2 chicken or turkey bones *2 jars* *vinegar*

- Clean the two chicken or turkey bones and leave them to dry overnight. Place one bone in a jar of vinegar and the other in a jar of water.
- Allow the bones to soak for at least three days. Then remove the bones and observe any changes.

Vinegar is an acid and dissolves minerals such as calcium and phosphorus, removing them from the bone.

- Return the bone to the jar of vinegar for another week, then remove and observe any further changes in the bone. Try to tie the bone in a knot.

DISCUSS AND EXPLAIN

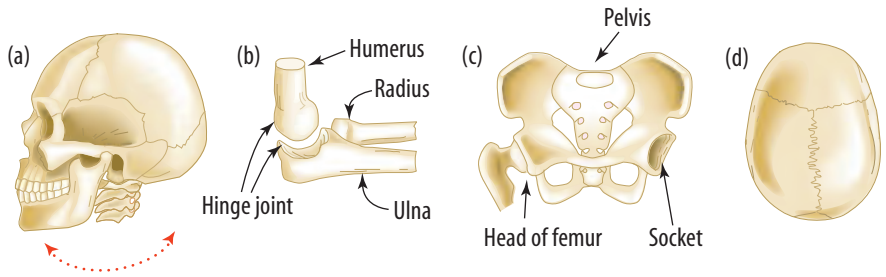
1 What changes occurred in each of the two bones?
2 How did the bone change after more than a week in vinegar?
3 Why was the jar of water used in the first part of this experiment?

Muscles

Tough, elastic fibres called **muscles** are connected to the bones of your skeleton by bundles of tough fibres called **tendons**. Muscles pull on bones by **contracting**, or shortening. Muscles never push.

CONTROL OF MUSCLES

The movement of muscles is controlled by the brain, which sends signals through your nerves.

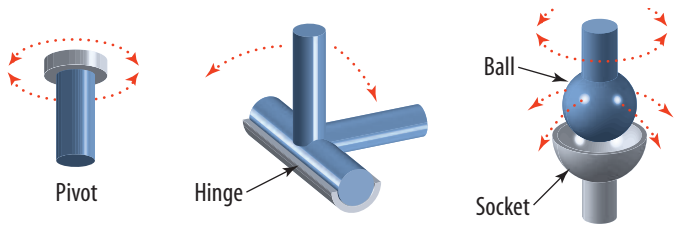


The joint between your skull and spine is a **pivot joint**, allowing a twisting type of movement.

Your knees and elbows are **hinge joints**, like those in a door, allowing movement in only one direction.

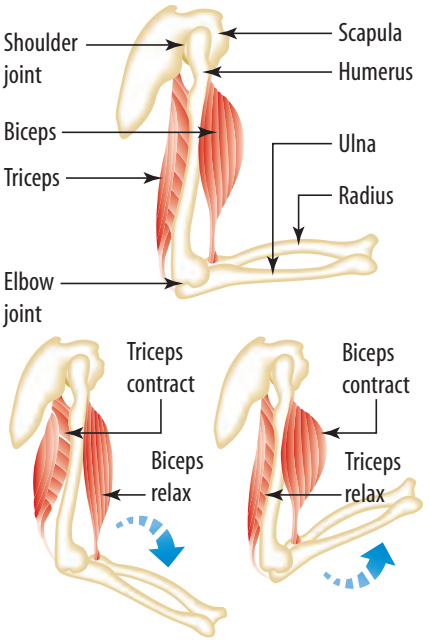
Your hip and shoulder joints are **ball and socket joints**, allowing movement in many directions.

Joints such as those between the plates of the skull are immovable joints.



Different types of joints:
(a) pivot joint
(b) hinge joint
(c) ball and socket joint
(d) immovable joint

Muscles such as those that make your heart pump and those that control your breathing are called **involuntary muscles**. They work without you having to think. The muscles that are connected to bones are called **voluntary muscles** because you have to choose to use them.



When your biceps contract, your arm bends upwards. When your triceps contract, your arm straightens.

OUCH!

- **Sprains** occur when ligaments joining bones at a joint are torn or stretched. Sprains usually happen when you fall onto a joint, such as an elbow or an ankle, and twist it.
- **Arthritis** is a swelling of the joints that makes movement difficult. Osteoarthritis occurs mainly in elderly people and is caused by the wear and tear of the joints. The cartilage gradually breaks down, thus allowing bare bones to grate against each other instead of sliding or turning smoothly. Rheumatoid arthritis is a swelling of the tissue between the joints. The swelling causes the joints to slip out of place, which then causes great pain and deformities.
- **Tennis elbow** is caused when the lining of the elbow joint swells and produces too much synovial fluid. The joint becomes swollen and painful. This occurs when the joint is used a lot and is most common in tennis players.

Torn hamstrings are a common but painful sporting injury.

- **Torn hamstrings** are a common sporting injury. The hamstring muscle joins the pelvis to the bottom of the knee joint, running along the back of the thigh. It controls the bending of the knee and straightening of the hips. A sudden start or turn in sport often stretches the hamstring muscle too far. It tears, causing great pain. Cold and unprepared muscles are more likely to tear. Proper warming up before strenuous sporting activity is one way of reducing the chances of tearing a muscle.

INQUIRY: INVESTIGATION 4.2

Chicken wing dissection

KEY INQUIRY SKILLS:

- planning and conducting
- processing and analysing data and information

Equipment:

chicken wing	*dissection tray or board*
scalpel	*newspaper*
scissors	*disposable gloves*

- Using the scissors and scalpel, gently pull away the skin from the chicken wing. Put the tip of the scalpel blade between the skin and the muscle to separate the skin from the muscle.
- When you have completely removed the skin from one joint, inspect it carefully. Follow each muscle near this joint from one end of the muscle to the other. Try pulling on the muscle. Can you get the bones to move by pulling on the muscle?
- Use scissors to cut through the joint. As you do so, look for tendons and shiny white cartilage.

DISCUSS AND EXPLAIN

1. Sketch one of the joints in the chicken wing. Label the bones, the tendons and the muscles. Show clearly where the muscle inserts (attaches to the bones). Use arrows to show how the bones move when the muscle is shortened.
2. Feel the cartilage with a gloved hand. Does the cartilage feel rough or slippery? Why does it need to be slippery?
3. Is cartilage harder or softer than bone?

INQUIRY: INVESTIGATION 4.3

Inside or out?

KEY INQUIRY SKILLS:

- planning and conducting
- processing and analysing data and information

Equipment:

2 cardboard tubes, each at least 30 cm long

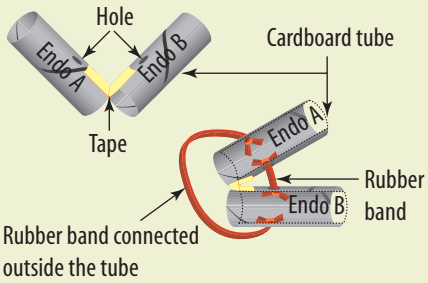
sticky tape

rubber bands

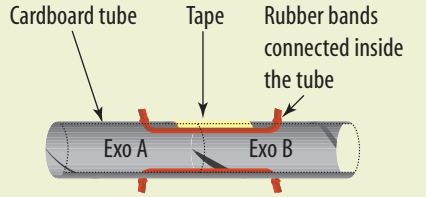
large nail or other pointed object

Being vertebrates, we have internal skeletons called endoskeletons. Many invertebrates (such as insects, spiders and crustaceans) have an external skeleton or exoskeleton. Make these models to investigate differences in how the muscles are joined to the skeletons.

- Cut each cardboard tube into two pieces about 15 cm long.
- Using the nail, make two holes on opposite sides of each tube. These should be about 5 cm from one end of each piece.
- Label two pieces 'Endo A' and 'Endo B' and the other two pieces 'Exo A' and 'Exo B'.
- Tape Endo A and Endo B together on one side, so that they form a hinge at the ends with the small holes.
- Cut two rubber bands and thread the cut ends through the holes from the outside.
- Tie knots so that the rubber bands can't pull back through the holes.
- Tape Exo A and Exo B together in the same way as Endo A and Endo B.
- Cut another two rubber bands and thread the cut ends through the holes so that they run *inside* the tube.
- Make sure that they are stretched very tightly, and then tie knots on the outside of the tubes.



The rubber bands are like the muscles in your arm. They are attached to the bones on either side of your elbow. The arm bends at the joint when the muscle contracts.



The rubber bands are like the muscles in an insect's limb. When a muscle contracts, the joint on which it operates straightens.

DISCUSS AND EXPLAIN

1. When one rubber band contracts, what happens to the one on the opposite side?
2. Draw sketches of each and record your observations when the joint is moved.
3. Describe how the two skeletons are different.

UNDERSTANDING AND INQUIRING

REMEMBER

1. Cover up the diagram of the human skeleton on page 119 and test your memory of the names of some of your important bones by completing the table below.

Scientific name	Common name
Vertebrae	
	Skull
Clavicle	
	Breastbone
Mandible	
	Thighbone
Patella	
	Shinbone

2. Describe the job done by each of the following parts of a joint.
   (a) Ligament
   (b) Cartilage
   (c) Synovial fluid
3. Some joints are referred to as immovable joints. What is the use of having joints that don't move?
4. Write down an example of each of the following types of joint.
   (a) Hinge
   (b) Ball and socket
   (c) Pivot
   (d) Immovable
5. Ligaments and tendons are bundles of tough fibres. What is the major difference between a ligament and a tendon?
6. Describe the action of the biceps and triceps muscles as you bend your elbow to raise your forearm.

THINK AND INVESTIGATE

7 Your **musculoskeletal system** consists of your **skeletal system** (bones and joints) and your **skeletal muscle system** (voluntary or striated muscle). Working together, these two systems protect your internal organs, maintain posture, produce blood cells, store minerals and enable your body to move.

Use information in this section and other resources to relate structural features to the functions of the following parts of these systems.

Part of system	Structural features	Function
Bones		
Cartilage		
Joints		
Skeletal muscles		

8. Find out more about the structure and function of skeletal, smooth and **cardiac muscle** tissue.

9 What is dietary rickets and how is it caused?

10 Look carefully at each of the skeletons below. Three of them are incomplete. Identify the incomplete skeletons and name the missing parts.

11 Apart from warming up just before a game, how do the best basketball and netball players reduce the likelihood of torn muscles and tendons?

12 What would happen if the cartilage in your knee joint wore out?

13 Research and report on one of the following science careers: orthopaedic surgeon, physiologist, physiotherapist, occupational therapist, rheumatologist, fitness trainer.

INVESTIGATE AND DISCUSS

14 (a) In teams of four, use a 'lucky dip' system to match each member of the team with one of the following topics.
- Deviated septum
- Broken nose
- Nose cancer
- Rhinoplasty

(b) Each member should investigate their topic and report their findings to their team.

(c) As a team, construct a cluster map or mind map to summarise the key points of your team findings.

(d As a team, select one of the four topics for further research. Brainstorm questions for your selected topic and research these questions.

(e) Report your team's findings to the class.

CREATE

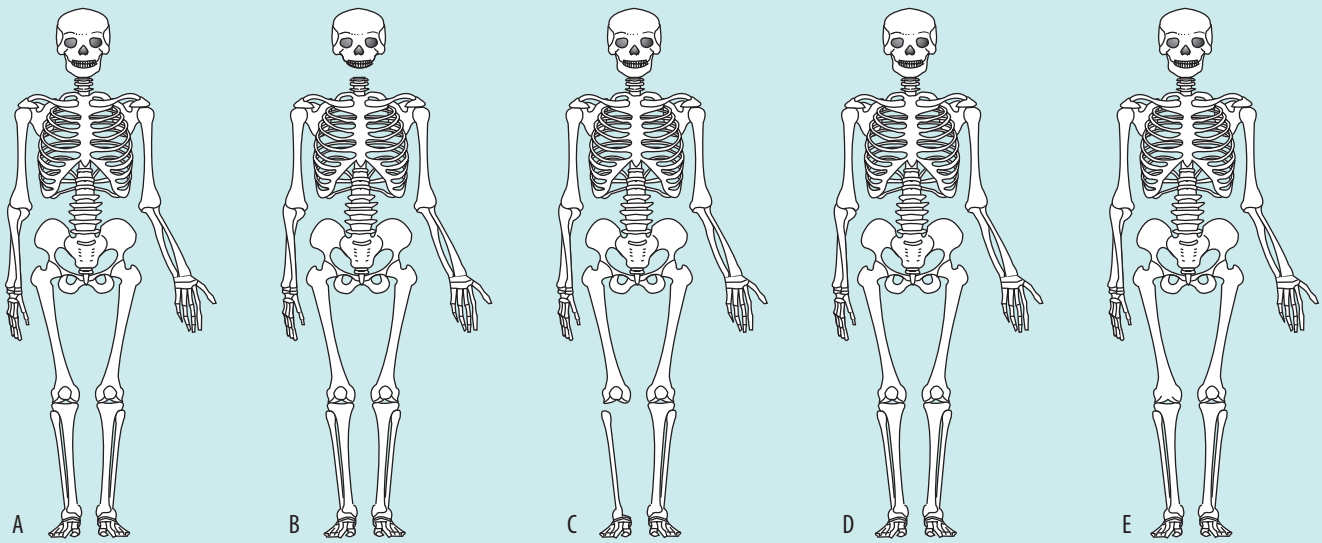
15 Make a skeleton mobile to hang from the ceiling.

(a) Trace the skeleton diagram on page 119 (or a larger one from another book), colour it and cut it into a number of sections.

(b) Paste each section onto cardboard and thread the sections together to make a skeleton mobile.

16 Use a cut-out human skeleton to make a new, imaginary animal by rearranging the bones. Suggest a name and describe the lifestyle of your animal.

17 Make a working model of an arm to show how the biceps and triceps work. Use the illustration on page 121 as a guide. Materials you might use include icy-pole sticks or stiff cardboard (for bones), split pins (for ligaments), string or rubber bands (for muscles), polystyrene foam (for cartilage) and glue. Draw a labelled diagram of your model.



Identify the incomplete skeletons and name the missing parts.

work sheet 4.1 Bones, joints and muscles

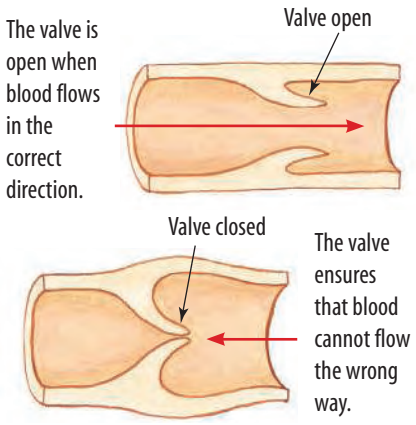
Blood highways

If you cut yourself, you bleed. The red liquid that oozes, trickles or bursts from your body is called **blood**.

Blood by the bucketful

An average-sized human has about five litres of blood; that's about a bucketful. It travels around the body in tubes called **blood vessels**. If these vessels were laid end to end, they would encircle the Earth two and a half times. These tubes enable materials in your body to be transported from one place to another.

Some of these blood vessels are called **arteries**. They have thick, elastic, muscular walls and carry blood under high pressure away from your heart. Some other vessels are called **veins**. They have thinner walls and valves that prevent the blood from flowing backwards. Veins carry blood to the heart.



Veins have valves to ensure that blood flows in only one direction.

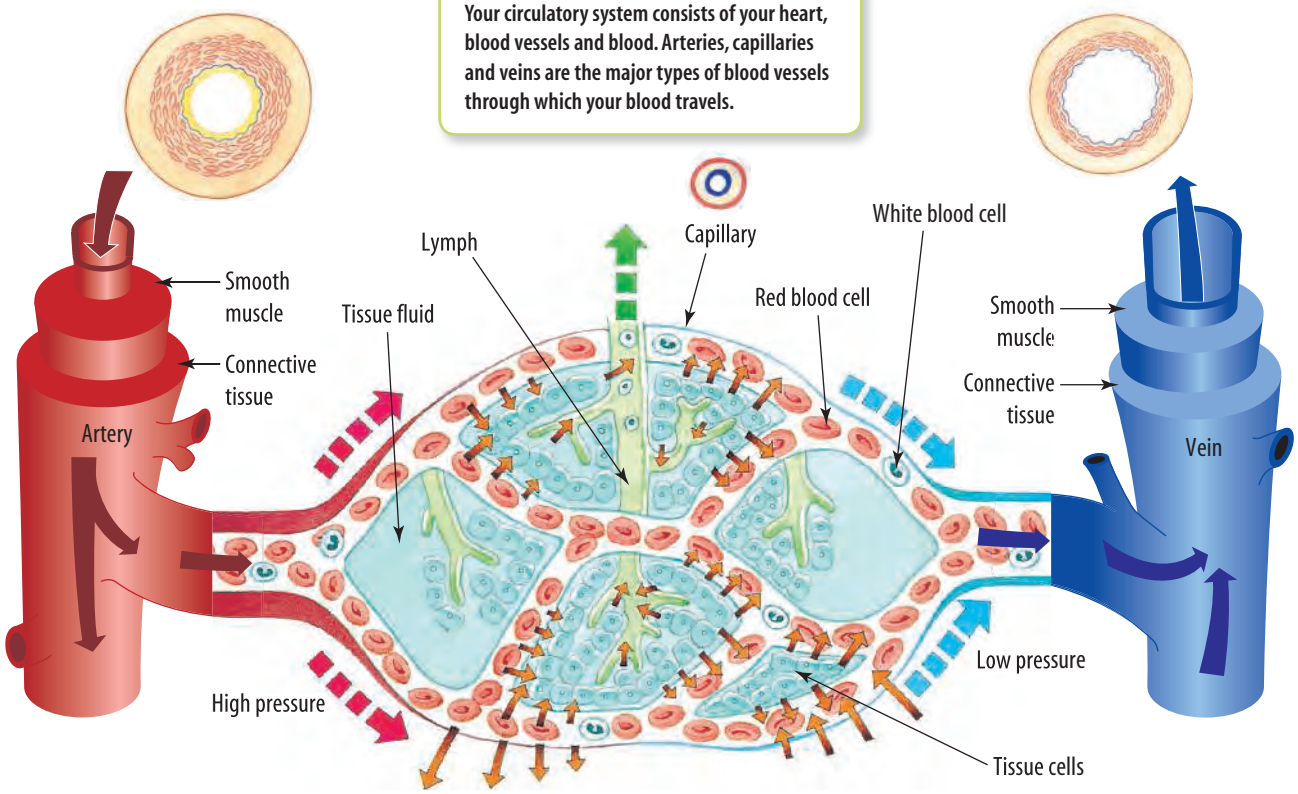
The most numerous and smallest blood vessels are called **capillaries**. Your body contains about 1 000 000 km of capillaries, which penetrate almost every tissue. No cell is very far away from one. Capillaries are very important blood vessels because they carry materials such as oxygen and nutrients to the cells and remove wastes such as carbon dioxide.

What's in blood?

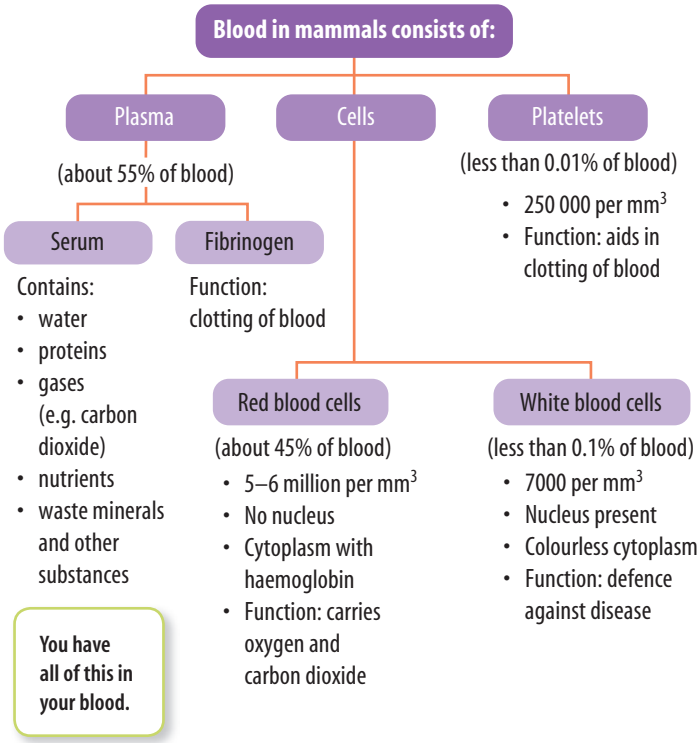
Blood is made up of red blood cells (**erythrocytes**), white blood cells (**leucocytes**), blood platelets and the straw-coloured fluid that they all float in, called **plasma**.

IN A DROP OF BLOOD

Each drop of blood contains about 300 million red blood cells.



Your circulatory system consists of your heart, blood vessels and blood. Arteries, capillaries and veins are the major types of blood vessels through which your blood travels.



These red blood cells travel around the body up to 300 000 times, or for about 120 days. After this they literally wear out and die. Each second you are manufacturing about 1.7 million replacement red blood cells in your bone marrow.

There is a pigment containing iron in the red blood cells, called **haemoglobin**. This is what gives them their reddish colour. The job of haemoglobin is to carry oxygen around your body. When haemoglobin is carrying oxygen it is called **oxyhaemoglobin**. Red blood cells can pack in a lot of haemoglobin because they have no nucleus taking up room, and also because of their special shape.

Someone who has an iron deficiency may become **anaemic**. In this illness, less haemoglobin is carried in the blood. Because less oxygen is available to the cells, the person becomes tired and lethargic.

Blood barriers

Blood also helps us to prevent and fight diseases. White blood cells are the 'soldiers' in the blood. They eat bacteria and other foreign matter and help us to fight infections. Platelets in blood help to heal cuts. They form sticky clots that plug the damaged blood vessel. This seals the cut to prevent germs getting in.

Mix and match?

How much do you know about the red stuff that flows throughout your body? Did you know that your blood might not mix too well with that of your friends? Blood can be grouped into eight types using the ABO system and the Rhesus (Rh) system. Your blood type is inherited from your parents.

These classification systems are based on whether particular chemicals (antigens) are present or absent on your red blood cells. If you are Rh-negative, you do not have the Rhesus factor on your red blood cells; if you do, you are Rh-positive.

INQUIRY: INVESTIGATION 4.4

Viewing blood cells

KEY INQUIRY SKILLS:

- planning and conducting
- processing and analysing data and information

Equipment:

prepared slide of blood smear

microscope

- View the prepared slide under the microscope on high power.
- Find a white blood cell on the slide.

DISCUSS AND EXPLAIN

1. Sketch a few red blood cells and one white blood cell.
2. Estimate how many red blood cells would fit inside a white blood cell.
3. Estimate the number of red blood cells that can fit across the field of view.

HOW ABOUT THAT!

If you bump yourself but haven't cut your skin, a bruise may form. Bruises are caused by burst blood capillaries under your skin. The bruise changes from black to purple to yellow as the blood clears away.

The ABO system divides blood into groups A, B, AB and O. If you need a blood transfusion, it is very important to know your blood type and that of the donor because some blood types cannot be mixed. If the wrong types are mixed, the blood cells may clump together and cause fatal blockages in blood vessels.

HOW ABOUT THAT!

Insect blood looks a little like raw eggwhite, because it contains no pigment. The blood of crabs and crayfish, however, contains the pigment haemocyanin. This pigment has copper in it and is blue when combined with oxygen. This is different from haemoglobin in humans, which is red when combined with oxygen.

Patterns, order and organisation

Multicellular organisms contain organised systems of organs that perform specialised functions that enable them to survive. Your circulatory system, for example, contains organs (such as your heart and blood vessels) that are involved in transporting substances in your blood to where they are needed and wastes are removed.

Multicellular organisms show a pattern of organisation in which there is an order of complexity.

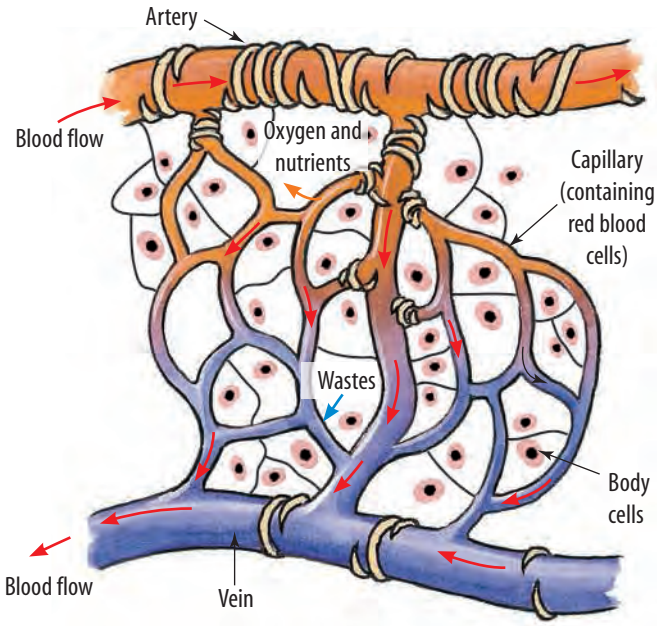
HOW ABOUT THAT!

Could the study of the green stuff in snot help treat heart disease? Research by Australian scientists at the Heart Research Institute in Sydney suggests that this may be the case. Inflammation of the artery wall is a key factor in a type of heart disease called atherosclerosis. This inflammation is caused by an inappropriate defence system response in which activated white blood cells release myeloperoxidase, the enzyme that gives nasal mucus and pus its green colour. The research team is investigating inhibitors to control this enzyme. Their research may result in the discovery of new drugs that could treat not only heart disease but also other inflammatory diseases such as asthma, rheumatoid arthritis and some cancers.

William Harvey published his ideas on how the blood circulated through the body in 1628.

Connected pathways

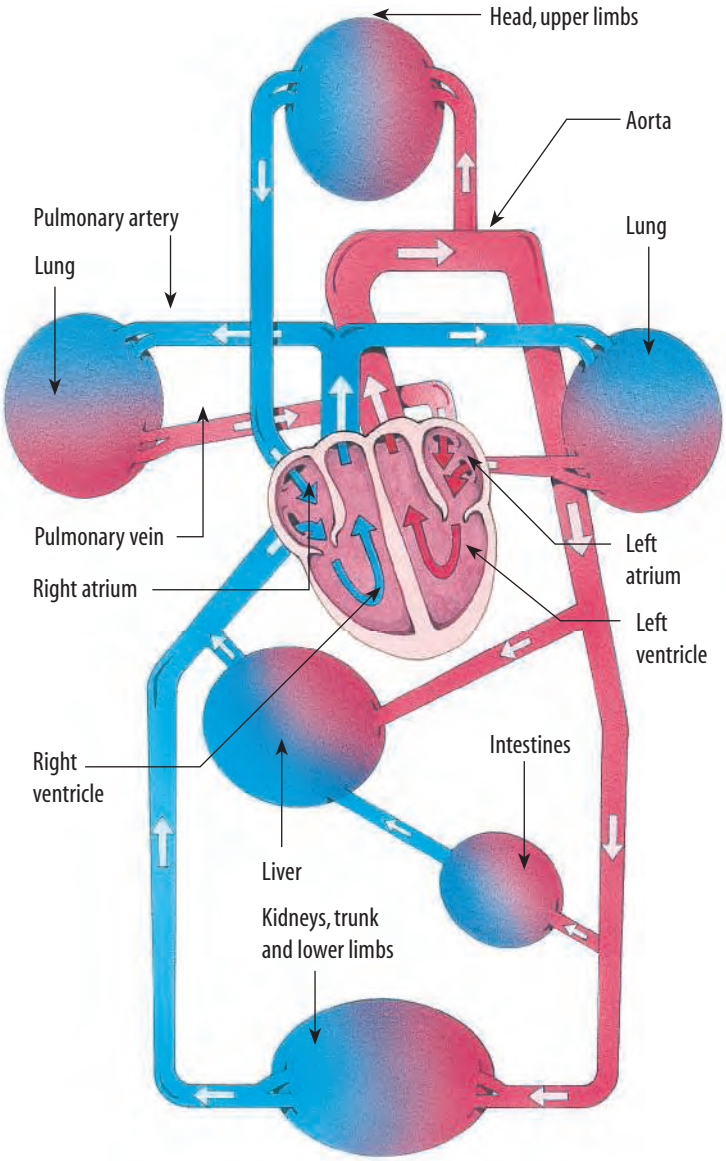
Arteries take blood away from your heart and veins take blood towards your heart, but in between these are capillaries. Capillaries have a very close relationship with your cells. It is through the walls of these tiny blood vessels that oxygen and nutrients move into your cells from your blood, and waste products, such as carbon dioxide, are moved out into your blood.



In the capillaries, oxygen diffuses out of the blood and waste produced by cells diffuses into the bloodstream.

Connected highways

Substances in your blood travel through your blood's busy highway system to areas for use, storage or removal. Blood carries carbon dioxide, a waste product from cellular respiration, to your lungs so that it is removed when you exhale. A variety of metabolic wastes also travel in blood to your kidneys so that they may be excreted through your urinary system.



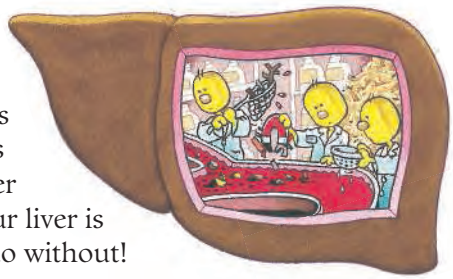
Connected highways — the routes for blood circulation

eBookplus Weblink

Use the **Interviews with Australian scientists** weblink in your eBookPLUS to find out more about the work of vascular biologist Professor Julie Campbell.

Not without my liver I don't!

Over a litre of blood passes through your liver each minute. Your liver is like a chemical factory, with more than 500 different functions. Some of these include sorting, storing and changing digested food. It removes fats and oils from the blood and modifies them before they are sent to the body's fat deposits for storage. It also helps get rid of excess protein, which can form toxic compounds dangerous to the body. The liver converts these protein wastes into urea, which travels in the blood to the kidneys for excretion. It also changes other dangerous or poisonous substances so that they are no longer harmful to the body. Your liver is something you cannot do without!



Gassy blood

Your body is more sensitive to changes in levels of carbon dioxide than of oxygen. If there is too much carbon dioxide in your body, it dissolves in the liquid part of blood and forms an acid. The resulting acidic blood can affect the functioning of your body.

The amount of carbon dioxide in your blood influences your breathing rate. The level of carbon dioxide in the blood is detected by receptors in the walls of some arteries and in the brain. If the level of carbon dioxide in your blood increases, your breathing rate will be increased so that carbon dioxide can be exhaled from your lungs and passed out of your body.

If you were to climb up high on a mountain, you would need time for your body to adjust. Initially you would feel tired and out of breath because you would be restricted by the limited amount of oxygen available to your cells. Your breathing and heart rate would increase, in an effort to get more oxygen around your body. In time, your body would begin to produce more red blood cells and hence more haemoglobin. After this, your breathing and heart rate would return to normal.

HOW ABOUT THAT!

The amount of oxygen carried by haemoglobin varies with altitude. At sea level, about 100 per cent of haemoglobin combines with oxygen. At an altitude of about 13 000 metres above sea level, however, only about 50–60 per cent of the haemoglobin combines with oxygen.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Outline what blood is, and what it does.
2 Name and describe the types of blood vessels in which blood travels around your body.
3 Compare red blood cells, white blood cells and blood platelets.
4 Explain the advantage of not having a nucleus.
5 Explain why haemoglobin is important.
6 Suggest why blood is not the same colour in all animals.
7 Suggest why our blood system is described as a 'transport highway'.
8 Describe the relationship between arteries, capillaries and veins.
9 Outline the route that carbon dioxide travels to get out of your body from your cells.
10 Explain why you can't live without your liver.
11 Is your breathing rate more sensitive to levels of carbon dioxide or of oxygen in the blood? Explain.
12 Explain why mountain climbers sometimes find it difficult to breathe during a climb.

THINK

13 Use information in this section and other resources to relate structural features to the functions of the following parts of the circulatory system.

Part of system	Structural features	Function
Arteries		
Veins		
Capillaries		
Red blood cells		

14 Think of other ways that information about the components of blood could be organised visually. Organise the material in one of these ways.

THINK AND CREATE

15 (a) Copy the 'connected highways' diagram on the previous page into your workbook.
(b) Use a coloured pencil to show the path taken for a red blood cell to travel from the pulmonary vein to the pulmonary artery, if it goes via the intestines.
16 Mark the following sites (a, b, c, d) on your diagram. In which blood vessel(s) would you expect the highest:
(a) blood pressure?
(b) blood glucose levels?
(c) blood carbon dioxide level?
(d) oxygen level?
17 List the following in the order that a red blood cell would reach them after leaving the aorta: pulmonary artery, left ventricle, right atrium, intestine, lung, pulmonary vein, left atrium, liver, right ventricle.
18 Convert your classroom or sports oval into a 'circulatory highway system'. Pretend to be a red blood cell and travel along the route it would take around the body.
19 Divide the class into groups, with each group making a model of a type of blood cell or vessel. Combine all of the models to convert the room into a circulatory system. In teams, write a play to use your circulatory system. Act it out for the class or get the class to act it out for you.

THINK AND DISCUSS

20 (a) Some people have religious grounds for disagreeing with the use of blood transfusions. Imagine a four-year-old child with a life-threatening condition. Her parents will not allow her to have the blood transfusion that she needs. What should the doctors do? Discuss this with your team and report your decision to the class. If there are any differences of opinion, organise a class debate on the issue.
(b) Would your response be different if the child was 18 years old and wanted the blood transfusion, but her parents would not allow it?
21 A day after donating blood, a person finds that they have an infectious disease that can be transmitted by blood. What should they do? Discuss this with your team, giving reasons for your opinions.

INVESTIGATE

22 The higher the altitude, the less oxygen there is in the air. Propose a reason people living at high altitudes usually have more red blood cells than people living at low altitudes.
23 Research one of the following circulation topics and report your findings to the class: blood transfusions, rhesus babies, varicose veins, leukaemia, haemophilia, thrombosis, embolisms, aneurisms.
24 Find out more about how blood circulates in insects and lobsters.
25 Plasma is the liquid part of blood. It can be used to make a number of products to help others in need. Report back on the uses of three of the following: Intragram, Anti D, Albumex 20, Factor VIII, Monofix, Prothrombinex, Thrombotrol VF, normal immunoglobulin, hyper-immunoglobulin.
26 Examine prepared blood slides under a light microscope.
27 Construct a bar graph to show the proportions of the different parts of blood.

28 Find out what happens when people donate their blood at a blood bank. How often can you donate blood, how long does it take and how much blood do they take? Prepare a brochure, storyboard, PowerPoint presentation or cartoon to share your findings.

29 Use the internet to research waste removal and excretion for an animal of your choice. Present your findings in PowerPoint or as a poster.

USING DATA

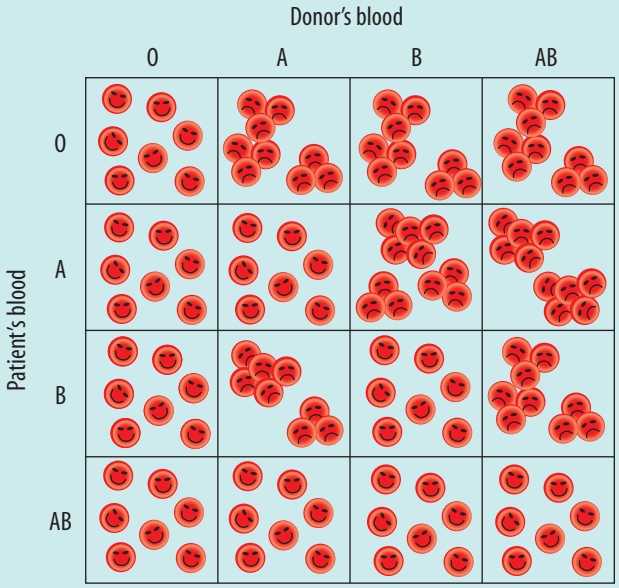
Use the table and illustration below to answer the following questions.

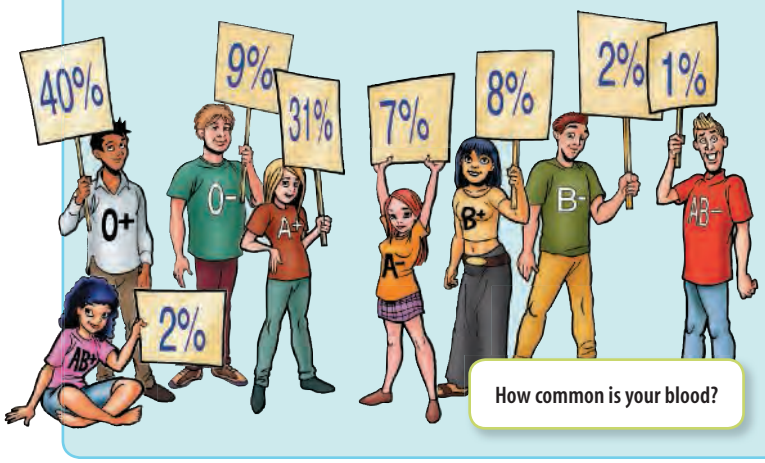
30 Which blood type is the most common? Which is the least common?

31 Which blood group(s), A, B, AB or O, can be accepted by:
(a) all blood groups?
(b) blood group AB?
(c) blood group A?

32 Which blood group, A, B, AB or O, can receive transfusions from all blood types?

33 Convert the information in the table below into a Venn diagram, target map or another visual thinking tool.





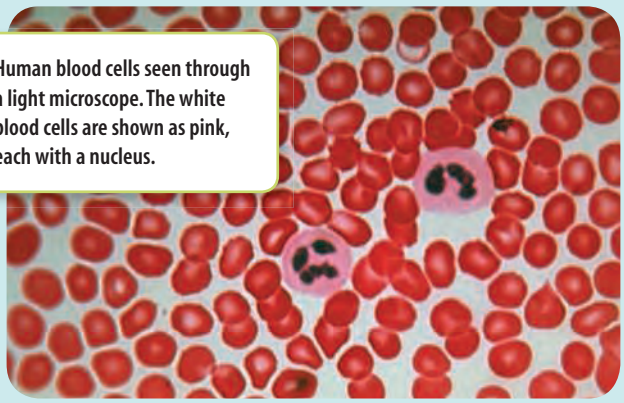
How common is your blood?

INVESTIGATE, THINK AND DISCUSS

34 Imagine that you have a friend who is anaemic. She is constantly tired and very pale.
(a) Using the internet and other resources, find out what you could do to help her improve her health.
(b) Report back to your team, sharing your ideas and any other relevant information. Have your team scribe summarise your ideas in a cluster map or mind map.
(c) As a team, decide on a strategy for helping your anaemic friend.
(d) Share your strategy with other teams as a mind map, flowchart, concept map or another visual tool.
(e) Reflect on what you have learned during this activity. How might it influence your future behaviour or thinking? Could any of the strategies designed by the groups be used to solve any other problems? If so, which ones?

35 With a partner, construct a PMI chart for a law that makes it compulsory for everyone over 16 to donate blood at least once a year.

36 Observe the image of human blood cells.



Human blood cells seen through a light microscope. The white blood cells are shown as pink, each with a nucleus.

(a) Identify which are white blood cells and which are red blood cells.
(b) Describe how you distinguished between the two types of blood cells.
(c) Which are in the greatest abundance? Suggest a reason for this.

37 Dr Mary Kavurma and Dr Seana Gall are Tall Poppy Science Award winners. This award recognises young scientists who excel at research, leadership and communication. Dr Kavurma is a scientist at the University of New South Wales involved in research into atherosclerosis and cardiovascular disease. Dr Gall is based at the Menzies Research Institute, University of Tasmania, and her research field is cardiovascular epidemiology.
(a) Find out more about their research and that of other scientists in this field of science.
(b) Find out more about Australia's Tall Poppy Science Awards and other winners.

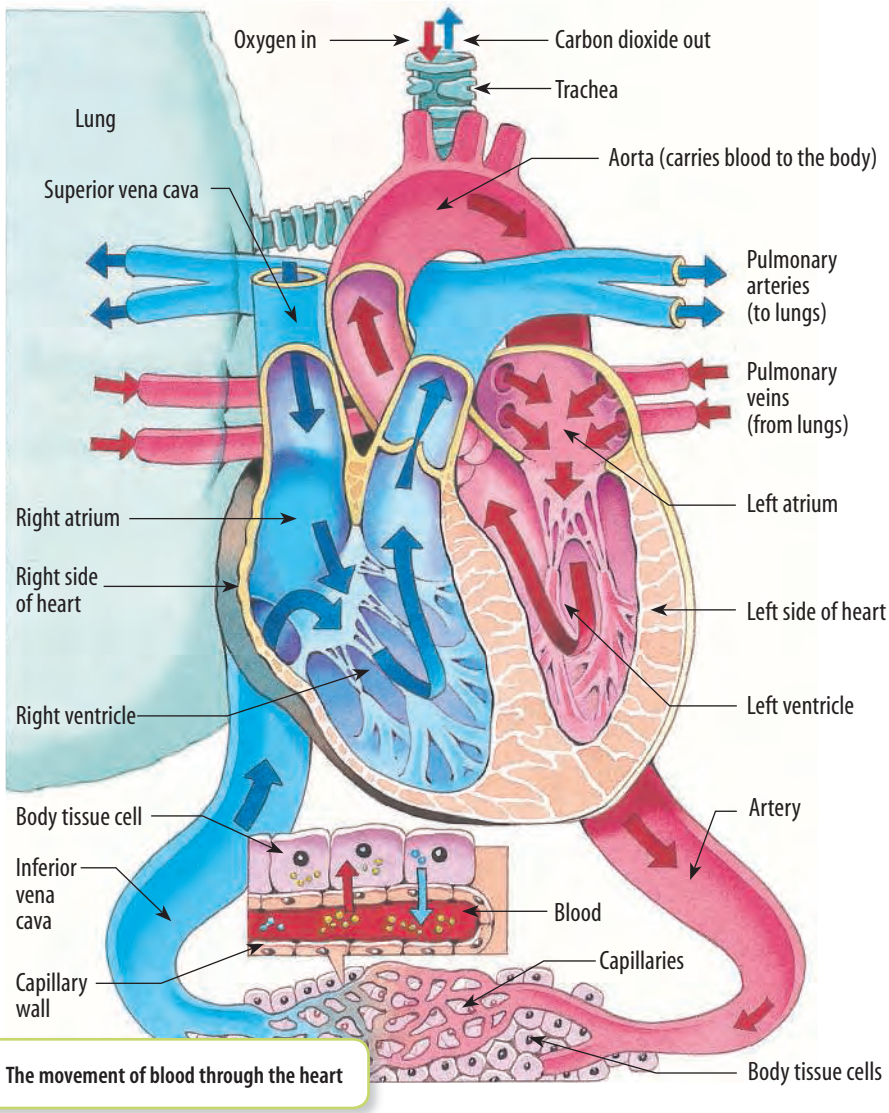
4.4 OVERARCHING IDEA

Form and function: Have a heart

Often linked with emotions, love and courage, the heart has a special meaning for most of us. In a clinical sense, however, it is merely a pump about the size of your clenched fist.

Two pumps in one

To be more precise, the human heart is actually *two* pumps. One side contains oxygenated blood and the other deoxygenated. Your veins bring 'used' **deoxygenated** blood (stripped of oxygen and bluish in colour) back to your heart. All of these veins join up into a larger vein called the **vena cava**. Entering the top right chamber of your heart, blood is pumped into the bottom right chamber. It is then pumped out to your lungs where it picks up oxygen and becoming **oxygenated** and more reddish in colour. It also loses some of the carbon dioxide from it. The oxygenated blood then returns to the left-hand side of your heart to be pumped out through arteries to your body tissues, where it delivers oxygen and nutrients. The deoxygenated blood then returns to the right-hand side of the heart for the cycle to be repeated.



The movement of blood through the heart

Four chambers

The human heart has four chambers. The upper two chambers are called the **left atrium** and **right atrium** (plural = atria), and the lower two chambers are the **left ventricle** and **right ventricle**. The two sides of the heart are different. The walls of the left side are thicker and more muscular because they need to have the power to force the blood from the heart to the rest of the body.

Flap-like structures attached to the heart walls, called **valves**, prevent the blood from flowing backwards and keep it going in one direction. If you listen to your heart beating, you will hear a **'lub dub'** sound. The 'lub' sound is due to the valves between the ventricles and atria shutting. The 'dub' sound is due to the closing of the valves that separate the

eBookplus eLesson

Heart valve

Watch this video eLesson to learn more about replacing heart valves without the substantial trauma of open heart surgery, a procedure set to revolutionise cardiovascular medicine for patients.

eles-0858

heart from the big blood vessels that lead to the lungs and the rest of the body.

Blood pressure

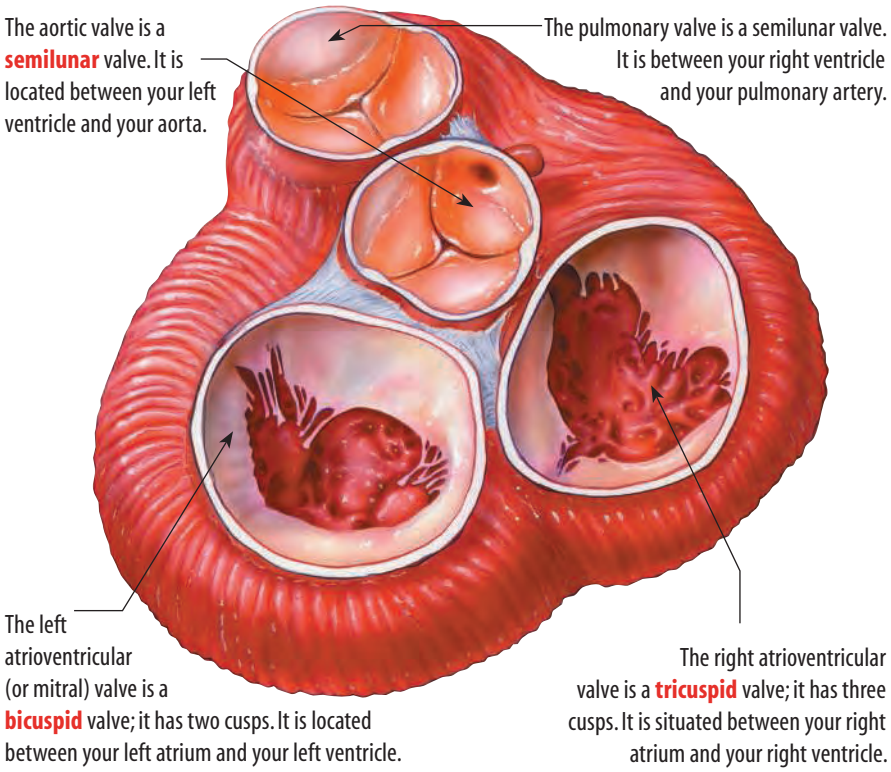
The heart's pumping action and the narrow size of the blood vessels result in a build-up of considerable pressure in the arteries. The force with which blood flows through the arteries is called **blood pressure**. It is affected by different activities and moods. It also goes up and down as the heart beats, being highest when the heart contracts (**systolic pressure**) and lowest when the heart relaxes (**diastolic pressure**). A person's blood pressure is expressed as a fraction. This fraction is the systolic pressure over the diastolic pressure, such as 120/70.

Keeping the pace

During each minute that you are sitting and reading this, about 5–7 litres of blood completes the entire circuit around your body and lungs. In a single day, your heart may have beaten about 100 000 times and pumped about 7000 litres of blood around your body.

A normal human heart beats about 60–100 times a minute, this rate increasing during exercise or stress. With each **heartbeat**, a wave of pressure travels along the main arteries. If you put your finger on your skin just above the artery in your wrist, you can feel this **pulse** wave as a slight throb. Your pulse rate immediately after exercise can be used as a guide to your physical fitness. The fitter you are, the less elevated your heart rate will be after vigorous exercise.

The regular rhythmic beating of the heart is maintained by



INQUIRY: INVESTIGATION 4.5

Dissect a heart

KEY INQUIRY SKILLS:

- planning and conducting
- processing and analysing data and information

Equipment:

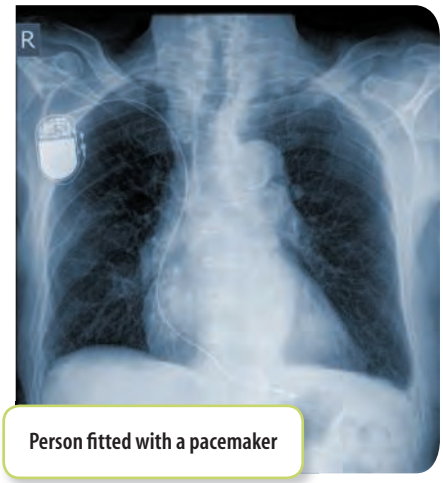
sheep's heart preferably with the blood vessels still attached
dissecting instruments
dissecting board

- Identify the parts of the heart using the illustration on the previous page.
- Try to locate where blood enters and leaves the heart:
  (a) to and from the lungs
  (b) to and from the rest of the body.
- Sketch and label the heart and use arrows to show the direction of blood flow.
- Cut the heart in two so that both halves show the two sides of the heart (similar to the illustration on the previous page).
- In a diagram, record your observations of the thickness of the walls on the left side of the heart compared with the right side.
- Suggest reasons for the differences observed.
- Try to locate the valves in the heart.

DISCUSS AND EXPLAIN

1 Describe the valves and suggest their function.
2 Write a summary paragraph about the structure and function of the heart.

electrical impulses from the heart's **pacemaker**, which is located in the wall of the right atrium. Some people with irregular heartbeats are fitted with artificial, electronic pacemakers to regulate the heart's actions and correct abnormal patterns.



Person fitted with a pacemaker

Try clenching your fist every second for five minutes. Getting a little tired? The heart is made up of special muscle called cardiac muscle, which never tires. Imagine having a 'cramp' or 'stitch' in your heart after running to catch the bus! Owing to its unique electrical properties, heart muscle will continue to beat even if it has been removed from the body. Scientists have shown that even tiny pieces of this muscle cut from the heart will continue to beat when they are placed in a test tube of warm salty solution.

HOW ABOUT THAT!

Not all animals have four-chambered hearts; in fact, some don't have hearts at all! A fish heart has two chambers, while amphibians and reptiles have three-chambered hearts. Can you suggest any advantages or disadvantages of these hearts over a four-chambered mammalian heart?

INQUIRY: INVESTIGATION 4.6

Check your heart

KEY INQUIRY SKILLS:

- planning and conducting
- processing and analysing data and information

Equipment:

stopwatch

blood pressure monitor

- Find your pulse, either on the inside of your wrist or in your neck (see the illustrations). Make sure you use two fingers, not your thumb, to find your pulse.

Two places where your pulse should be easy to find:
(a) radial location (wrist)
(b) carotid location (neck)

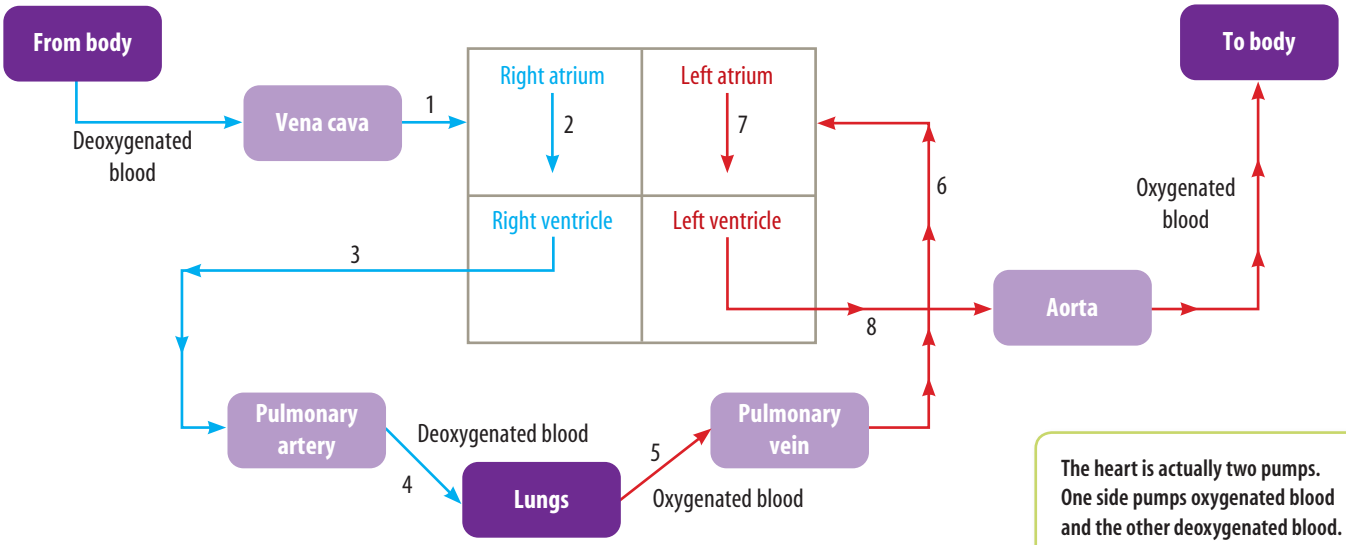
- Measure your heart rate in beats per minute (bpm) by counting the number of times your heart beats in 15 seconds and then multiplying this number by 4.
- Measure your blood pressure using the blood pressure monitor.
- Go for a walk in the playground or around the school oval. Measure your heart rate and blood pressure again.
- Run up and down a flight of stairs. Measure your heart rate and blood pressure again.
- Copy the table below into your workbook and enter your own results.

Test	Heart rate (bpm)	Blood pressure (mm Hg)
Before exercise		
After walking		
After running up stairs		

DISCUSS AND EXPLAIN

1 What effect does exercise have on heart rate and blood pressure?

2 Design and carry out an experiment to test the following hypothesis: 'There is a link between a person's resting heart rate and the number of hours the person spends exercising each week'.



The heart is actually two pumps. One side pumps oxygenated blood and the other deoxygenated blood.

UNDERSTANDING AND INQUIRING

REMEMBER

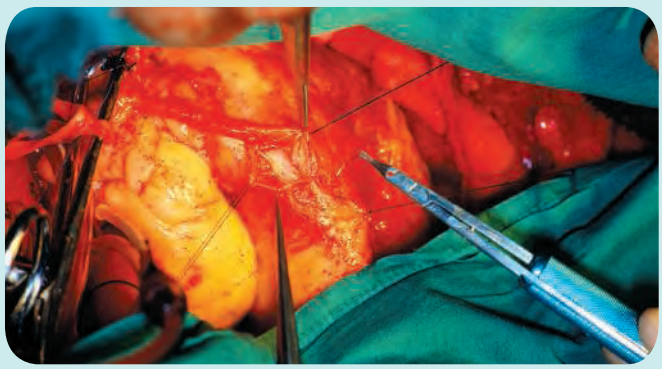
1 What is the difference between:
   (a) the blood in the two sides of the heart?
   (b) the structure of the two sides of the heart?
   (c) systolic and diastolic pressure?
2 Explain why there are valves in the heart.
3 Outline what blood pressure is caused by.
4 (a) How many times does a normal human heart beat each minute?
   (b) Suggest what may cause the heartbeat to increase.
   (c) Explain how the rhythmic beating of the heart is maintained.
5 What is unusual about cardiac muscle?

INVESTIGATE AND CREATE

6 In your team, design and perform an experiment to investigate the effect of different types of activities on your heartbeat.
7 Doctors use a stethoscope to listen to heartbeats. Make and test your own stethoscope using rubber tubing and a plastic funnel.
8 (a) Construct a model of the human heart using clay or bread dough.
   (b) Use information in this section and other resources to relate the structural differences between the atria and ventricles of the heart to their function.
9 Make up a rhyme or poem to describe the flow of blood through the heart. Use as many of the **bold red** words in this section as possible.
10 Construct a 'working' model of a human heart that shows the movement of blood through the various chambers and blood vessels.
11 What does a cardiologist do? Find an example of an Australian cardiologist and write a 'diary entry' for a day at work for them.
12 Find articles in the media that advertise foods or drinks that can reduce heart disease. In a team, research their claims and summarise your findings in a SWOT diagram. As a class, be involved in a debate that includes members from different interest groups or with different perspectives or biases.
13 Can diet, exercise or lifestyle choices change the chances of you having a heart attack? Research this question, summarising your findings in a PMI chart. On the basis of your data, what is your personal answer to this question? Give reasons for your opinion.
14 Test your ability to label the parts of the heart by completing the **Beat It!** interactivity in your eBookPLUS. **int-0210**

eBookplus

15 Use the **Heart surgery** weblink in your eBookPLUS to complete the animation activity and find out more about heart surgery and the anatomy of a human heart.



work sheet 4.2 Blood and blood highways

Transport technology

Heart and blood vessel diseases are the major killers in Australia. They claim twice as many lives as cancer and 20 times more than traffic accidents.

Modern medicine and technology have produced techniques and procedures that attempt to minimise the effects of diseases and disorders of the circulatory system.

Faulty heart and vein valves

The heart, like many other pumps, depends on a series of valves to work properly. These valves open and close to receive and discharge blood to and from the chambers of the heart. They also stop the blood from flowing backwards. If any of the four heart valves becomes faulty, the function of the heart may be impaired.

Veins throughout the body may also contain valves that keep the blood flowing in one direction. Defective valves in leg veins can cause blood to drain backwards, and to pool in the veins closest to the skin surface. These veins can become swollen, twisted and painful and are called **varicose veins**.

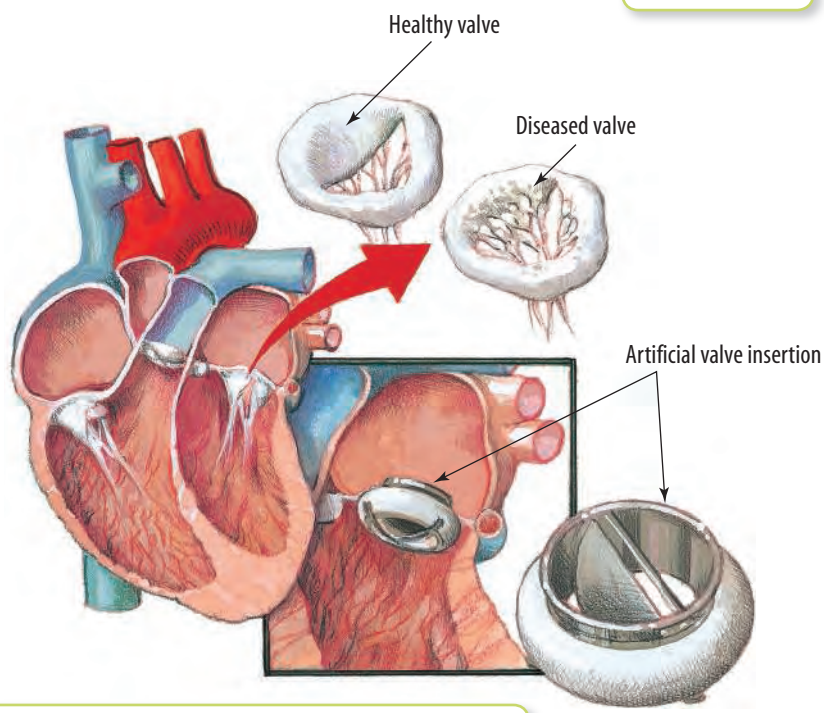
HOW ABOUT THAT!

About 15 per cent of Australians aged between 20 and 65 have hypertension (high blood pressure). This increases their chances of developing heart disease and strokes. To prevent this, people should maintain a healthy body weight, take regular exercise and eat a diet that is low in fat and salt.

'If I only had a heart . . .'

The tin man from *The Wizard of Oz* would have been very happy with the development of an artificial heart. This mechanical device can be made of titanium and plastic. Surgeons also implant a small electronic device in the abdominal wall to monitor and control the pumping speed of the heart. An external battery is strapped around the waist and can supply about 4–5 hours of power. An internal rechargeable battery is also implanted inside the wearer's abdomen. This is so they can be disconnected from the main battery for about 30–40 minutes for activities such as showering.

An artificial heart



A faulty heart valve may be replaced by an artificial valve. Why are the heart valves so important to the functioning of the heart?

A heart — but no pulse?

If only the left ventricle is damaged, and the rest of the heart is in good working order, a back-up pump may be implanted alongside the heart. One model of these devices results in its wearers having a gentle whirr rather than a pulse. This is the sound of the propeller spun by a magnetic field to force a continuous stream of blood into the aorta.

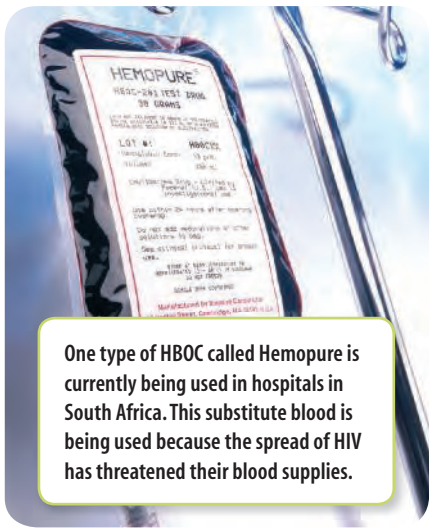
Getting the beat!

An **electrocardiogram (ECG)** shows the electrical activity of a person's heart. ECG patterns are valuable in diagnosing heart disease and abnormalities.

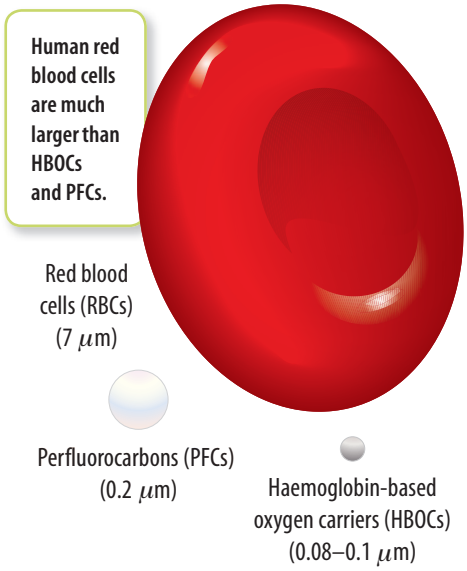
Artificial blood

A current wave of interest in vampire movies and books has brought with it discussion about the merits of artificial blood sources. The interest in artificial blood, however, is not new. There has been interest in the idea of blood transfusions for hundreds of years. William Harvey's description in 1628 of how blood circulated through the body prompted a variety of unsuccessful investigations into the use of alternative fluid substitutes. Shortage of blood supplies during war and disease epidemics has fired up the quest for an artificial blood substitute. Currently the two most promising red blood cell substitutes are haemoglobin-based oxygen carriers (HBOCs) and perfluorocarbon-based oxygen carriers (PFCs).

PFCs are usually white, whereas HBOCs are a very dark red. Although PFCs are entirely synthetic, HBOCs are made from sterilised haemoglobin. The haemoglobin may be from human or cow blood, human placentas or bacteria that have been genetically engineered to produce haemoglobin. As the haemoglobin doesn't have a cell membrane to protect it, various techniques such as cross-linking and polymerisation are used to make it less fragile. Some scientists are even investigating the idea of wrapping it in an artificial membrane.



One type of HBOC called Hemopure is currently being used in hospitals in South Africa. This substitute blood is being used because the spread of HIV has threatened their blood supplies.



Human red blood cells are much larger than HBOCs and PFCs.

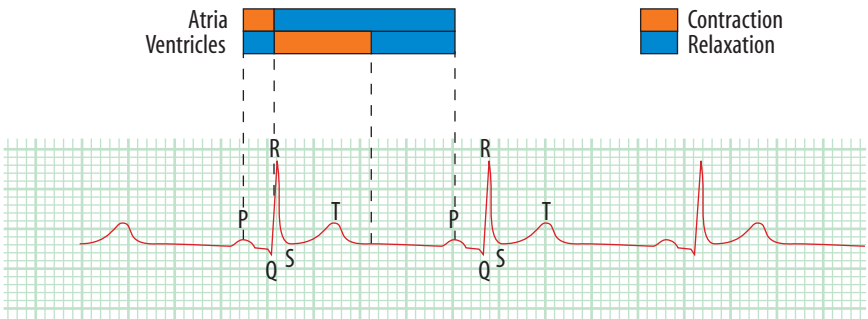
Red blood cells (RBCs) (7 μm)

Perfluorocarbons (PFCs) (0.2 μm)

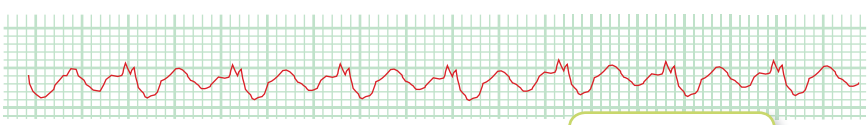
Haemoglobin-based oxygen carriers (HBOCs) (0.08–0.1 μm)

ARTIFICIAL BLOOD VESSELS?

Will the artificial blood vessels of the future be made by bacteria? Molecular biologist Helen Fink, working in Sweden, has suggested this may be the case. The cellulose produced by *Acetobacter xylinum* bacteria is strong enough to cope with blood pressure and function within our bodies, and could be used for artificial blood vessels in heart bypass operations in the future.



(a) Normal electrocardiogram



(b) Abnormal electrocardiogram

Electrocardiograms

In the future, will artificial blood vessels like this one be made by bacteria?

Image courtesy of the University of Gothenburg

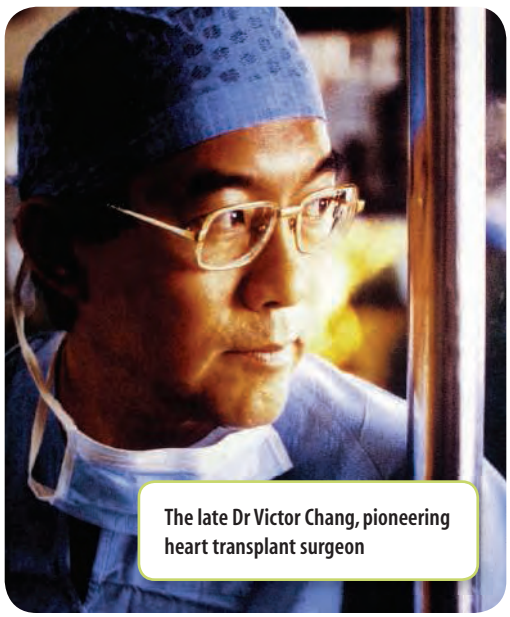
Transplant pioneer

If your heart or lungs were not working properly and you had needed a heart or lung transplant in the 1980s, the doctor to see was Victor Chang.

Victor Chang was an Australian doctor who was awarded a Companion of the Order of Australia for his contribution to medicine. Dr Chang played an important role in establishing the heart transplant unit at St Vincent's Hospital in Sydney. He set up a team of 40 health professionals who were the finest in their field and developed new procedures and techniques that led to an improved rate of success. Of his patients, 92 per cent were still alive one year after their heart or lung transplant operation and 85 per cent were still alive five years later.

The first heart transplant operation that Victor Chang carried out at St Vincent's Hospital was in 1984 on a young girl called Fiona Coote. Fiona is now an adult and, although she has since needed a second heart transplant, she owes her life to Dr Chang.

Dr Victor Chang also developed an artificial heart valve, called the St Vincent heart valve, and was working on developing an artificial heart. Unfortunately his life was tragically cut short in 1991 when he was murdered by gunshot.



The late Dr Victor Chang, pioneering heart transplant surgeon

UNDERSTANDING AND INQUIRING

REMEMBER

1 Identify which group of diseases is the major killer in Australia.
2 What are varicose veins and what causes them?
3 What is an electrocardiogram, and when is it useful?
4 Explain why valves are important to the functioning of the heart.
5 Describe how an ECG is used to detect heart abnormalities.
6 Outline how heart valves are similar to the valves in veins.
7 Construct a matrix table (see page 340) to show the differences between red blood cells, HBOCs and PFCs.

THINK

8 Look at the electrocardiograms on the previous page.
(a) At 'P', are the muscle cells of the atria contracted or relaxed?
(b) After the 'QRS' wave, is the ventricle relaxed or contracted?
(c) How does the normal electrocardiogram differ from the abnormal electrocardiogram?
(d) Suggest what might be wrong with the heart activity shown on the abnormal electrocardiogram.

INVESTIGATE

9 What are artificial hearts made of and how do they work?
10 How can blood loss cause death?
11 Use the internet to research one of the following: strokes, heart murmurs, 'hole in the heart', atherosclerosis, angina, heart attack, arrhythmias, pericarditis, hypertension. Present your findings as a PowerPoint presentation or a poster.
12 Find out more about Dr Victor Chang and report your findings to others in the class.
13 There are a number of issues surrounding the development and use of artificial blood. Find out what these are and then construct a PMI chart as a summary. What is your opinion about artificial blood? Provide reasons for your opinion.
14 Find out and report on 'transport technology' research that Australian scientists are currently involved in.
15 (a) Which organs are most successfully transplanted into humans?
(b) List sources of the organs for transplant and identify associated issues.
(c) Describe how donors and organ recipients are matched.
(d) Organ recipients can require specific treatment after the operation. Outline what this involves and why it is needed.
16 If you required a new heart, would you prefer an artificial one or one from a human or other natural source? Provide reasons for your response.
17 Outline your opinion on being an organ donor yourself.
18 Find out issues related to organ transplants and construct a PMI summary.

eBookplus

19 Use the **Electrocardiogram game** weblink in your eBookPLUS to simulate performing ECGs on patients referred to you by medical doctors.

Sucked in and blown out

Breathe in deeply … now breathe out. You have just introduced some extra oxygen into your body and removed some unwanted carbon dioxide. You do this about 15–20 times per minute without thinking. The muscle movements required for **breathing** are automatic and controlled by the respiratory centre in the brain.

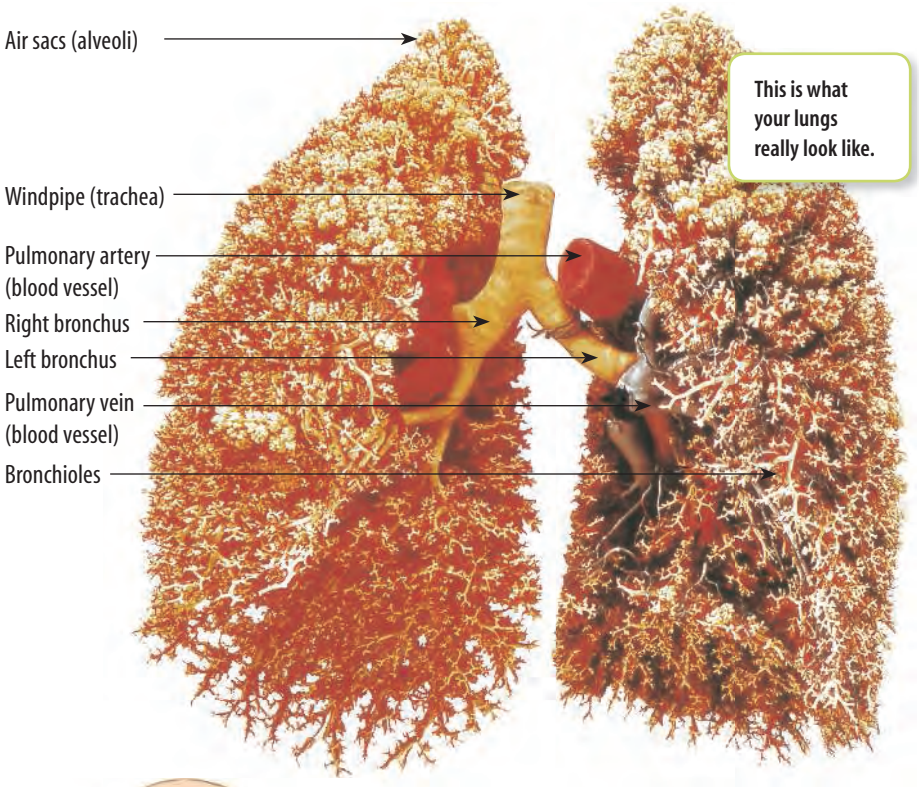
When you breathe in, you take in the mixture of gases called air. Oxygen and carbon dioxide are gases found in the air around you. Oxygen makes up about 21 per cent of the air, while carbon dioxide makes up only about 0.04 per cent. Your body uses some of the oxygen you take in. The table above right shows that the air that you breathe out contains less oxygen and more carbon dioxide than the air you breathe in. The percentages in the table are approximate and vary a little with weather conditions and height above sea level.

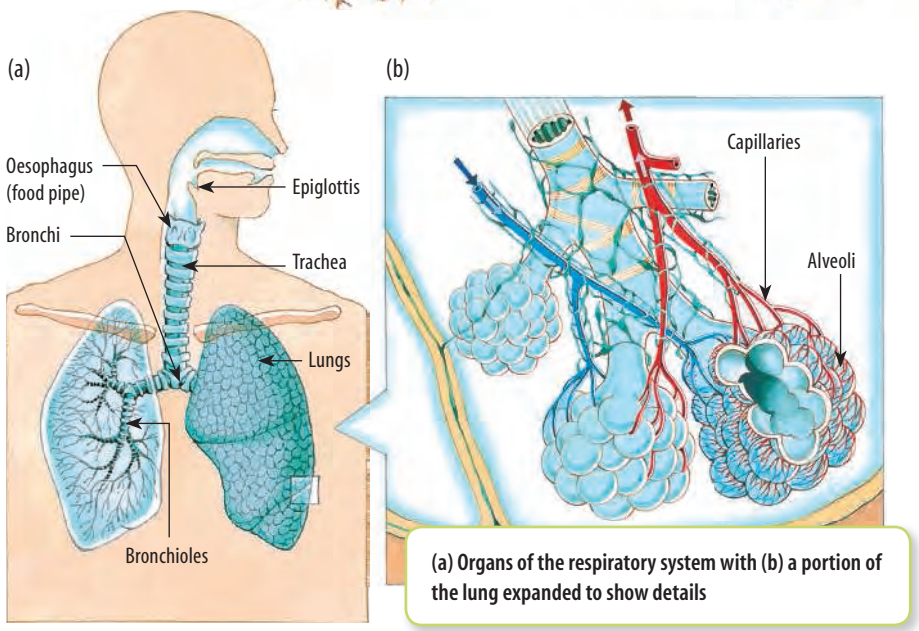
All animals and plants need energy to grow. Animals also need energy both to move and to keep their body systems working. Energy is obtained from food. However, oxygen is also needed to break down the food so that the energy in it can be used by the body. The process of using oxygen to release the energy from food is called cellular respiration. Cellular respiration takes place in the cells of living things.

glucose + oxygen ⟶ carbon dioxide + water + energy

What goes in and what comes out

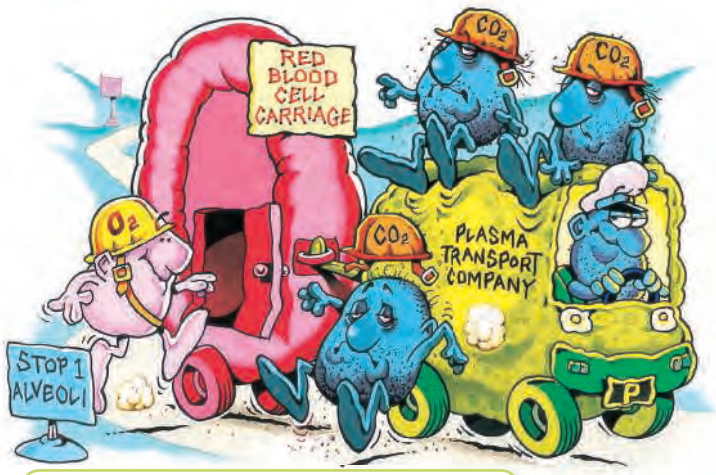
Gas	Oxygen (%)	Carbon dioxide (%)	Water vapour (%)	Nitrogen (%)
Air breathed in	21	0.04	1	78
Air breathed out	15	4	5	76



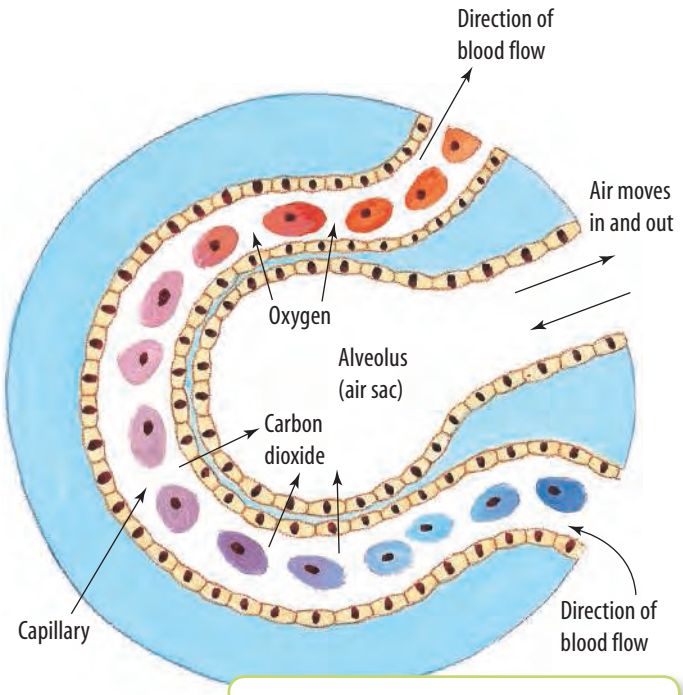


HOW ABOUT THAT!

The air that you breathe enters your body through your nose and mouth. Unless your nose is clogged up by a cold, it is the most important airway. The hairs and sticky mucus in your nose trap dust and dirt and other harmful material such as disease-causing bacteria. Breathing in through your mouth gets the air in faster but without being filtered by the nose. When you play sport, your body uses oxygen more quickly and it is often necessary to breathe in through your mouth, bypassing the filter system in your nose.



Where the action is. **Gas exchange** occurs at the alveoli.



In an alveolus, oxygen diffuses into the blood and carbon dioxide diffuses out of the blood.

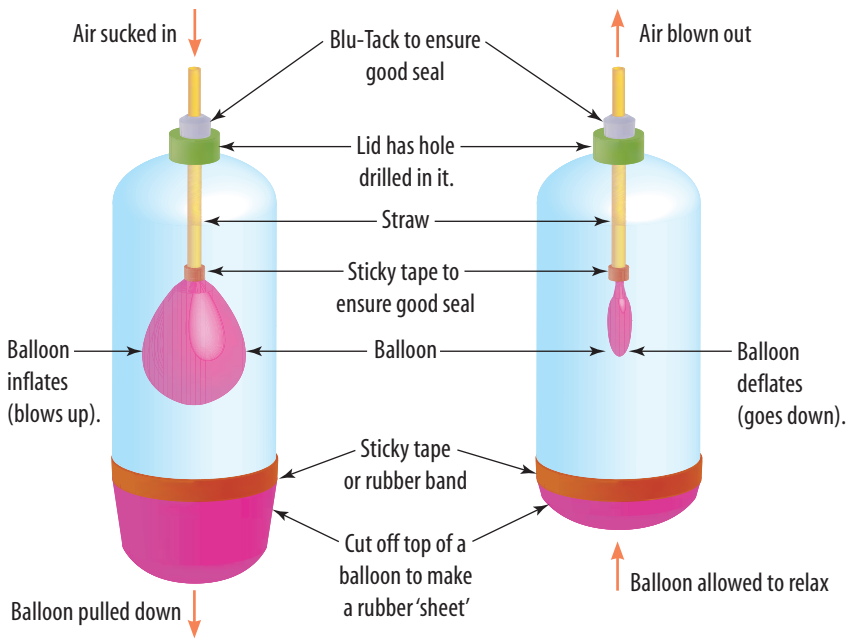
Going down?

After entering your body, the air moves into a narrow tube called the **trachea**, which is more commonly known as the windpipe. At the top of this tube is a flap of tissue called the **epiglottis**. The job of this tissue is to stop food from going down into your lungs. If food does manage to pass it and 'go down the wrong way', a cough soon brings it back up again.

The trachea divides into two narrower tubes called the bronchi. Each of these tubes leads to a lung. Inside the lung, each tube divides into many smaller tubes called **bronchioles**. The bronchioles branch out, getting smaller and smaller until they end at thousands of tiny air sacs called **alveoli**.

Where the action is

It is at the alveoli that the exchange of gases actually takes place. Some of the oxygen in the air that you breathe in moves through the alveoli into narrow capillaries. From there it moves into the red blood cells.



A model lung. When the rubber sheet at the bottom is pulled down, the pressure inside the jar drops and air is sucked into the balloon. The balloon inflates (blows up).

Carbon dioxide takes the opposite journey, moving out of the red blood cells through the capillaries into the alveoli so that it can be breathed out.

The movement of a muscle called the **diaphragm** helps the lungs do their job by sucking in and pushing out air. The images on page 141 show how this happens.

Lung capacity

Although adults can breathe out up to 5 litres of air with each breath, they usually breathe out only about half a litre. The largest volume of air that you can breathe in or out at one time is called your **vital capacity**.

INVESTIGATION 4.7

Measuring your vital capacity

KEY INQUIRY SKILLS:

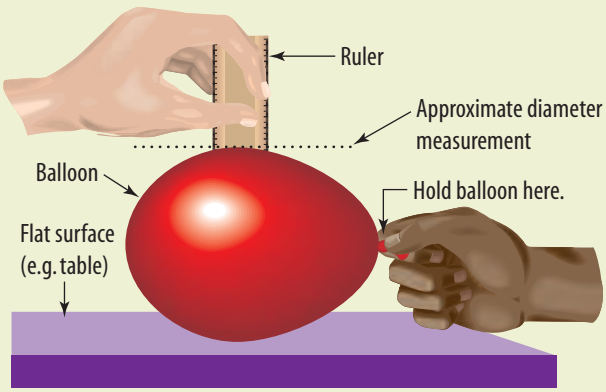
- planning and conducting
- processing and analysing data and information
- evaluating

Equipment:

balloon

ruler

- Blow up a balloon to about 20 cm in diameter two or three times to stretch it. Release the air each time.
- Take the biggest breath you can, then blow out all the air you can into the balloon. Tie up the end of the balloon to hold in your 'blown out' air.
- Use a ruler to measure the diameter of the balloon as shown below.



How to measure the diameter of the balloon

- Use the table at the bottom of this page to determine your approximate vital capacity in litres.
- Release the air from the balloon and repeat your measurement of vital capacity three more times. Average your results to get your best estimate of the maximum 'blow-out' of your lungs.

DISCUSS AND EXPLAIN

1 Why were you asked to stretch the balloon first?

2 Why did you measure your vital capacity four times?

3 (a) Draw up a table with the following headings.

Name	Male or female?	Does this student play a wind instrument?	Lung capacity (L)

(b) Collect results from all the students in your class and complete the table.

(c) Calculate the average lung capacity for all the girls and all the boys. Do girls have a bigger or smaller lung capacity than boys in your class?

(d) Calculate the average lung capacity for all the students in your class who play a wind instrument. Compare that with the average value for the other students in the class. Does playing a wind instrument have an effect on lung capacity?

4 Suggest another way of measuring the amount of air exhaled with each breath.

Determining vital capacity

Balloon diameter (cm)	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Approx. vital capacity (litres)	0.3	0.4	0.5	0.7	0.9	1.2	1.4	1.8	2.1	2.6	3.0	3.6	4.2	4.8

HOW ABOUT THAT!

Phew … garlic breath! Have you ever heard someone say this? Garlic or onion breath comes from further down than your mouth! It has travelled through a number of your body systems. After you have eaten food containing either of these, and it has been digested, it is absorbed through the walls of your intestines and then into your blood. When the smelly onion or garlic blood reaches your lungs through your circulatory system, you breathe out the smelly gas.

INQUIRY: INVESTIGATION 4.8

Hands on pluck

KEY INQUIRY SKILLS:

- planning and conducting
- processing and analysing data and information

Equipment:

sheep's pluck (heart and lungs) with part of the liver and trachea attached

newspaper and tray to place the pluck on

plastic disposable gloves

balloon pump and rubber tubing

- Copy the table below into your workbook.

Organ	Shape (sketch)	Approx. size (cm)	Colour	Texture	Other comments?	System to which the organ belongs
Trachea						
Lung						
Heart						
Liver						

- Carefully observe and record the shape, size, colour and texture of the sheep's trachea, lung, heart and liver. Include notes on how they are connected. Can you see any blood vessels?
- Push a piece of rubber tubing down the trachea to the lungs and use a balloon pump to blow some air into the trachea. **CAUTION: For hygiene reasons, it is not recommended that you use your mouth to blow into the tube inserted in the trachea.**
- Cut through the lung, heart and liver tissue. Make a record of your observations describing how they are similar and how they are different. Discuss possible reasons for the differences with your team members.
- Using a scalpel or scissors, cut off a small piece of heart, lung and liver. Place each piece into a beaker of water and observe what happens. Discuss possible reasons for your observations with your team members.

DISCUSS AND EXPLAIN

1 Could you see any blood vessels? Try to find out their names and what sort of blood they carry.

2 Suggest why there are rings of cartilage around the trachea.

3 Suggest reasons for the differences in texture between the heart and lungs.

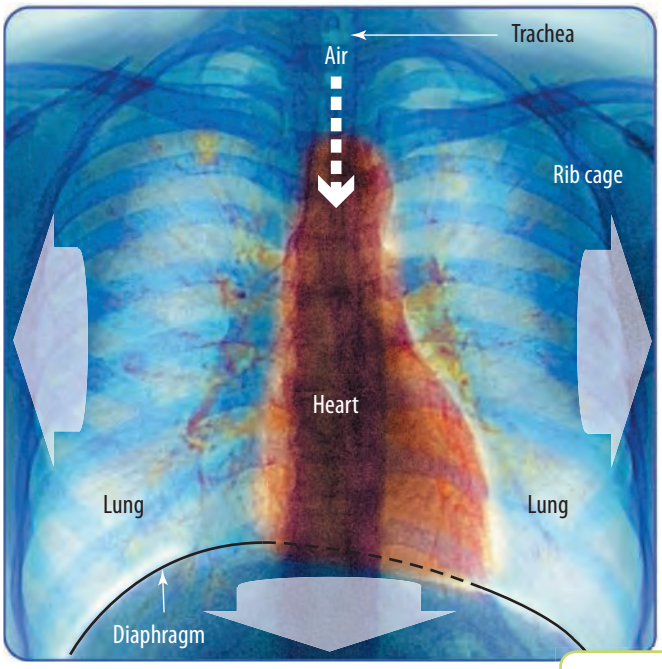
4 Suggest reasons for the differences in the shapes of the organs that you have observed.

5 Comment on something that you learned or found particularly interesting from this investigation. Share your comment with others.

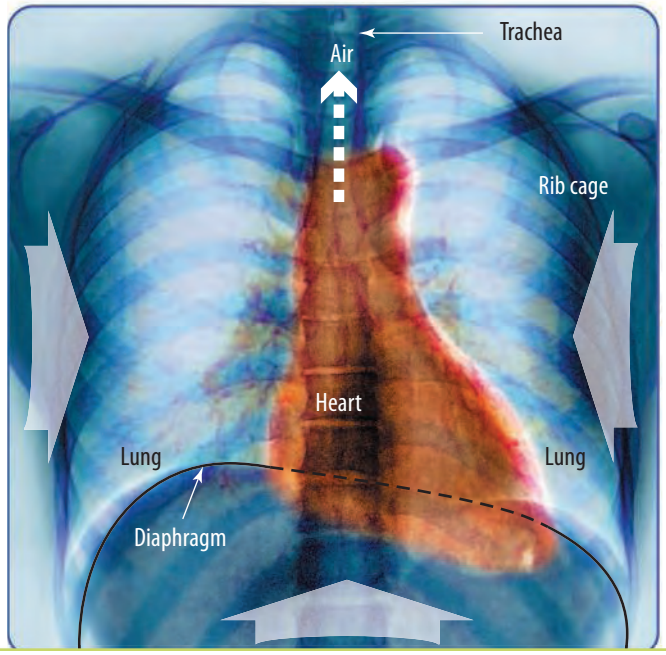
6 Research and report on the following points for each of the organs in this investigation:

- its function and how it carries this out
- the system to which it belongs
- a disease relevant to it.

(a) Breathing in



(b) Breathing out



(a) Breathing in. The diaphragm tightens, allowing the lungs to expand, and the air is sucked in.
(b) Breathing out. The diaphragm relaxes, making the lungs smaller, and the air is pushed out.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Construct a mind map to summarise the key points in this section.

2 Describe the job done by each of the following parts of the respiratory system.
(a) Epiglottis
(b) Diaphragm
(c) Alveoli
(d) Lungs

THINK AND INVESTIGATE

3 Use information in this section and other resources to relate structural features to the functions of the following parts of the respiratory system.

Part of system	Structural features	Function
Trachea		
Alveoli		
Lungs		
Capillaries		

4 Some people describe the structure of the lungs as an upside-down hollowed-out tree. Which parts of the lungs might be the following parts?
(a) Trunk
(b) Branches
(c) Twigs
(d) Leaves

5 Give reasons for each of the following pieces of advice.
(a) It is better to breathe through your nose than your mouth.
(b) You should blow your nose when you have a cold rather than sniff it back.
(c) You should not talk while you are eating or drinking.

6 Find out what a spirometer is.

7 Did you know that mountain climbers often find it difficult to breathe? Some wear oxygen tanks to allow them to climb very high mountains. Research the effects of high altitude on breathing and report your findings.

8 Some singers can hold a musical note for a very long time — investigate what muscles and techniques they use in order to be able to do this.

CREATE

9 Construct a working model of the lungs using the following items.
- Clear plastic soft-drink bottle
- 2 balloons
- 2 rubber bands
- Plasticine or 'Blu-Tack'
- Scissors
- 2 plastic drinking straws

work sheet 4.3 Breathing — constructing a report

Short of breath?

If you do not suffer from **asthma**, it is very likely that you know someone who does. Asthma is a very common condition, which affects about one in seven Australian adolescents.

About one in ten, or 10 per cent, of adults are affected. Young children are the greatest sufferers of asthma with one in four affected. One alarming fact about asthma is that the number of people who suffer from it has doubled in the last 30 years. The reasons for this increase are not clear but you might have some ideas of your own after reading this article.

What is asthma?

Asthma is a narrowing of the air pipes that join the mouth and nose to the lungs. The pipes most affected are the bronchi. They become narrower as:

- the muscle wall of the air pipes contracts
- the lining of the air pipes swells
- too much mucus is produced.

The narrow pipes make breathing difficult and can result in wheezing, coughing and a tight feeling in the chest. The coughing is usually worse at night.

What causes asthma?

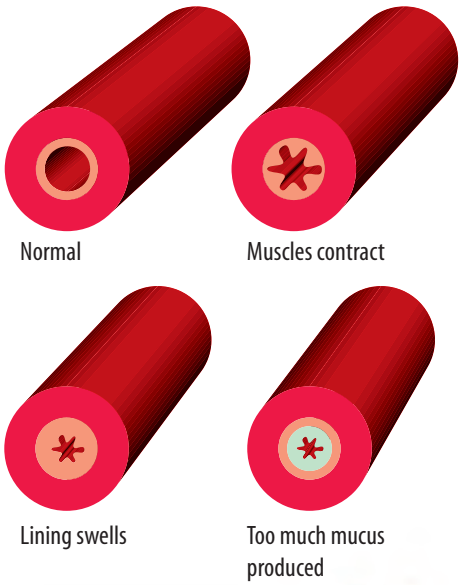
It is not known why some people get asthma and others do not. It seems that it can be inherited, but many people from families without a history of asthma are affected. Asthma is certainly the result of sensitive airways. An asthma attack occurs when those sensitive airways are 'triggered'. If the sufferer has a cold, the airways are already inflamed and are more likely to be triggered.

Triggers

Some of the common triggers of an asthma attack are:

- vigorous exercise
- cold weather
- cigarette smoke
- dust and dust mites
- moulds
- pollen
- air pollution
- some foods and food additives
- some animals.

Not all asthma sufferers are affected by the same triggers. Some people suffer attacks only as a result of exercise. Others might be affected by any one or more of the triggers. It is important that those who get asthma try to find out what triggers the attacks. Many of the triggers can be avoided.



Asthma is a narrowing of the air pipes.

Controlling the triggers

The best way to control asthma is to avoid the triggers. Of course, it is not always possible to identify the triggers. People who are affected by cold weather, pollen or air pollution often move to other places to avoid their triggers.

Pollen from some grasses and trees is very light and becomes airborne on even slightly windy days. The inhaling of pollen can be reduced by avoiding outdoor activities and keeping windows and doors closed on breezy spring days. Moulds live in warm, humid conditions and thrive in bathrooms, kitchens and bedrooms. Their spores are easily breathed in, triggering attacks in some asthma sufferers. Moulds can be reduced by airing the house regularly.

Pollen and moulds are also the main triggers of hay fever. Hay fever clogs up the nose in much the same way as asthma affects the air pipes. It causes sneezing and a runny nose.

Those asthma sufferers whose attacks are triggered by air pollution are warned to remain indoors as much as possible and avoid vigorous activity on smoggy days. If tobacco smoke is a trigger, the cigarette smoke of others needs to be avoided.

Dust mites are a common trigger of asthma attacks. Dust mites are microscopic animals that live in their thousands in warm, moist and dark places like doonas, sheets, pillows, carpets and curtains. Dust mite droppings float in the air and are easily inhaled.

Since you share so much of yourself and where you live with this fellow Australian, you should probably know its name. It is the most common dust mite (a relative of spiders and ticks) in Australia, *Dermatophagoides pteronyssinus*. The good news is that it is half a millimetre long and doesn't bite. The bad news is that there may be thousands of them living in your pillow, each defecating about 20 faecal pellets a day, reproducing (each female laying about 30 eggs in her lifetime), dying and decomposing. The fact that dust mites mate for 24 hours at a time (perhaps because their penis is only about as wide as their sperm) may make this particularly disturbing!

HOW ABOUT THAT!

Dust mites thrive best in bedding and carpets because these contain plenty of dead human skin cells. Humans shed a complete layer of dead skin cells every month. That amounts to about 1 kilogram of skin cells each year. In fact, most of the dust in your house consists of dead skin cells.

Dr Peter Dingle (Associate Professor in Health and the Environment at Murdoch University's School of Environmental Science) suggests that our skin scales are the main food source of these dust mites, so wherever we are, they are. Dr Janet Rimmer (a respiratory physician and Director of the National Asthma Council Australia) also suggests that, of the 45 per cent of Australians who are affected by allergies, about 80 per cent are allergic to dust mites. But not all researchers have bad news about dust mites. Dr Matthew Colloff, a CSIRO researcher, has found them so interesting that he wrote a book (called *Dust mites*) about them.

A house dust mite

Even the cleanest house has dust mites, but their numbers can be reduced by:

- exposing the mattress to the sun, because dust mites are susceptible to drying out
- washing bedding materials and bedclothes in tea-tree or eucalyptus oil or in hot water (more than 55°C)
- removing soft toys that collect dust or hot washing them weekly
- regularly vacuuming curtains and carpets
- airing the bedroom by keeping doors and windows open
- replacing carpets with hard flooring.

Chemicals in foods, and animals, are less common triggers of asthma attacks. However, they are easier to avoid if they have been identified as a trigger.

Asthma medication

Asthma medications can be divided into two main groups: preventers and relievers. Preventers make the lining of the airways less sensitive and therefore less likely to be triggered. Relievers open up the airways once an attack has commenced. Most asthma medications are applied with inhalers or 'puffers', which direct the medication straight

into the air tubes for fast action. Severe attacks of asthma require other drugs and sometimes extra oxygen needs to be supplied.

Up in smoke

About 18 000 Australians die each year as a result of diseases caused by smoking. In fact, smoking is the largest preventable cause of death and disease in Australia.

Just one cigarette

There are clearly many long-term effects of smoking. However, the diagram below shows what happens to you after smoking just one cigarette.

There are some more obvious effects such as bad breath, body odour and watery eyes. After several cigarettes, your teeth and fingers become stained. Your sense of taste is reduced. Even your stomach is affected as acid levels increase.

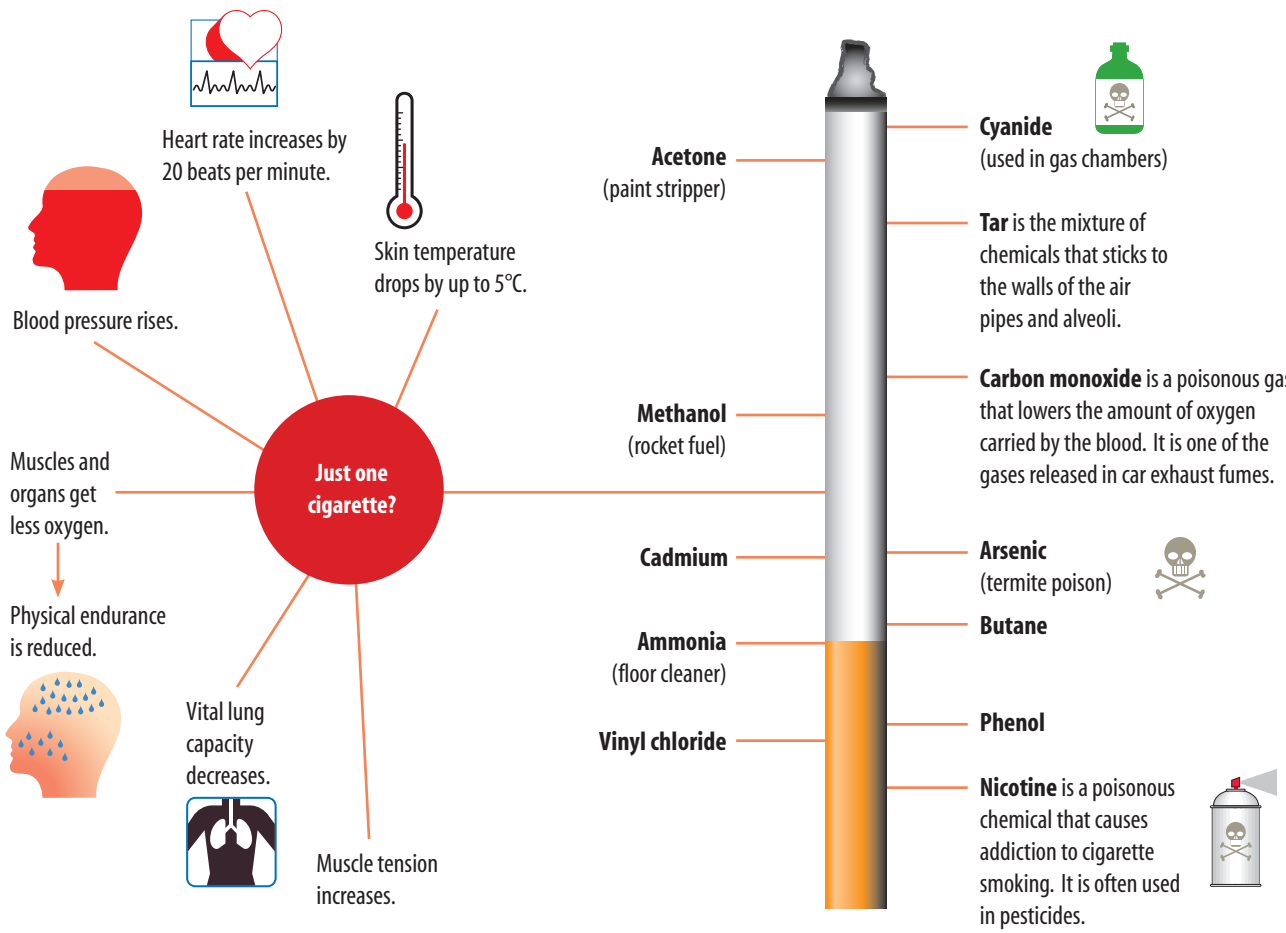
Smoking and your lungs

Lung cancer is the most well-known disease caused by smoking. Chemicals that cause cancer are called **carcinogens**. Cigarette tobacco contains a number of carcinogens. The chemicals in cigarettes also clog up the fine hairs in your air tubes with a mixture of mucus and foreign chemicals.

Cough it up?

Coughing is the body's way of trying to clear the air tubes. However, not all of the clogging can be cleared by coughing. The dirty mixture remains in the air tubes, causing swelling, making them sensitive and slowing down the passage of air. Eventually the sticky mixture sinks down into the lungs, where it blocks some of the pathways to the alveoli, where freshly breathed air should deliver oxygen to the blood.

The diseases caused by this blocking process are called chronic obstructive pulmonary diseases, or COPD. **Emphysema** is the worst of these diseases and results in the eventual destruction of the alveoli.



Professor Robyn E. O'Hehir

BSc, MBBS (Hons I), FRACP, PhD, FRCP, FRCPath

1 What is your current science-related title?

I am a Professor of Medicine, with particular responsibilities for allergy, clinical immunology and respiratory medicine, at Monash University, Melbourne. I am also the Director of the Department of Allergy, Immunology and Respiratory Medicine at the Alfred Hospital in Melbourne.

2 What field of science are you in?

Allergy, cellular immunology and respiratory medicine. I was appointed to the first Chair in Allergy and Clinical Immunology in Australia.

3 Describe some 'science' that you are involved in at the moment.

Millions of people around the world suffer from allergies. I am sure you know several friends who have asthma or hay fever, or you may even have them yourself. Asthma and hay fever are usually triggered by proteins called allergens, from house dust mites or grass pollens. Allergies to peanuts and shellfish are less common but often more serious, because they can trigger life-threatening allergic reactions called anaphylaxis. Allergies are caused by reactions between white blood cells ('T cells') and environmental proteins that are usually harmless. My research group is trying to find ways to damp down the allergic T-cell responses.

Allergen immunotherapy (allergy shots) is the only treatment that can prevent allergic diseases, but currently it can't be used for peanut, even though this is one of the most serious allergens. To develop a safe and effective vaccine against peanut allergies, we are identifying parts of critical peanut proteins that can build up tolerance in allergic patients without risking anaphylaxis.

4 What do you enjoy about being a scientist?

I enjoy the fact that my research not only is laboratory-based, exploring novel methods for switching off allergic responses, but also lets me see patients and train other doctors in how to do research from bench to bedside to the community. I head an active clinical department, still carry out clinics with patients, and am actively engaged in national and international tests of new preventions and treatments for allergies. My combined research and clinical duties allow translation of our research findings into better clinical practice.

5 What triggered your interest in science?

I decided to specialise in allergy and respiratory medicine, focusing on asthma, following my experiences as a young trainee physician at the Alfred Hospital in Melbourne. Asthma was a huge problem in Australia at that time, and many times I resuscitated young adults in the hospital emergency room — and I watched them return, with appropriate medication and careful education, to confident, full lives. Some remain my patients today. The ability to dissect underlying mechanisms of disease and then work towards new therapeutics and practices to benefit patients is a great excitement and honour. The diversity of patients and their needs ensures that every day is quite different.

6 Do you have any other comments that may be of interest to Year 8 Science students?

A career in science combined with medicine may take a bit longer in terms of training, but it gives you a fantastic ability to do interesting work that is intellectually demanding and also involves working with lots of people who need your help. I am very glad that I chose a career in science and medicine.

UNDERSTANDING AND INQUIRING

ANALYSE AND EVALUATE

1 If you were part of an audience of 1400 Year 8 students in a concert hall for a music excursion, how many of them would be likely to be asthma sufferers? (*Hint:* Use the information at the beginning of this section.)

2 The number of people who suffer from asthma has doubled in the last 30 years. Put forward one or more hypotheses suggesting why this might have happened. Write down any evidence that supports each of your hypotheses.

REMEMBER

3 What happens to the air pipes to the lungs during an asthma attack to make breathing difficult?

4 Why is an asthma attack more likely to be triggered in a person with a cold?

5 What is an asthma trigger?

6 What are the two major types of asthma medication and how are they different from each other?

THINK AND DISCUSS

7 Why is it unlikely that you would ever rid a house completely of dust mites? With your partner, brainstorm as many ideas as you can into a cluster map.

8 (a) In your team, brainstorm ideas about the common triggers of asthma that can be controlled. Summarise your discussion in a bubble map.
(b) Construct a table similar to the one below.
(c) Again as a team, add suggestions to your table of ways that the trigger could be controlled.

Trigger	How the trigger can be controlled
Moulds	Air the house regularly.

9 (a) If you suffer from asthma, prepare a talk for the rest of your class explaining:
(i) what it is
(ii) how it affects you
(iii) how you control it or try to prevent attacks.
(b) If you do not suffer from asthma, write a set of at least five questions that you could ask an asthma sufferer in an interview. If possible, conduct the interview and record the answers in writing, on audio cassette or on videotape.

INVESTIGATE AND DISCUSS

10 Propose a series of questions to find out more about each of the areas below, investigate them, and then share your findings with others.
(a) Allergies
(b) Asthma
(c) Anaphylaxis
(d) Allergen immunotherapy
(e) Clinical immunology and respiratory medicine

Peanuts are a common cause of allergies.

11 (a) Find out more about Anaphylaxis Australia Inc.
(b) Outline the topics covered in a first aid course for management of anaphylaxis.
(c) What is the EpiPen® and how is it used?

ANALYSE AND EVALUATE

12 The table below shows how the popularity of smoking has changed over the past 65 years or so.

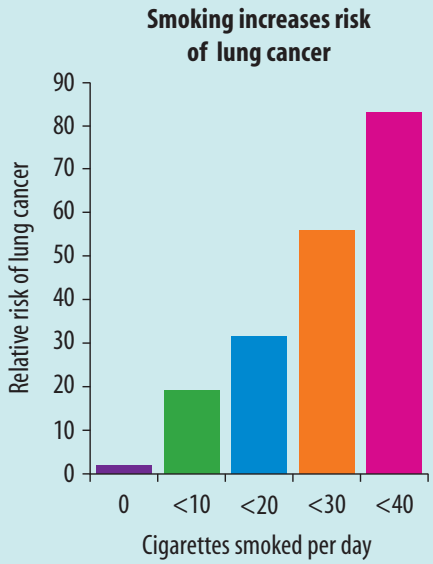
Percentage of adult Australians who smoke

Year	1945	1964	1969	1974	1976	1980	1983	1986	1989	1992	1998	2001	2004
Males (%)	72	58	45	41	40	40	37	33	30	28	29	28	26
Females (%)	26	28	28	29	31	31	30	28	27	24	24	21	20

(a) Draw a line graph of the data in the table. Use 'Year' on the *x*-axis and '% of adult Australians who smoke' on the *y*-axis. Draw lines for males and females in different colours.

(b) Why do you think that the percentage of females who smoke has changed little while the percentage of males who smoke has declined greatly?

(c) Use dotted lines to show your prediction of the trends up to the year 2020. What percentage of males and females do you predict will be smoking in the year 2020?



Graph 1: The risk of getting lung cancer increases with the number of cigarettes smoked daily.

13 Study graph 1 above.

(a) Copy and complete the following statements:

(i) People who smoke 10 cigarettes a day are _____ times more likely to develop lung cancer than non-smokers.

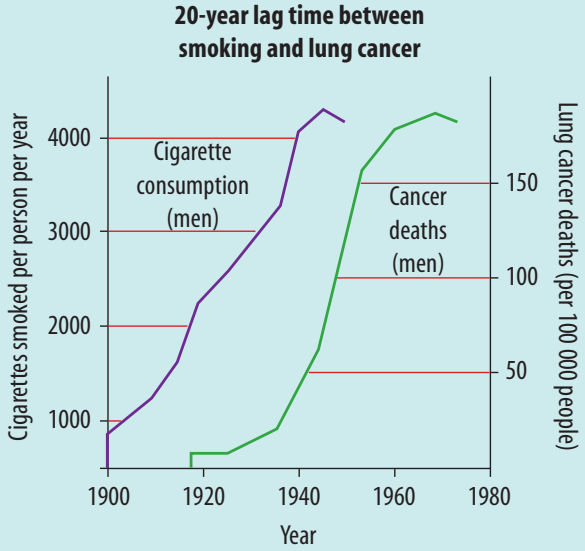
(ii) People who smoke 30 cigarettes a day are _____ times more likely to develop lung cancer than people who smoke 10 cigarettes a day.

(b) If a packet of cigarettes costs $15 and contains 20 cigarettes, calculate how much a person smoking 40 cigarettes a day spends on smoking:

(i) each day

(ii) each week

(iii) each year.



Graph 2: This graph shows that the number of deaths from lung cancer has risen as cigarette consumption has increased but there is a 20-year lag time because lung cancer takes many years to develop.

14 Study graph 2 above.

(a) Describe how the incidence of lung cancer changed between 1900 and 1980.

(b) Identify when the number of male smokers peaked.

(c) Identify when the number of deaths from lung cancer peaked.

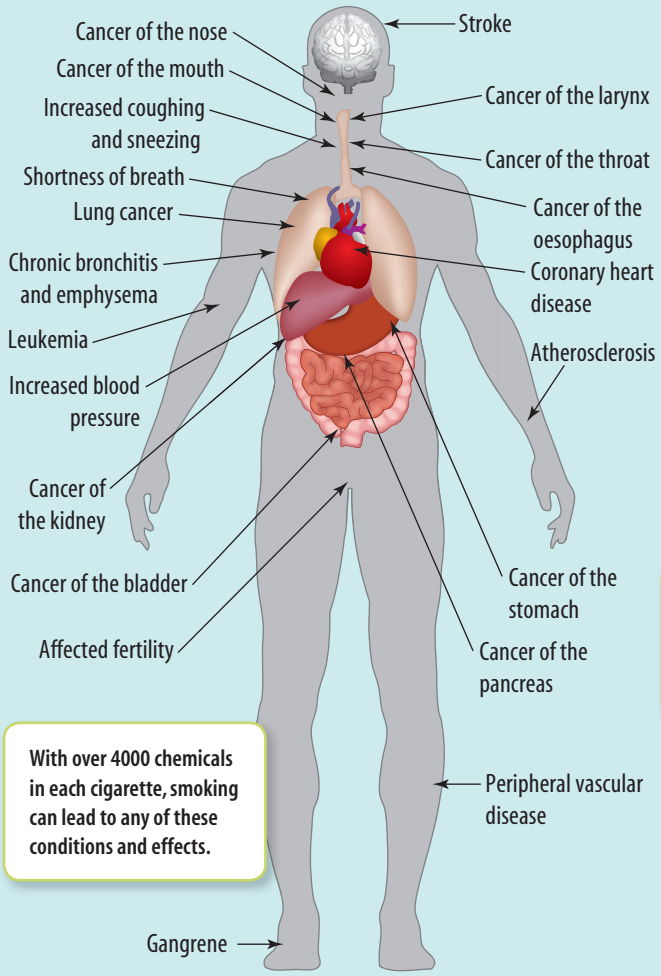
(d) Explain why there is a 20-year gap between the two numbers.

(e) The graph shows data for male smokers only. Predict when the number of cases of lung cancer in women peaked (use the graph you drew for question 1 to answer this).

THINK

15 Draw up a two-column table. The first column should be headed 'Reasons for smoking'; the second column should be headed 'Reasons for not smoking'. With at least one other person, complete the table. Then compare your table with others. You might be able to construct a large table for the whole class.

16 Smoking-related diseases cost taxpayers many millions of dollars because hospitals are mostly paid for by governments. Write down your opinion of each of the proposals below. Give reasons for your opinion.
- (a) The cost of hospital treatment for diseases caused by smoking should be paid for by the patient because it was their fault that they got sick.
- (b) Cigarettes should cost more. The extra money made from them could then be given to hospitals to help pay for treating smoking-related diseases.
- (c) Cigarette companies who make profits from smoking should be made to pay for hospital treatment of patients with diseases caused by smoking.



17 Although smoking is now banned in many places, including public transport vehicles, workplaces and restaurants, it is still legal. Why do you think smoking has not been made illegal when it causes so much damage?

INVESTIGATE AND CREATE

18 Draw a poster that sends one single important message about smoking.

19 Design an experiment that would investigate the effect of passive smoking on heart rates. Investigate whether any relevant research has been performed in this area. If so, share it with others in your class.

20 Research the evidence showing the effect of smoking on human lungs and construct a model to show its impact that could be used in a campaign against smoking.

21
- (a) In a small team, research media articles that relate to smoking.
- (b) In your team, discuss your findings.
- (c) As a team, evaluate the claims made. How accurate are they? How true are they? Are there any biases?

22
- (a) Is it ever illegal to smoke a cigarette in Australia? If so, what are the conditions?
- (b) Do you agree with Australia's laws and guidelines on smoking? Explain.

23
- (a) Research the structure and function of an alveolus.
- (b) Suggest how the structure of an alveolus is related to its function.
- (c) Suggest how smoking affects the ability of an alveolus to perform its function.

eBookplus

24 Use the **Quit Now** weblink in your eBookPLUS to learn about the National Tobacco Campaign. Create a poster that sends one single important message about smoking.

work sheet 4.4 Smoking and diseases

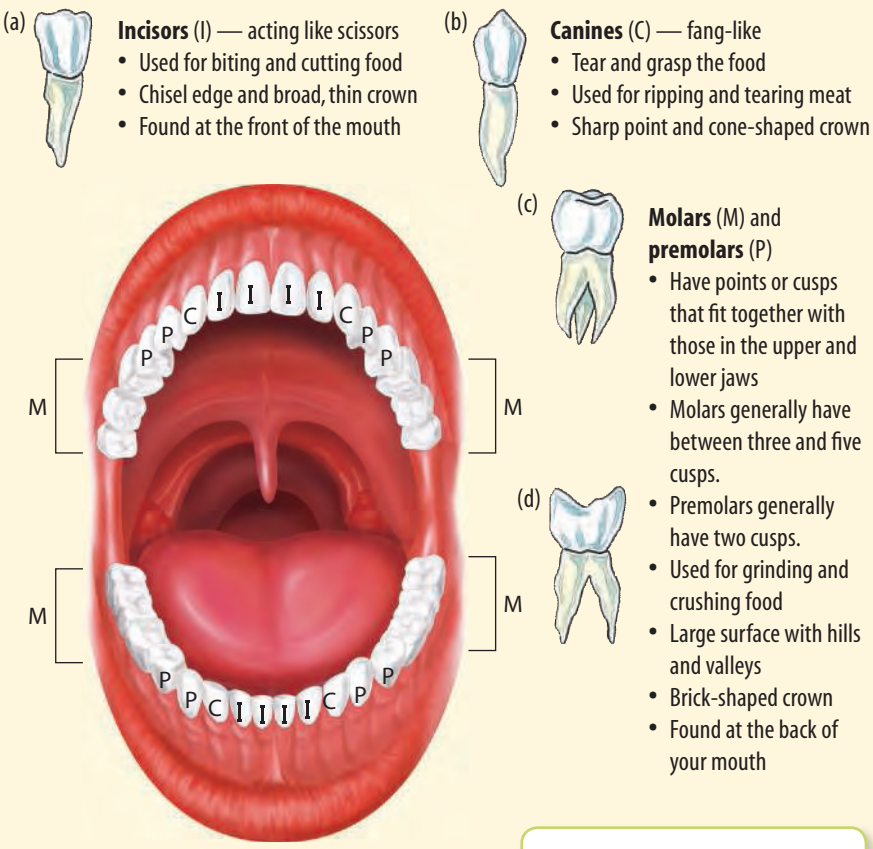
Break it down

Digestion is the breaking down of food so that the nutrients it contains can be absorbed into your blood and carried to each cell in your body.

Five processes are important in supplying nutrients to your cells:
- ingestion — taking food into your body
- mechanical digestion
- chemical digestion
- absorption of the broken-down food into your cells
- assimilation — converting the broken-down food into the chemicals in your cells.

Mechanical and chemical digestion

Mechanical digestion involves physically breaking down the food into smaller pieces. Most of this process takes place in your mouth when your teeth bite, tear, crush and grind food. **Chemical digestion** occurs when chemicals in your body react with the food. The chemical reactions that take place change the substances in food into simpler chemicals that are more easily absorbed into your blood.



Four different types of human teeth

Look at those teeth!

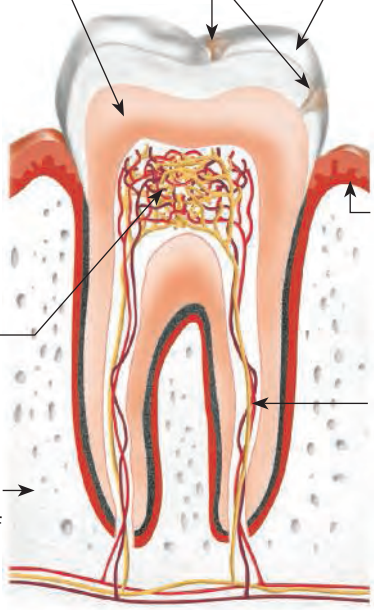
In many vertebrates, mechanical digestion begins with the teeth. There are four main types of teeth in humans, each type having a different function and position in your mouth as shown below. Your teeth are your very own set of cutlery.

Do you look after your teeth?

Your teeth can decay when bacteria in your mouth turn sugar from your food into acid. This acid can 'eat' a hole in your tooth enamel and dentine. Once this hole reaches a nerve, you get a toothache. The illustration opposite shows the structure of a tooth and where decay usually occurs — at the top of large back teeth and at the side where one tooth touches another.

If you don't clean your teeth regularly (at least once a day), they can become covered with a thin film of food, saliva and bacteria. This is called plaque. As this plaque rots, it causes your gums to swell and bleed. This is known as gum disease.

Our water supply and toothpaste often contain fluoride, which helps prevent tooth decay. Fluoride protects the enamel and helps repair or rebuild the enamel in your teeth. Damaged or missing teeth can make it difficult for you to chew your food properly and therefore may affect digestion of foods.



Structure of a tooth showing where tooth decay occurs

What do they eat?

HERBIVORE (WOMBAT)

Herbivores eat plants. They have large incisors for biting and cutting. Herbivores do not have canines. They have large premolars and molars because the fibrous plant material needs a lot of grinding.

CARNIVORE (TASMANIAN DEVIL)

Carnivores eat other animals. Because their prey is alive and moving, they have large canines for stabbing and holding on to it. Their incisors are used for tearing meat. The molars and premolars in carnivores have cutting edges.

OMNIVORE (HUMAN)

Omnivores eat both plants and animals. They have all of the different types of teeth needed to break down both meat and plants.

INQUIRY: INVESTIGATION 4.9

How well do you brush your teeth?

KEY INQUIRY SKILLS:

- planning and conducting
- processing and analysing data and information
- evaluating

Equipment:

3 nutrient agar plates	*toothbrush*
3 small labels	*toothpaste*
3 cotton buds	*incubator set at 35°C*
sticky tape	*dissection microscope*

Note: This is best done after lunch, prior to cleaning teeth.

- Label the three agar plates as 'Dirty', 'Toothpaste' and 'Brush only'.

- Wipe a cotton bud carefully over your uncleaned teeth and gums.
- Gently wipe in a zigzag pattern over the agar plate labelled 'Dirty'.
- Replace the lid and seal around the edges with sticky tape.

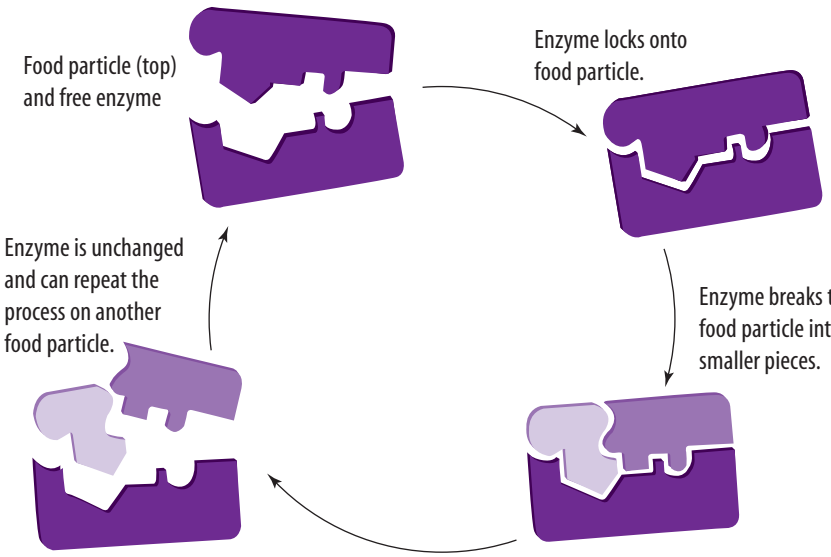
- Repeat the steps above after brushing with no toothpaste and then with toothpaste.
- Incubate the agar plates for 24–48 hours.
- Observe the agar plates using the dissection microscope. Do not open the agar plates. Observe through the plastic dish.

DISCUSS AND EXPLAIN

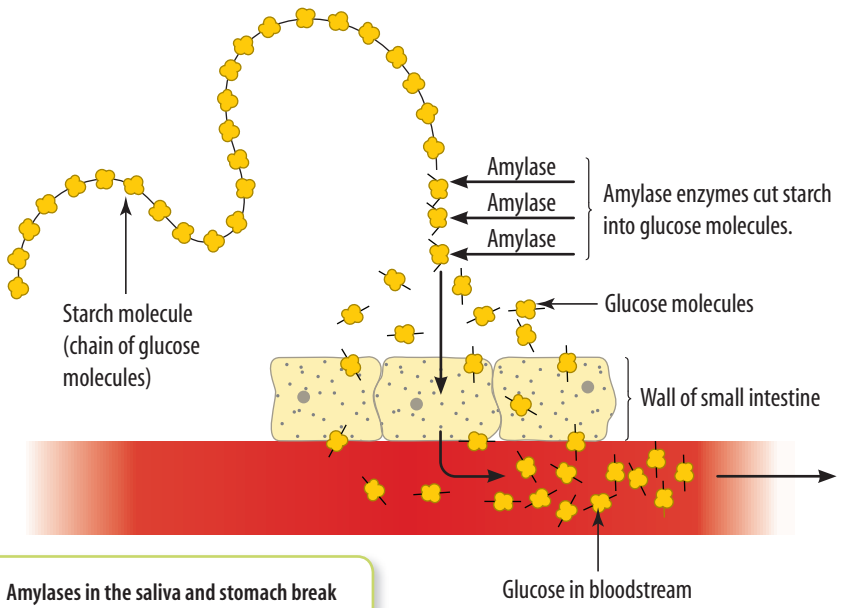
1. Sketch the three agar plates, showing any growth.
2. Which agar plate had the most growth? Why?
3. Suggest why we brush our teeth with toothpaste.
4. Suggest improvements to the design of this investigation.

INSECTIVORE (NUMBAT)

Insectivores are carnivores that eat only insects. Their teeth are small and pointed so that they can crush the exoskeleton of the insect. Insects are then swallowed whole.



Enzymes speed up chemical reactions in the body, but are not changed so can be reused again and again.



Amylases in the saliva and stomach break starch down into glucose molecules.

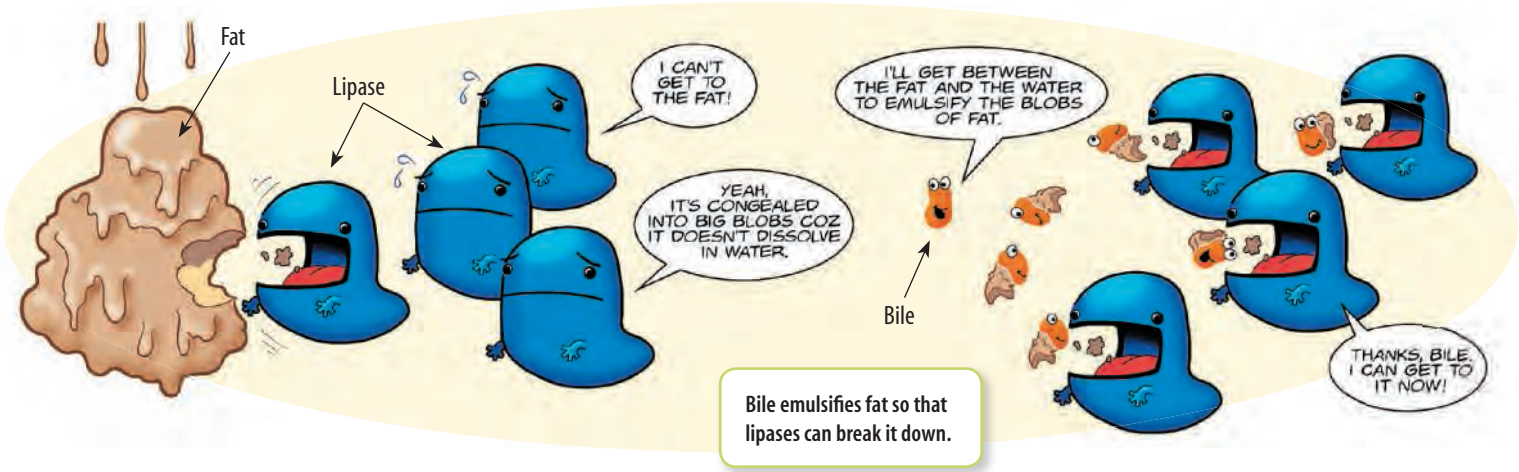
Enzymes — licensed to speed

Chemical digestion is usually assisted by compounds called **enzymes** that increase the rate of the chemical reactions. Without enzymes, a single meal could take many years to break down. Mechanical digestion increases the rate of chemical digestion because it increases the surface area of the food particles. This exposes more of the food surface to the digestive chemicals and enzymes.

Chemical digestion begins in your mouth where enzymes in saliva begin to break down some of the carbohydrates in the food that you eat.

NOT TOO HOT!

Enzymes are made of protein. That is why it is important that they are not overheated. If they are too hot, they can become **denatured**. It's a bit like cooking meat — once they are denatured, they can't go back to how they were before, so they can't work as enzymes anymore. Different enzymes operate best within specific temperature ranges.



Bile emulsifies fat so that lipases can break it down.

'ASE' ENDINGS

There are specific enzymes for specific tasks. The substance that they are breaking down is called a **substrate**. The name given to the resulting substance is referred to as the **product**. As the diagram above left shows, the enzyme remains unchanged at the end of the process.

Enzymes that break down carbohydrates, such as starch, into glucose are called **amylases** (this process is shown in the diagram at left). Those that break down fats and oils into fatty acids and glycerol are called **lipases**. **Proteases** are enzymes that break down proteins into amino acids.

Each enzyme has specific conditions in which it works. For example, amylases that break down carbohydrates in the stomach work in acidic environments, while those in the small intestine work best in alkaline conditions.

Fat stuff

Breaking down lipids, such as fats and oils, is hard work! Because lipids are insoluble in water, they tend to clump together into large blobs. A substance called **bile** helps solve this problem. Bile is produced by your liver and stored in your gall bladder. As half of the bile molecule is attracted to water and the other half attracted to lipids, it helps to **emulsify** or separate the lipids so the lipase enzymes can gain access to them and do their job. This is an example of mechanical digestion (bile) and chemical digestion (lipase) working together to get the job done!

INQUIRY: INVESTIGATION 4.10

Does temperature affect enzymes?

KEY INQUIRY SKILLS:

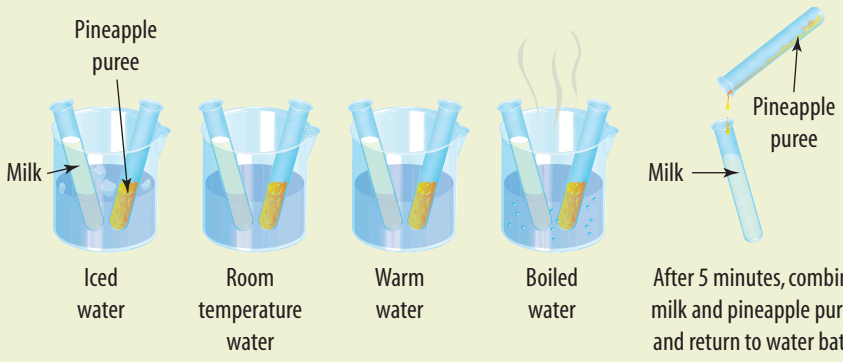
- planning and conducting
- processing and analysing data and information
- evaluating

Equipment:

4 beakers *8 test tubes* *milk* *4 thermometers*

fresh pineapple puree (Fresh pineapple can be pureed using a food processor. If fresh pineapple is not available, use junket powder or a junket tablet dissolved in 10 mL water.)

- Add water to the beakers so that they are two-thirds full. Use cold tap water and ice for beaker 1, cold tap water for beaker 2, hot tap water for beaker 3 and boiling water (from a kettle) for beaker 4. These are the 'water baths'.



- Half-fill four test tubes with milk and put one test tube in each water bath.
- Place one teaspoon of fresh pineapple puree (or 1 mL junket solution) in the other four test tubes. Put one of these test tubes in each water bath.
- Allow the test tubes to stand in the water baths for at least 5 minutes.
- For each water bath, pour the fresh pineapple puree into the milk and stir briefly. Quickly record the temperature of the milk and pineapple mixture and then allow it to stand undisturbed. The mixture will eventually set. Record the time taken to set. If the milk has not set after 15 minutes, record the time as 15+.
- Copy and complete the table of results below.

Water bath	Temperature of milk and pineapple mixture (°C)	Time taken to set (min)

DISCUSS AND EXPLAIN

1. Pineapple juice and junket contain an enzyme that causes a protein in milk (casein) to undergo a chemical reaction and change texture; that is why the milk sets. At what temperature did the enzyme work best? Explain your answer.
2. Did the enzyme work well at very high temperatures? Explain your answer.
3. Which variables were controlled in this experiment?
4. Do you think that the same results would be obtained if tinned pineapple puree was used instead of fresh pineapple? Explain your answer.

A future in teeth

Dentistry is only one example of many different 'tooth pathway' careers that you may be aware of. Examples of other dental specialities include oral and maxillofacial surgeons, dental–maxillofacial radiologists, endodontists, oral physicians, oral pathologists, orthodontists, paediatric dentists, periodontists, prosthodontists, public health dentists and special needs dentists.

Missing a tooth? A synthetic replacement for a tooth root is used in a tooth implant.

Oral surgeon is one of the many tooth-related careers you can choose from.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Explain why it is important to break down the food that we eat.
2 Use a Venn diagram to compare mechanical digestion and chemical digestion.
3 Identify four types of teeth and describe their functions.
4 Construct a matrix table (see page 340) to compare the diets and teeth of herbivores, carnivores, omnivores and insectivores.
5 Outline what enzymes are and what they do.
6 State the name of the:
(a) type of digestion that enzymes are involved in
(b) enzymes that break down fats
(c) enzymes that break down proteins
(d) substance that enzymes act on.
7 Describe what happens to enzymes when they get too hot.
8 Describe how bile helps lipase enzymes get their work done.

THINK

9 Which teeth do you use to bite into a pear?
10 Which teeth are used to crush and grind nuts?
11 Why don't herbivores have canine teeth?
12 How do we know what different types of dinosaurs ate, even though they haven't existed for about 65 million years?

THINK AND DESIGN

13 Design an investigation to test the following hypotheses:
- Drinking fluoridated water reduces tooth decay.
- Mouthwash prevents the growth of bacteria that cause tooth decay.
- Drinking bottled water rather than tap water increases tooth decay.

14 Design an investigation to test the following hypotheses:
- Fresh pineapple results in a faster enzyme reaction than canned pineapple.
- The length of time that pineapple puree is kept in ice affects the rate of enzyme reaction.
- Different coloured junket tablets result in different rates of enzyme reaction.

INVESTIGATE AND CREATE

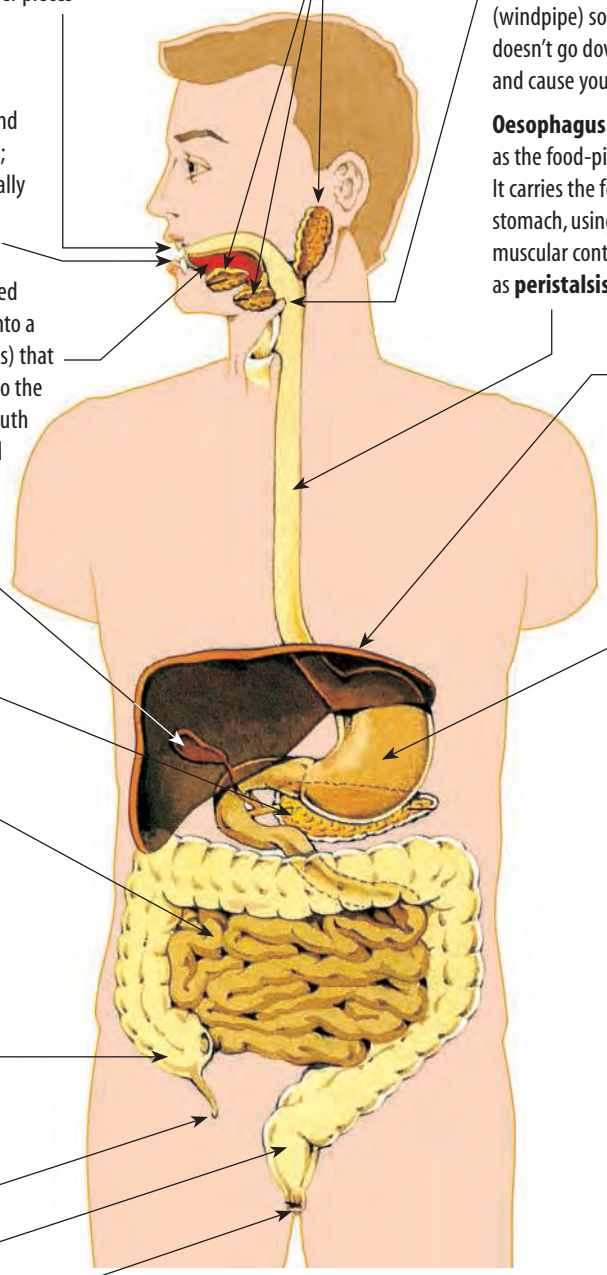
15 Research an enzyme of your digestive system. Find out what it does and where, then construct a poster or model to show how it works.
16 Select one of the 'tooth pathway' careers in the text 'A future in teeth'. Find out details of the training required and what a career in this pathway would entail. Present your findings in a brochure and include a section that describes what 'a day in the life of …' this career would be like.

work sheet 4.5 Mechanical and chemical digestion

Down we go...

The human digestive system

Your main digestive highway is called the **alimentary canal**. It consists of a long tube with coils, large caverns and thin passageways. Other organs that provide chemicals to break down the food or absorb nutrients are attached to the alimentary canal. The alimentary canal begins at the mouth and ends at the anus, where waste products are removed. Excretion of waste products produced by the body cells can also involve other organs, such as the skin, lungs and kidneys.



Salivary glands. Make about 1.5 litres of saliva each day. Saliva contains enzymes that begin breaking down starch in food.

Teeth. Used to bite and chew your food to break it down into smaller pieces

Epiglottis. A flap of tissue closes off your trachea (windpipe) so that food doesn't go down to your lungs and cause you to choke.

Mouth. Food and saliva are mixed; teeth mechanically break food into smaller pieces.

Oesophagus. Also known as the food-pipe or gullet. It carries the food to the stomach, using involuntary muscular contractions known as **peristalsis**.

Tongue. Involved in rolling food into a round ball (bolus) that is then pushed to the back of your mouth to be swallowed

Liver. The largest internal organ. It makes bile, which breaks down fats; controls blood sugar; destroys poisons; and stores vitamin A, vitamin D and iron.

Gall bladder. Bile made in the liver is stored here; bile breaks up fats into droplets small enough to be transported to the rest of the body.

Stomach. A temporary food storage area, which can expand to hold between 2 and 4 litres of food. Muscle movements in the stomach wall mix the food with gastric juice, which helps to break down proteins. The stomach also contains dilute hydrochloric acid, which kills germs and provides a suitable environment for protein digestion.

Pancreas. Makes pancreatic juice, which is alkaline (base dissolved in water) so it neutralises the stomach acid. Enzymes that break down proteins, fats and carbohydrates are also made here.

Small intestine. A tube about 6 m long. Food moves through it by peristalsis. The small intestine makes enzymes that complete the digestion process. The cells in the wall of the small intestine release over 5 litres of mucus and water each day. It is in the small intestine that nutrients from now almost totally digested food are absorbed into your bloodstream. The blood then carries the nutrients to all of the cells of your body.

Large intestine (colon). Undigested material passes into the large intestine. As the material is pushed through it by peristalsis, water, salts, vitamins and any remaining sugars are absorbed so that they can be reused by the body.

Appendix. Plays no part in digestion in humans. However, it is believed to play a role in fighting some diseases.

Rectum. The final part of the large intestine. This is where the faeces are stored.

Anus. The faeces pass through here when you go to the toilet.

eBook plus eLesson

From dinner plate to sewerage system

Watch the amazing journey of food through the human body.

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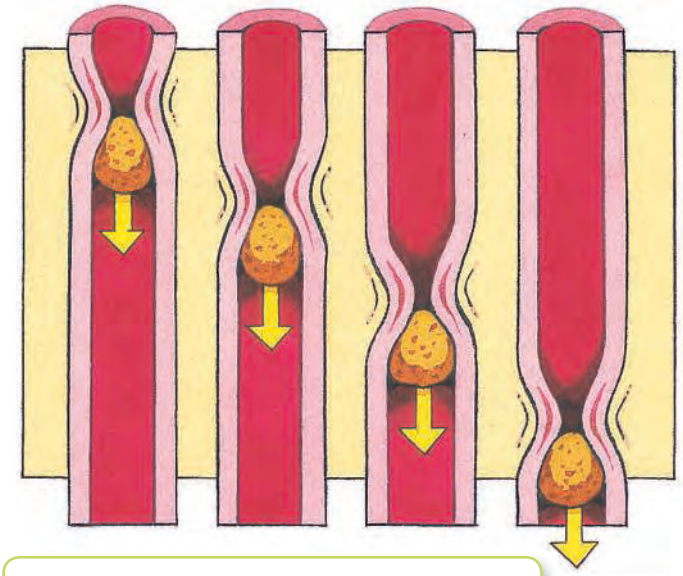
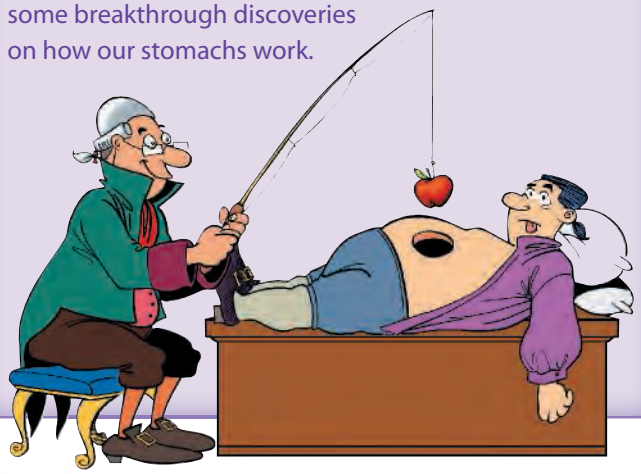


Partly digested food is forced along the oesophagus by peristalsis — a wave of involuntary muscular contractions.

HOW ABOUT THAT!

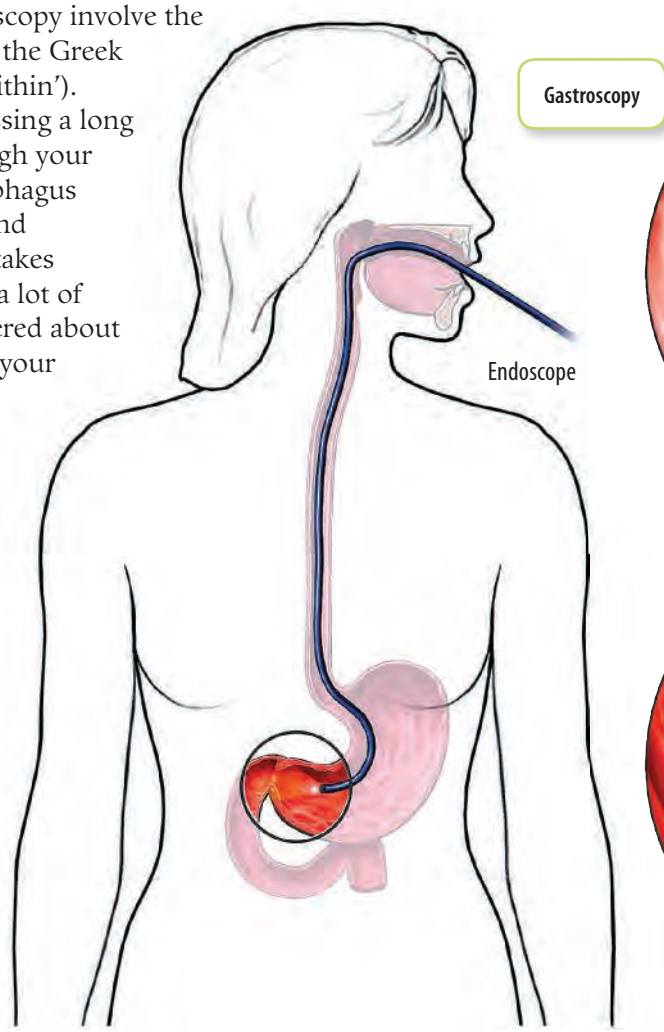
Just to whet your appetite . . . have you heard the story of Alexis St Martin? In 1822, he was shot in the stomach at close range. Wrong place at the wrong time! His wound healed, but left an open hole that showed the inside of his stomach! By dangling food suspended on a silk thread, his doctor William Beaumont made some breakthrough discoveries on how our stomachs work.

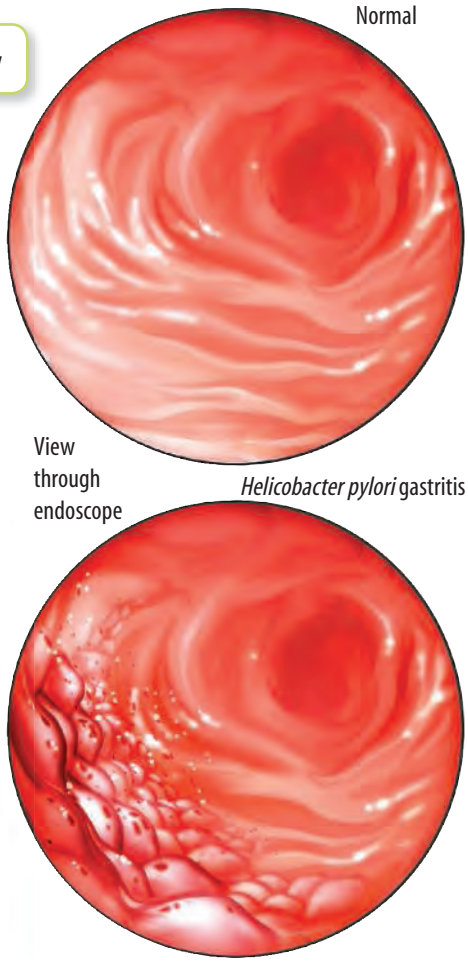


Going up or down?

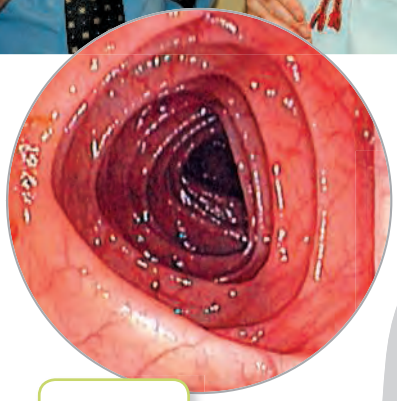
Gastroscopy and colonoscopy involve the use of endoscopes (from the Greek words meaning to 'see within'). Gastroscopy involves passing a long flexible endoscope through your mouth, down your oesophagus and into your stomach and duodenum. Although it takes only about five minutes, a lot of information can be gathered about the health of this part of your digestive system.

Colonoscopy enables the doctor to look directly at the lining of your colon or bowel. In this case the endoscope is inserted through your rectum. This procedure may take about thirty minutes. The results may be used to investigate abnormalities or detect the presence of colon polyps, which in some cases may turn into cancer.

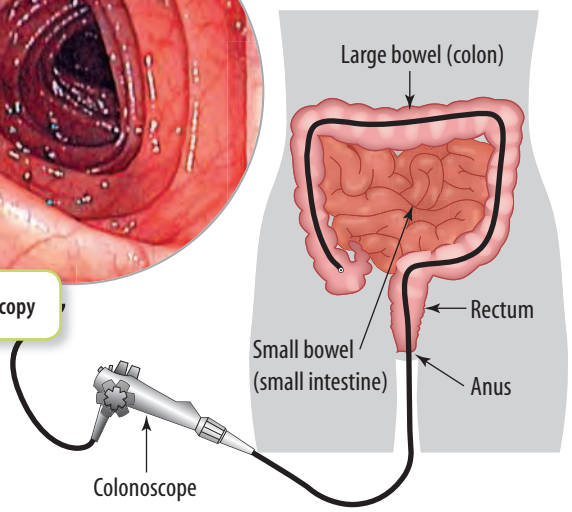




Australian scientists Dr Barry J. Marshall and Dr Robin Warren received the 2005 Nobel Prize in Medicine for their discovery that linked *Helicobacter pylori* bacteria to gastroduodenal disease. Their discovery dramatically improved the treatment of peptic ulcer disease.

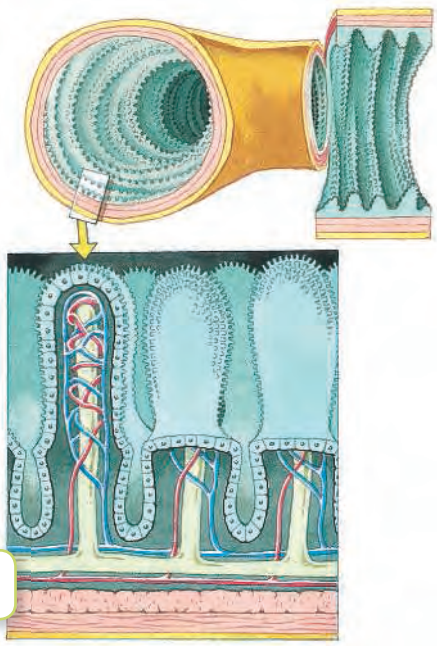


Colonoscopy



'Fingers' of absorption

Most nutrients are absorbed into your bloodstream when they get to the last section of your small intestine. The walls of this part of your intestine are lined with finger-like projections called villi.

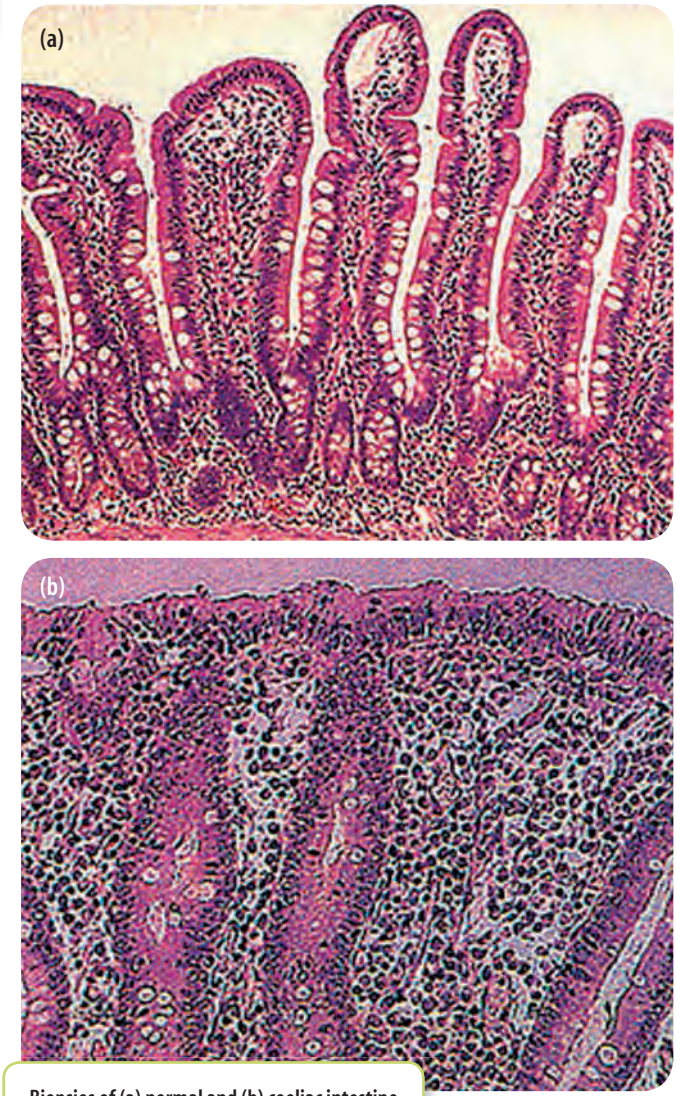


Villi

The shape of villi increases the surface area through which nutrients can diffuse through them into tiny blood vessels called capillaries. Nutrients are then transported to other parts of your body.

VILLI ALERT!

Coeliac disease is an auto-immune disease — that is, one in which your body produces antibodies to attack your own tissues. In this case, it is the villi of the small intestine that are damaged. This interferes with the absorption of nutrients.



Biopsies of (a) normal and (b) coeliac intestine

People with coeliac disease are intolerant to gluten. This protein is found in wheat, rye, barley and oats. Eating these foods triggers their immune system to damage the villi in their small intestine. The Coeliac Society of Australia refers to the condition as a 'hidden epidemic'. Coeliac disease affects approximately 1 in 100 people in Australia, with

many (about 75 per cent) not even knowing that they have it. If left undiagnosed, more severe consequences such as a variety of nutritional deficiencies, bowel cancer and osteoporosis may result.

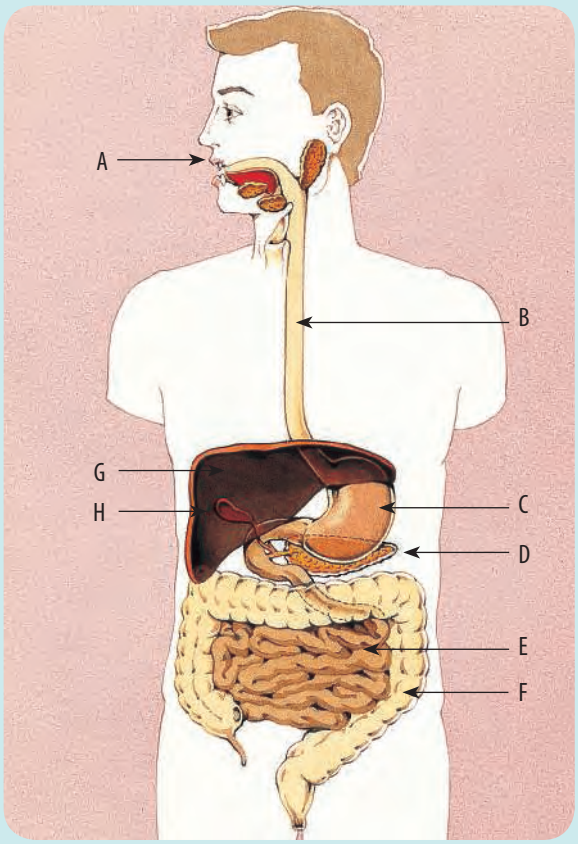
Australian researchers are attempting to develop a vaccine as a new treatment for coeliac disease. In 2009, Dr Robert Anderson and his team at the Walter and Eliza Hall Institute of Medical Research in Melbourne began the world's first trials of a coeliac vaccine. If this treatment is successful, it could mean the end of gluten-free diets for people with the condition.

Dr Robert Anderson and his team at the Walter and Eliza Hall Institute of Medical Research in Melbourne began the world's first trials of a coeliac vaccine.

UNDERSTANDING AND INQUIRING

REMEMBER

1 (a) Construct a table with the column headings 'Letter', 'Organ', 'Description', 'Function' and 'Interesting comment'.



(b) Write the letter label from the figure on the left in the 'Letter' column in your table.
(c) Complete the remaining columns.

2 Describe the process of peristalsis and suggest why it occurs.

3 Describe what happens to:
(a) digested food
(b) undigested food.

4 Outline the relationship between diet, coeliac disease and the digestive system.

5 Approximately how many people in Australia are affected by coeliac disease?

6 Use a Venn diagram to compare gastroscopy and colonoscopy.

7 Describe the discovery that led to two Australian scientists winning the 2005 Nobel Prize in Medicine.

THINK AND DISCUSS

8 Explain why it is necessary for your body to digest the food that you eat.

9 Suggest how you could still swallow food even if you were positioned upside down.

IMAGINE, INVESTIGATE AND CREATE

10 (a) Imagine that you are either a cheese and tomato sandwich or a hamburger.
(b) List the ingredients of the food you chose in part (a).
(c) Research what happens (and where) to each of these ingredients when eaten.

(d) Construct a flowchart to show the process of digestion in the human body including events and locations.
(e) Use this information to write a story in either a cartoon or picture book format.
(f) Convert your story into a play.
(g) Perform your play to the class using animations, team members or puppets.

11 Research one of the digestion-related diseases below and report on the cause, symptoms, treatment or cure, possible consequences and current research.

- Heartburn
- Inflammatory bowel disease
- Irritable bowel syndrome
- Appendicitis
- Constipation
- Crohn's disease
- Diverticulosis
- Gallstones
- Haemorrhoids
- Pancreatitis
- Peptic ulcer

12 Use information in this section and other resources to relate structural features to the functions of the following parts of the digestive system.

Part of system	Structural features	Function
Oesophagus		
Stomach		
Small intestine		
Villi		
Large intestine		

13 Imagine that you have invited two friends over for a sleepover. One of them has coeliac disease and the other is lactose intolerant.
(a) Find out the cause and/or symptoms associated with each of these conditions.
(b) Find out what sorts of foods you could offer your friends.
(c) Design a dinner and breakfast menu that includes foods that each of your friends would be able to eat.

14 Construct a 'working' model of the human digestive system.

15 Design and construct a 'trivial pursuit'–type board game about the digestive system. Include questions in three different categories. Create game pieces that are relevant to the digestive system.

16 Create a picture book or poster that would help explain to primary students how food is digested.

17 Construct a plasticine model (to scale) of the human digestive system, with each organ being a different colour.

INVESTIGATE AND REPORT

18 Find out more about one of the following digestion-related scientific careers and report your findings as a diary journal entry.

- Gastroenterologist
- Endoscopist
- Colorectal surgeon

19 Research the symptoms, diagnosis and treatment of coeliac disease and investigate Australian research into the condition. Report your findings in a PowerPoint presentation, a poster or an article. Cite your references and include the **Coeliac Society** and **Australian Gastronoenterology Institute** weblinks in your eBookPLUS in your research.

eBookplus

20 Find out more about gluten-free diets and coeliac disease using the weblinks in your eBookPLUS. Report your findings to your team or use them to support your response to question 12.
(a) Use the **Coeliac dietary advice** weblink to find out more about gluten-free diets.
(b) Use the **Bob Anderson** weblink to find out more about coeliac disease, diet and research.

21 Test your knowledge of the digestive system by completing the **Digestive jigsaw** interactivity in your eBookPLUS. **int-0216**

22 Recently, scientists have suggested a link between the presence of bacteria *Helicobacter pylori* and cancer protection. Find out more about this research and suggest possible implications that it may have.

work sheet 4.6 The digestive system

Keeping your balance

Blood vessels and the heart are not just involved in the delivery of needed nutrients and gases to the cells of the body. They also take away the body's wastes so that they may be disposed of. If the wastes were allowed to build up inside us, we would die.

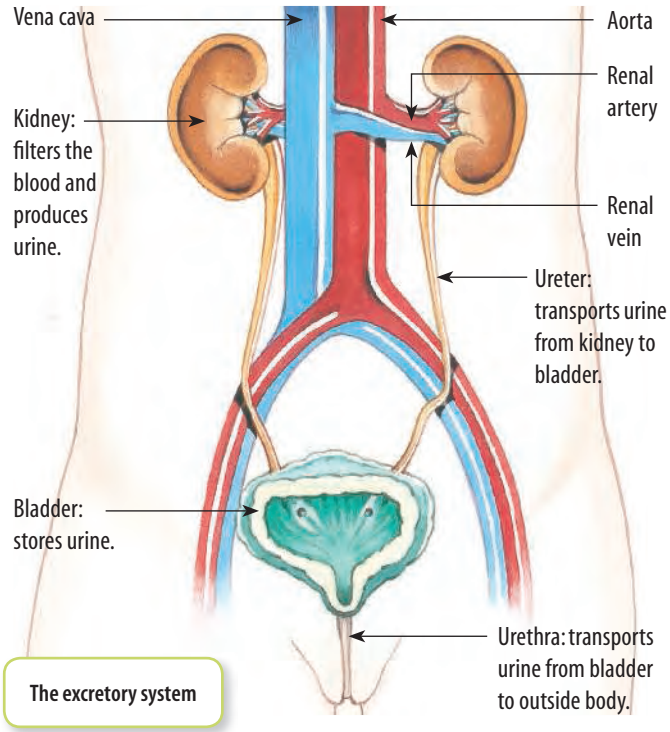
Getting rid of wastes

Excretion may be defined as any process that gets rid of unwanted products or wastes from the body. The main organs involved in human excretion are the **lungs**, the **liver** and the **kidneys**.

If you put your hands on your hips, your kidneys are close to where your thumbs are. You have two of these reddish-brown, bean-shaped organs. Without them you would survive only a few days.

Kidneys play an important role in filtering your blood. About a quarter of the blood that your heart pumps is sent to your kidneys. These small organs filter about 50 litres of blood each hour. Your kidneys remove waste products of chemical reactions, like **urea**, from your blood. Accumulation of these substances would otherwise be toxic or dangerous to your body. Other substances, like salts and water, which may be in excess, can also be removed. This keeps their concentration in the blood constant. If this did not occur, your cells would not work properly.

Urine is produced by your kidneys. This watery fluid contains unwanted substances. Tubes called **ureters** transport urine from your kidneys to your **bladder** to be stored temporarily. As it fills, your bladder expands like a balloon. It can hold about 400 mL of urine. **Urination** occurs when urine moves from your bladder through a tube called the **urethra** and out of your body.



The excretory system

HOW ABOUT THAT!

The human kidneys remove excess salt from the blood to help keep levels constant. Different types of animals have other ways of removing excess salt from their bodies. Turtles, for example, have salt-secreting glands behind their eyes. Hence you may see a turtle 'shedding tears'. On the other hand, penguins and some other seabirds, such as the Southern Giant Petrel, may appear to have runny noses because that is where their salt-secreting glands are located.

Blood, water and urine

Both blood and urine are mostly made up of water. Water is very important because it assists in the transport of nutrients within and between the cells of the body. It also helps the kidneys do their job because it dilutes toxic substances and absorbs waste products so that they may be transported out of the body.

A comparison of what is found in blood and in urine

Substance	Quantity (%)	
	In blood	In urine
Water	92	95
Proteins	7	0
Glucose	0.1	0
Chloride (salt)	0.37	0.6
Urea	0.03	2

Haemodialysis

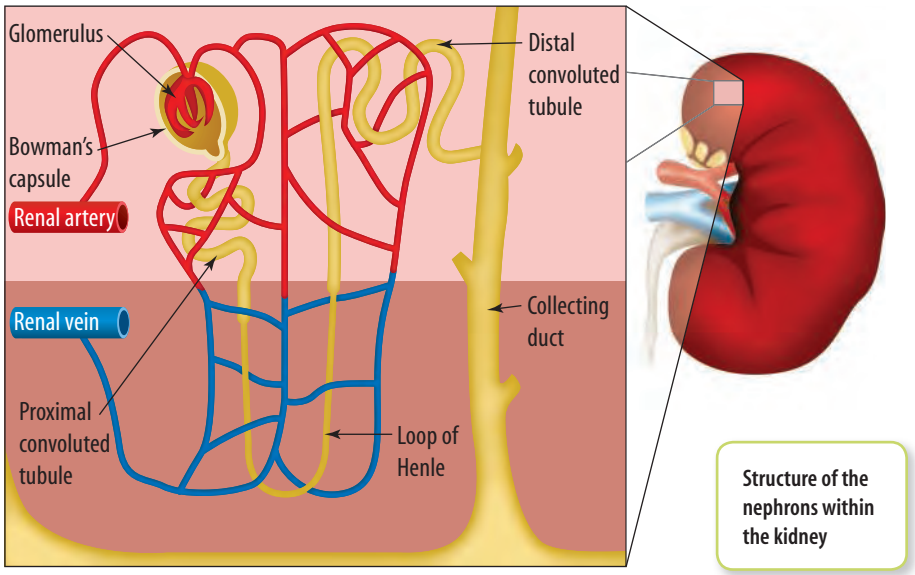
People with kidney disease may not be able to remove the waste materials from their blood effectively. They may be linked up to a machine that does this job for them. Their blood is passed along a tube that lets wastes, such as urea, pass out of it. However, useful substances, such as glucose, proteins and red blood cells, stay in the tube and are kept in the blood. This process is called **haemodialysis**.

Too much or too little

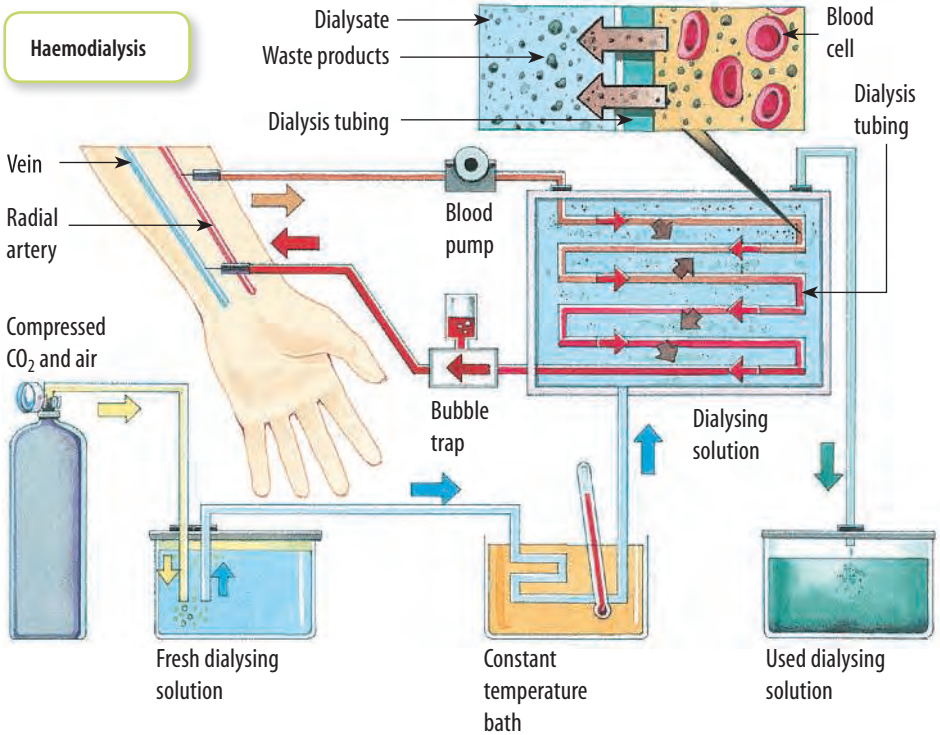
The concentration of substances in the blood is influenced by the amount of water in it. If you drink a lot of water, more will be absorbed from your large intestine and the kidneys will produce a greater volume of dilute urine. If you do not consume enough liquid, you will urinate less and produce more concentrated urine.

Millions of tiny filters?

Each of your kidneys is made up of about one million **nephrons**. Each nephron is made up of a long tubule (very fine tube) that forms a cuplike structure at one end. This structure is called the **Bowman's capsule** and it surrounds a cluster of capillaries called



Structure of the nephrons within the kidney



the **glomerulus** (from an ancient Greek word meaning 'filter').

'Dirty' blood containing wastes travels to the glomerulus within each nephron in your kidneys. It is here that the blood is filtered, with the wastes and excess water moving into the Bowman's capsule. From here, this waste fluid moves along the tubule and any useful substances are reabsorbed back into the circulatory system into capillaries that are 'twisted' around it. The remaining fluid becomes urine, which eventually travels in your ureters to your bladder.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Define the term 'excretion'.

2 Draw and label a diagram of the kidneys showing the following attachments: renal arteries, renal veins, ureters, bladder.

3 State features that blood and urine have in common.

4 Outline what happens when you drink a lot of water.

5 Describe one way in which excess salt is removed from your body.

6 Explain how haemodialysis assists people with kidney disease.

ANALYSE AND EVALUATE

7 Use the table on the previous page and the other information in this section to answer the following questions.
   (a) Draw two bar graphs to show the quantity of water, proteins, glucose, salt and urea in blood and in urine.
   (b) Which substance is in the greatest quantity? Suggest a reason for this.
   (c) Which substances are found only in blood?
   (d) Which substances are found in urine in a greater quantity than in blood? Suggest a reason for this.
   (e) When would the amount of these substances in the urine become greater or less than in the blood?

THINK

8 Carefully observe the haemodialysis diagram on the previous page. Suggest reasons the following are included in the process:
   (a) blood pump
   (b) bubble trap
   (c) constant temperature bath.

9 Suggest what you would expect to find in used dialysing solution.

10 Suggest why red blood cells don't pass through the dialysis tubing.

11 Use a Venn diagram to compare haemodialysis with real kidneys.

INVESTIGATE AND CREATE

12 Research and report on one of these conditions: urinary incontinence, kidney stones, kidney transplants, cystitis, blood in urine, proteinuria, nephritis.

13 Find out and report on:
   (a) the differences between the urethra in human males and females
   (b) why pregnant women often need to urinate more frequently
   (c) how the prostate gland in males may affect urination in later life
   (d) which foods can change the colour or volume of urine
   (e) which tests use urine in the medical diagnosis of diseases.

14 Find out more about nephrons and how they work. Construct a model of a nephron that shows how it is linked to blood vessels and how urine gets to your bladder from it.

15 Research the nephrons of animals that live in different environments (for example, deserts, oceans and rivers). Comment on similarities and differences in their structure. Suggest reasons for the differences.

eBook*plus*

16 Use the **Kidney Health Australia** weblink in your eBookPLUS to watch the presentation by Professor Allan Collins. Use this website or other resources to find the answers to the following questions:
   (a) What can you do to reduce your risks of developing kidney disease?
   (b) How much water should you drink each day to keep your kidneys healthy?
   (c) Is there any evidence to support the claim that cranberry juice can reduce your risk of urinary tract infections? If so, what is it?
   (d) Some people donate a kidney to another person. How can they survive with only one kidney? Are there any side effects?
   (e) Can you buy or sell a kidney in Australia?
   (f) How can you reduce your risk of developing a urinary tract infection?
   (g) What are kidney stones? How do you get them? What are the symptoms? What is the treatment?

17 Design and create a 'picture book' story that will teach primary school children about how their urinary system works and how to look after it.

Same job, different path

Similar, but different?

Patterns, order and organisation

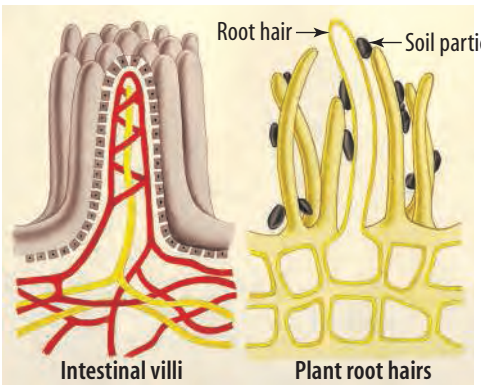
Organisms possess a variety of structures that help them to obtain the resources that they need to survive. While there are similarities and patterns in some of these structures, there are also differences. These differences provide examples of wonderful creative solutions to the continual challenge of staying alive.

See the human systems and tissues mind maps on page 79 for more examples of organisation in the body. Can you suggest other examples to include in the systems mind map? How would this map be different if it was for a different animal?

Organisms have different solutions to life's challenges within the same pattern of organisational framework.

Shaping clues

The structures of cells and tissues often provide clues to their function. For example, structures that are involved in absorption often have shapes that increase the surface area to volume ratio. Intestinal villi in humans and plant root hairs are examples of this. Can you see the similarities in the figures below? Can you think of other cells or tissues that also share this pattern?



Similar structures? What might their function be?

Respiratory routes

glucose + oxygen ⟶ carbon dioxide + water + energy

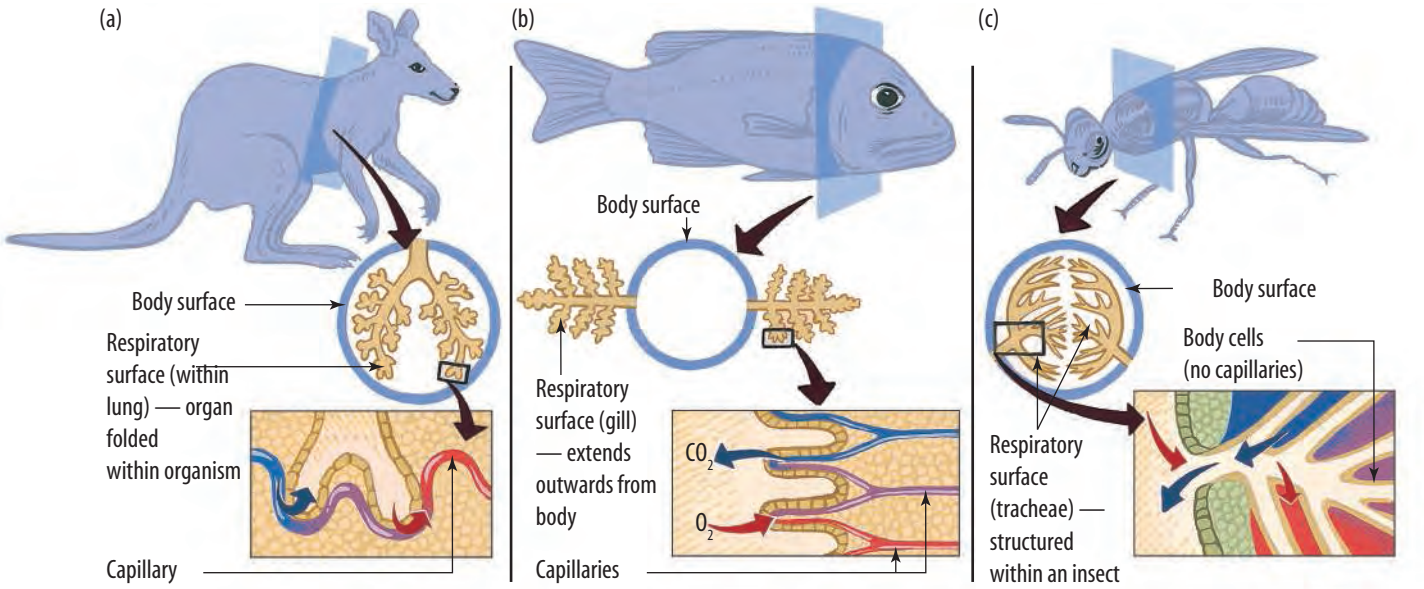
Cellular respiration is essential for life. Organisms require a supply of oxygen for this process, and they also need a way to remove the carbon dioxide that is produced as a waste product. Three main kinds of organs that are involved in this type of gas exchange are lungs in mammals and amphibians, gills in fish and tracheae in insects. Examine the figure below that shows the structures of these organs. How are they similar? How are they different?

Digestive differences

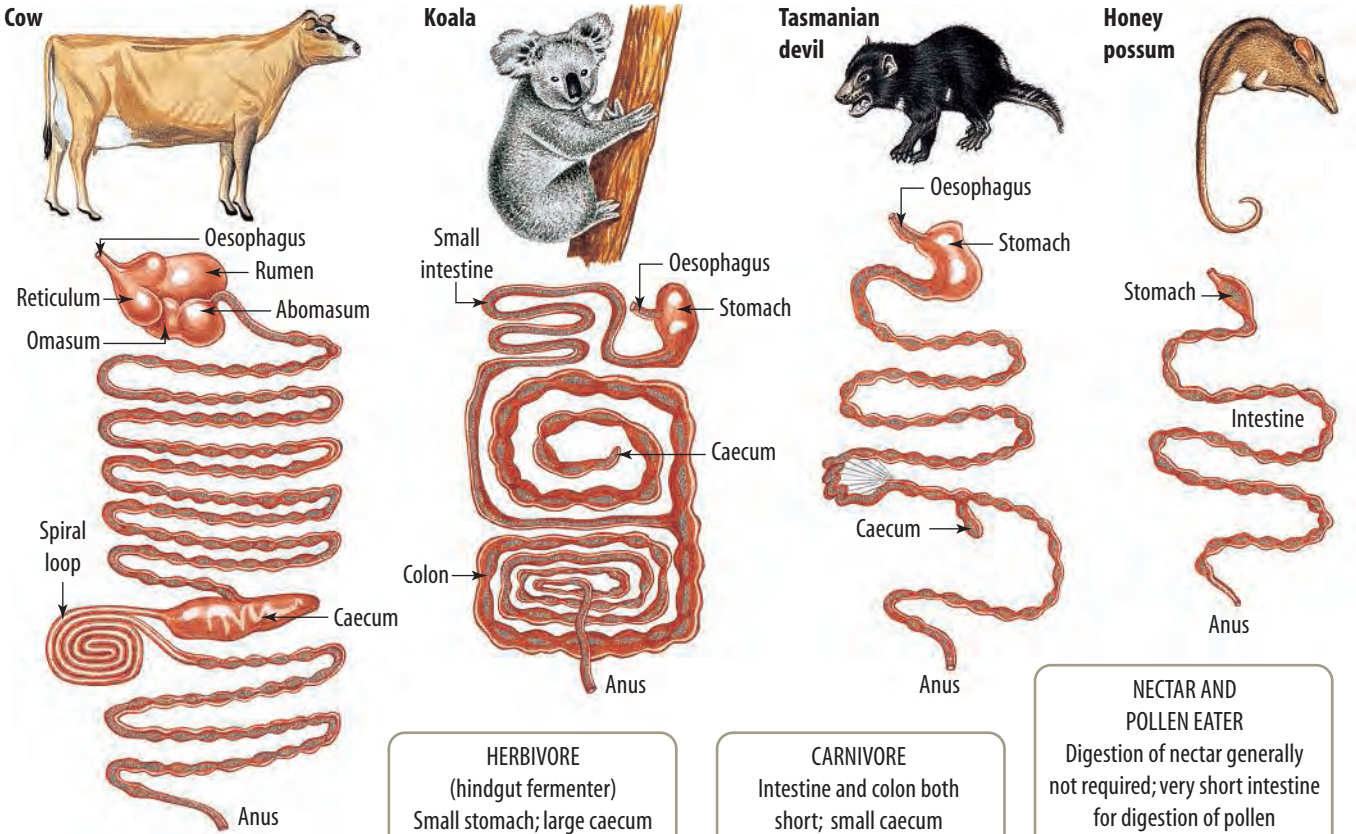
Although most vertebrates possess a digestive system that has a similar pattern, order and organisation, there may be differences that are related to nutritional needs and diet. Consider, for example, differences in the digestive systems of animals with diets that are high in plant material with lots of cellulose, such as diets of herbivores compared with those of carnivores with lots of animal flesh, high in protein. How would these compare with the digestive system of an organism that ate only nectar and pollen?

Heart count?

Two, three or four? Not all animals have a four-chambered heart like you. Fish have a heart with two chambers and blood passes through the heart only once each time around the body. The hearts of amphibians and most reptiles are three chambered and allow oxygenated and deoxygenated blood to mix. Birds and mammals are similar to amphibians and most reptiles in that blood flows through the heart twice in each circulatory trip, but they possess a heart with four chambers that does not allow the mixing of blood. What do they share? How are they different?



Notice any similarities or differences in these gas exchange surfaces?



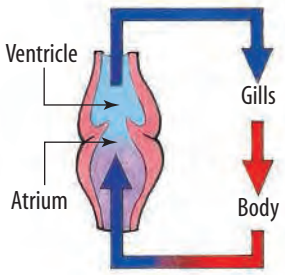
HERBIVORE (foregut fermenter)
Four-chambered stomach with large rumen; small and large intestines are long

HERBIVORE
(hindgut fermenter)
Small stomach; large caecum

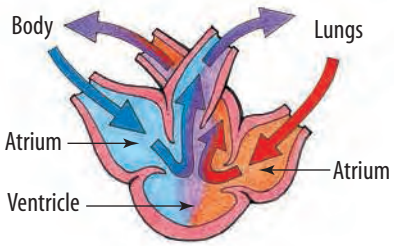
CARNIVORE
Intestine and colon both short; small caecum

NECTAR AND POLLEN EATER
Digestion of nectar generally not required; very short intestine for digestion of pollen

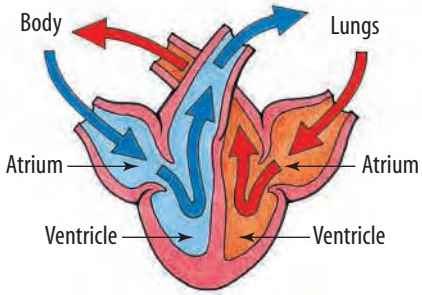
Notice any similarities or differences in these digestive systems?



(a) A fish heart has two chambers. Note that blood passes through the heart only once for every circulation within the body.



(b) Amphibians and most reptiles have a three-chambered heart. Oxygenated and non-oxygenated bloods mix in the single ventricle as blood flows through the heart twice for every circulation within the body.



(c) Birds and mammals have a four-chambered heart and blood flows through the heart twice for every circulation within the body.

Around we go … but which route do we take?

Congratulations!

The survival of a species depends on its members surviving the challenges related to both their internal and external environments. Over many generations, the selection of 'what works' and 'what doesn't work' has led to the diversity of organisms on our planet. Every organism is a celebration of the creative variety of solutions to challenges of survival.

INQUIRY: INVESTIGATION 4.11

Making a burp model

KEY INQUIRY SKILLS:

- planning and conducting
- evaluating

Equipment:

vinegar

baking soda

medium/large balloon

funnel

- Pour a small amount of vinegar into the bottom of the balloon 'stomach'.
- Add some baking soda to the balloon 'stomach' using a funnel.
- Using your fingers, pinch the balloon closed at its neck.
- Watch as your 'stomach' expands with gas.
- Unpinch the top of the balloon (or 'oesophagus/food tube') to release the gas (or burp).
- Try to make your model sound like the real thing!

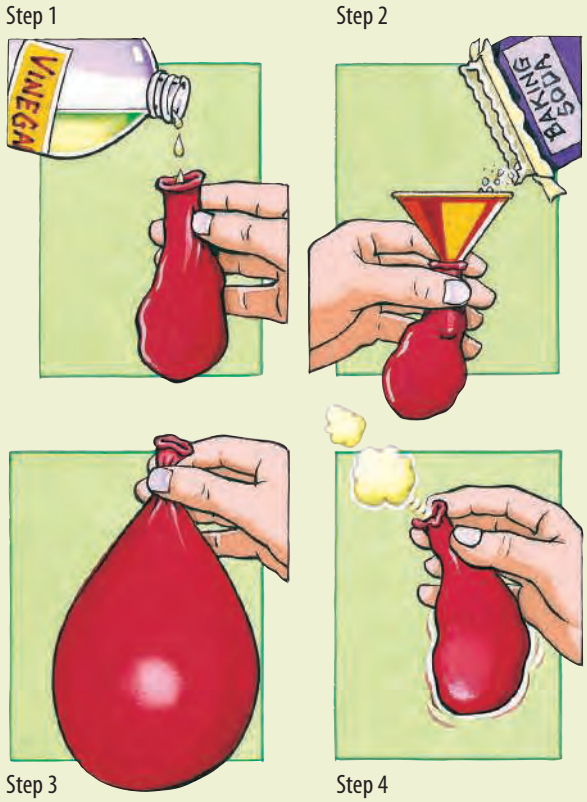
DISCUSS AND EXPLAIN

1 Select an organ belonging to an animal of your choice.

2 Find out more about the structure and function of your selected organ and how it does its job.

3 Design and make a simple model (such as the one used for this experiment) to show how your selected organ achieves its function, or what happens when something goes wrong.

4 Comment on the challenges you experienced during the design and construction of your model, and suggest ways that you could overcome these if you were to do it again.



UNDERSTANDING AND INQUIRING

REMEMBER

1 Place the following terms in order of simplest to most complex: cell, organ, system, multicellular organism, tissue.

2 Provide an example of how structure can give clues about function.

3 Write the word equation for cellular respiration.

4 Describe two key functions of gaseous exchange.

5 Suggest why there are differences between herbivores and carnivores in the structures of their digestive systems.

6 Construct a table to summarise similarities and differences between the hearts and circulation of fish, amphibians and mammals.

7 Name two organs belonging to each of the following systems.
(a) Respiratory system
(b) Circulatory system
(c) Excretory system

THINK

Use the mind maps on page 79 and information in this section to answer the following questions.

8 What kind of tissue:
(a) has the function of conducting and coordinating messages around the body?
(b) binds and connects tissues?
(c) supports the body?
(d) carries oxygen around the body?

9 Which body system has the function of:
(a) detecting stimuli?
(b) supporting and moving the body?
(c) taking in oxygen and getting rid of carbon dioxide?
(d) conducting messages from one part of the body to another?

INVESTIGATE, CREATE AND DESIGN

10 Research and prepare a poster on the hearts of different types of animals.

11 (a) Outline the key differences between the structures of the digestive systems of a cow, a koala, a Tasmanian devil and a honey possum.
(b) Suggest reasons for the differences.

12 Complete the following table.

Feature	Mammal	Fish
Number of chambers in the heart		
Times blood travels through heart in each circulatory trip		
Name of gaseous exchange respiratory organ		

13 Find out about the different tissues and systems that exist in plants. Present your information, using diagrams and lots of colour, on a poster or PowerPoint presentation. Be as creative as you can.

14 (a) Select one of the systems in the mind map on page 79 and find out more about what it does and how it works.
(b) Use your findings to write a brief play that other students in the class can act out.

15 In a small team, formulate scientific questions about how the structure of the heart, kidney or lungs is related to the function of that organ. Research these questions and present your findings to the class.

16 Select an organ (for example, heart, lungs or stomach) and find out the answers to the following questions:
(a) What is the function of the organ?
(b) Which system does it belong to?
(c) What other organs are in the same system?

17 Design and construct a model of one of the following systems: respiratory, excretory, reproductive, digestive.

INVESTIGATE AND DISCUSS

18 (a) In teams of three, use a 'lucky dip' system to match each member of the team with one of these organisms: earthworm, grasshopper, fish.
(b) Each member should investigate the respiratory system of their matched organism and report their findings to their team.
(c) As a team, construct a cluster map that summarises the key details and features of the respiratory systems of each of these organisms.
(d) As a team, construct a matrix table (see page 340) that summarises the similarities and differences between the respiratory systems of humans, earthworms, grasshoppers and fish.

19 Select an animal of your choice.
(a) Find out how it:
(i) detects stimuli
(ii) supports itself and moves
(iii) takes in oxygen and removes carbon dioxide
(iv) conducts messages from one part of its body to another.
(b) Construct a model or animation to demonstrate one of the functions above.

20 There are differences in the form in which groups of animals excrete nitrogenous wastes. Find out the differences between humans, freshwater fish, saltwater fish and insects. Communicate your findings using models or in a puppet play, 'documentary' or animation.

4.7 Organ systems

4.12 THINKING TOOLS

Flowcharts and cycle maps

1. Decide in which direction your flowchart will be read — from left to right, from the bottom up or from the top down.
2. Write the first action of the process you are describing inside a box.
3. Write the next event in another box and join this by an arrow to the first box.
4. Repeat until you have reached the final event.

how to ...?

Flowchart

- First event
- Next event
- Next event
- Next event
- Last event

why use?

Helps to show the order in which events happen

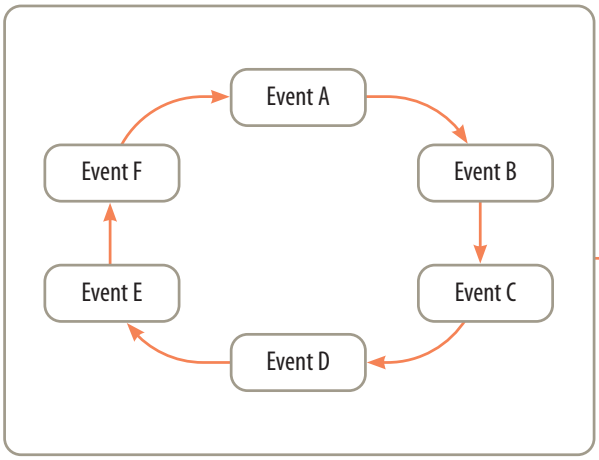
question

In which order did the stages occur?

also called

Flow map; sequence chart; chain of events

example



comparison

Similarity

Both show a sequence of events.

Difference

Cycle maps show the sequence of events repeated in the same order; flowcharts show only a linear sequence.

UNDERSTANDING AND INQUIRING

THINK AND CREATE

1 (a) Read through the information in section 4.4 to refresh your memory on the structure and function of your heart.
(b) Use a flowchart to show the movement of blood through your body using the following labels: left atrium, right atrium, right ventricle, left ventricle, pulmonary artery, pulmonary vein, lungs, aorta, vena cava, from body, to body.

2 (a) Use the cardiac cycle diagram below to answer the following questions.
(i) In which stage do the atria contract?
(ii) In which stage do both the atria and ventricles relax?
(b) Construct flowcharts to help you summarise the information in the diagram.

3 Systole is the contraction of your heart muscle and diastole is the relaxation of your heart muscle. What do you think the following mean?
(a) Atrial systole
(b) Ventricular systole
(c) Atrial diastole
(d) Ventricular diastole

4 (a) Construct a cycle map to outline the overall movement of blood through the heart.
(b) Use this information to design a working model of a human heart.
(c) Use a flowchart to plan the construction of your heart model.

5 (a) Find out more about Leonardo da Vinci's models of the human heart.
(b) Use a flowchart to map changes in scientific ideas about the heart throughout history.

One complete cardiac cycle can take about 0.8 seconds in an adult human with a pulse of about 75 beats per minute.

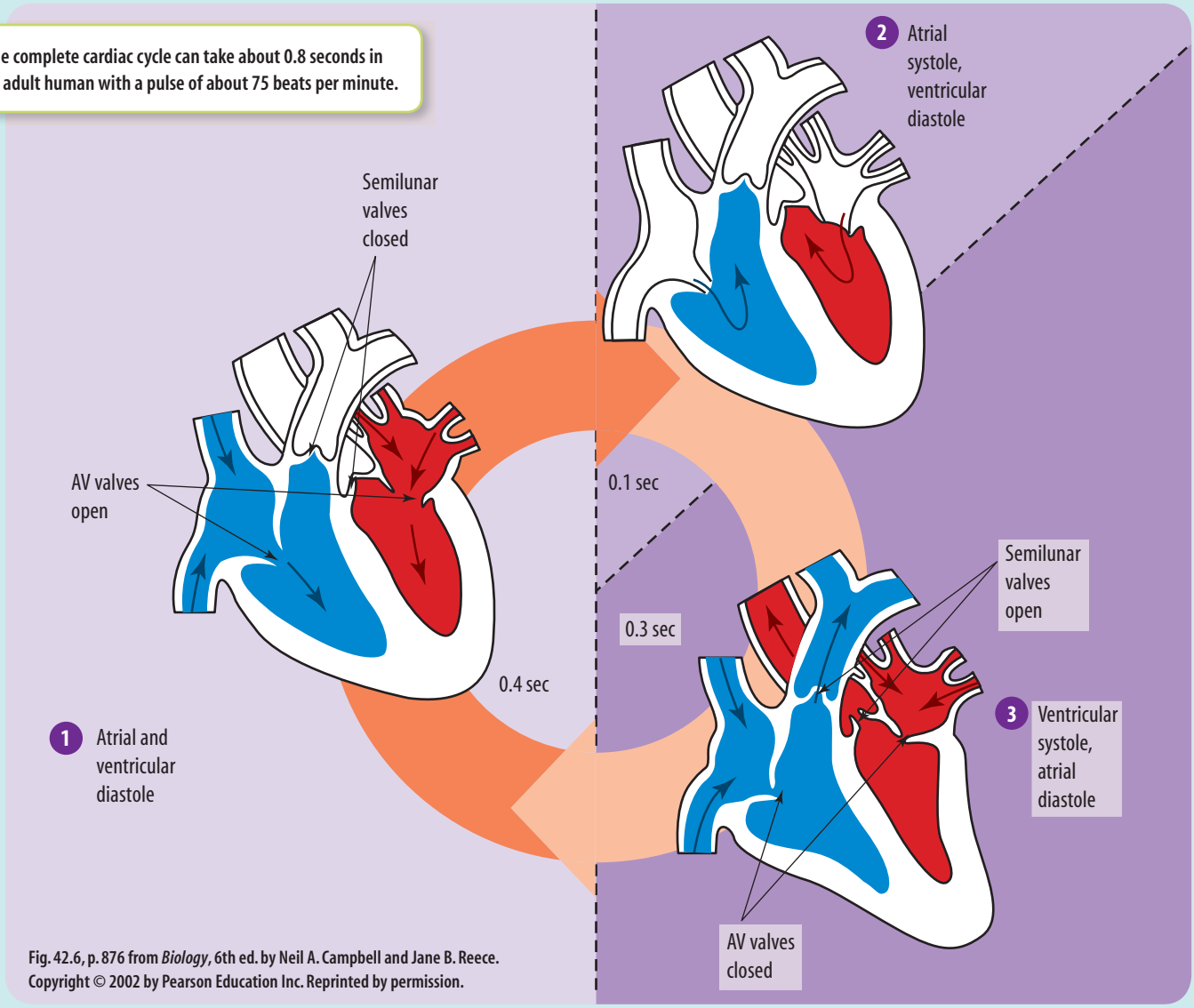


Fig. 42.6, p. 876 from *Biology*, 6th ed. by Neil A. Campbell and Jane B. Reece.

STUDY CHECKLIST

MULTICELLULAR ORGANISMS

- state the relationship between cells, tissues, organs, systems and multicellular organisms
- describe the key functions of the following body tissues: connective, epithelial, skeletal, blood, muscle, nerve
- identify the organs and overall function of a system of a multicellular organism
- describe the structure of each organ in a system and relate its function to the overall function of the system
- compare similar systems in different organisms

MUSCULOSKELETAL SYSTEM

- describe the structure of a human bone
- describe the relationship between bones, joints, ligaments and muscles

CIRCULATORY SYSTEM

- identify the components that make up blood
- compare red blood cells and white blood cells
- state the relationship between blood, heart, arteries, veins and capillaries
- give examples of technology related to the human heart

RESPIRATORY SYSTEM

- use a flowchart to describe the relationship between the trachea, alveoli, lungs, capillaries, oxygen and carbon dioxide

DIGESTIVE SYSTEM

- sequence the structures of the digestion system and state the function of each
- describe how the structure of the teeth, oesophagus and villi in the small intestine assist their function
- describe how the tongue, gall bladder, pancreas and liver are involved in the digestive process
- outline the importance of peristalsis
- distinguish between the processes of ingestion, mechanical digestion, chemical digestion, absorption of nutrients, assimilation and egestion

EXCRETORY SYSTEM

- explain how wastes are removed from the human body

INDIVIDUAL PATHWAYS

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Activity 4.1 Systems **doc-6081**	**Activity 4.2** Investigating systems **doc-6082**	**Activity 4.3** Analysing systems **doc-6083**

ICT

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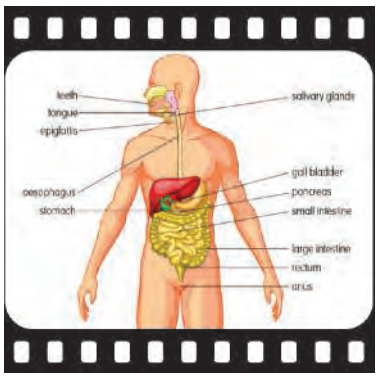
Summary

eLESSONS

From dinner plate to sewerage system

This video lesson explains the amazing journey of food through the human body, from dinner plate to sewerage system. Learn how our bodies release chemicals to break down food and absorb energy-giving nutrients, all without us even being aware of the process. A worksheet is attached to further your understanding.



Searchlight ID: eles-0056

Heart valve

This video lesson shows a revolutionary way of replacing heart valves.

Searchlight ID: eles-0858

INTERACTIVITY

Digestive jigsaw

This interactivity looks at the jigsaw puzzle that is the digestive system. Test your knowledge by re-creating the human digestive system. Instant feedback is provided.

Searchlight ID: int-0216

Beat it!

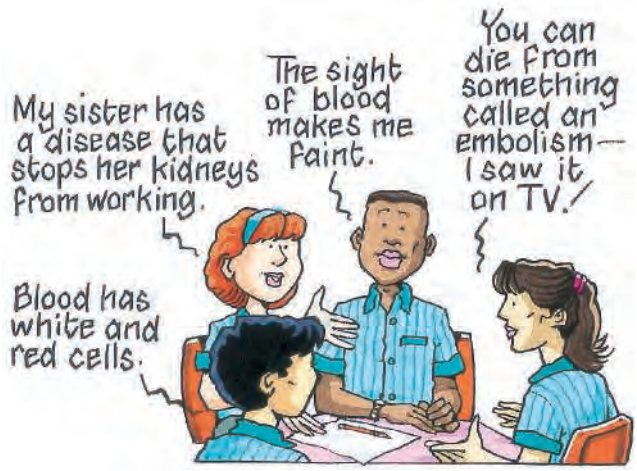
The heart is one of the most important organs in the human body. This interactivity tests your ability to label the parts of the heart. Instant feedback is provided.

Searchlight ID: int-0210

LOOKING BACK

1 In this chapter you have seen the importance of your transport system.
- (a) With your team, create mind or concept maps that summarise what you know about the following:
  - blood
  - blood vessels
  - heart
  - lungs
  - kidneys
  - liver.
- (b) For each of the six parts of your body listed above, brainstorm in your team as many questions as you can. Then select one question for each body part to do your own research. Report your findings back to the group.
- (c) Summarise your group findings in a creative way — this could be as a cartoon, song, poem, play, model or simulation.

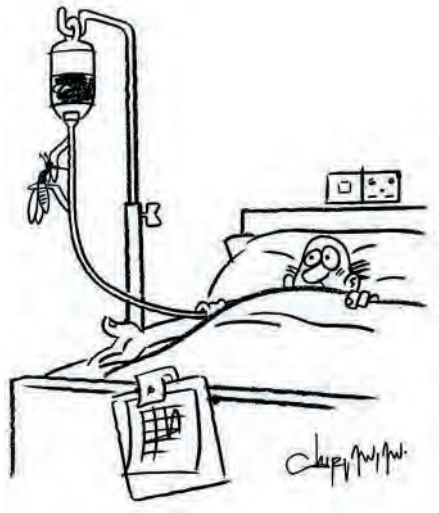
2 (a) In a pair, select one of the statements from the cartoon below and continue the conversation, taking turns asking relevant questions and answering them.
- (b) Find a new partner and repeat activity (a) with the same statement or another one.
- (c) In a team, create at least five other statements that could have been made on:
  - (i) animal transport systems
  - (ii) transport technology
  - (iii) transport system disorders or diseases.

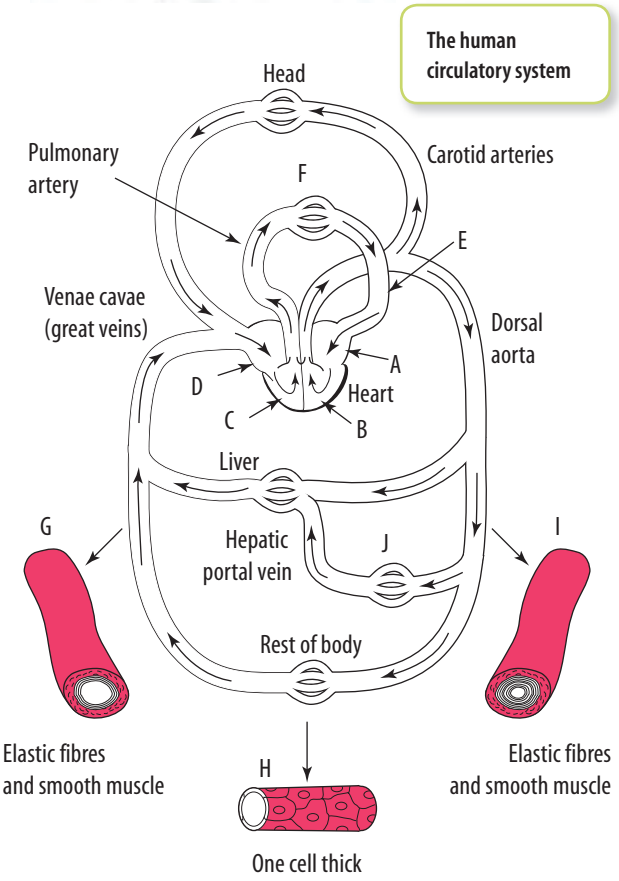


3 In a team, brainstorm ideas to come up with the following for transport systems.
- (a) Words for an alphabet key
- (b) Five 'what if' keys

4 Use your six thinking hats (see section 2.1) for three of the following issues or statements.
- (a) Drinking of any alcohol in Australia should be illegal.
- (b) Smoking in public should be punishable by a 10-year prison sentence.
- (c) Donating blood at least four times a year should be compulsory for all over the age of 16.
- (d) Only people under the age of 40 should be allowed to have a heart transplant.
- (e) Smokers should not be allowed to have surgery.
- (f) Blood transfusions should be illegal.
- (g) Everyone should have the right to a blood transfusion.
- (h) Organ donation should be compulsory.
- (i) Overweight people should not be allowed to have surgery on their circulatory system.

5 Using the cartoon below as a beginning, write a story that tells of the life of a red blood cell.





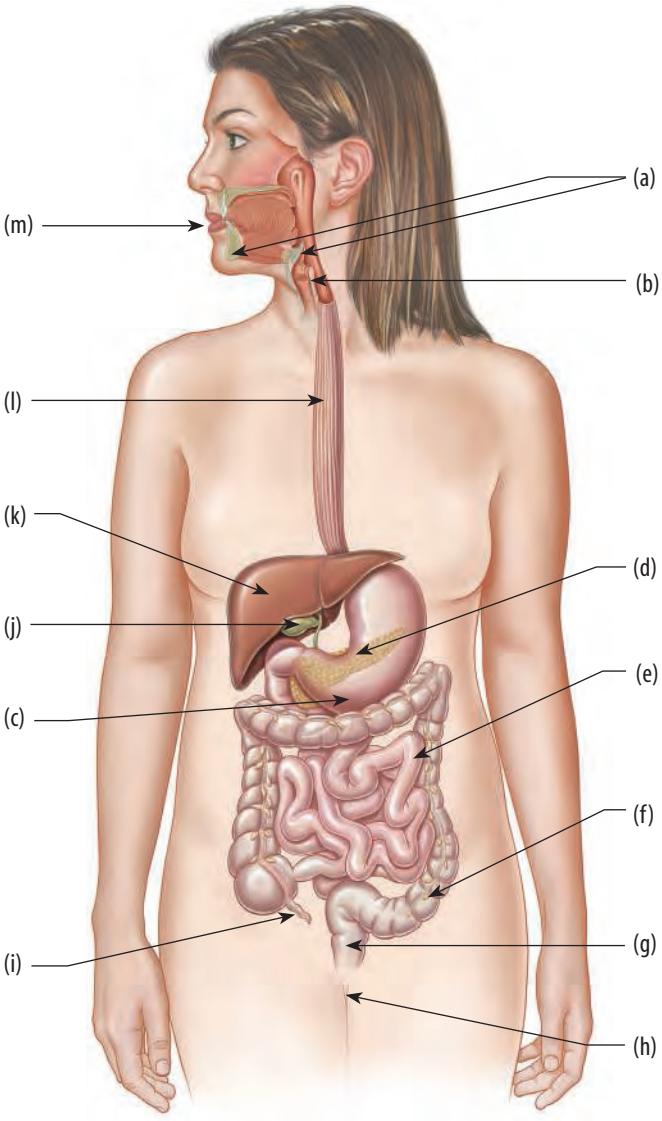
6 Make a copy of the diagram above for your workbook.
- (a) Label the lettered parts (A to J) of the human circulatory system and blood vessels on your diagram.

(b) Use a red pencil to colour in the blood vessels with oxygenated blood, and a blue pencil for those with deoxygenated blood.
(c) State whether the blood in the following blood vessels is deoxygenated or oxygenated:
  (i) aorta
  (ii) pulmonary artery
  (iii) pulmonary vein
  (iv) venae cavae
  (v) carotid arteries.
(d) Draw up a table that shows the differences in structure and function of the arteries, veins and capillaries.

7 Outline the purpose of digestion.

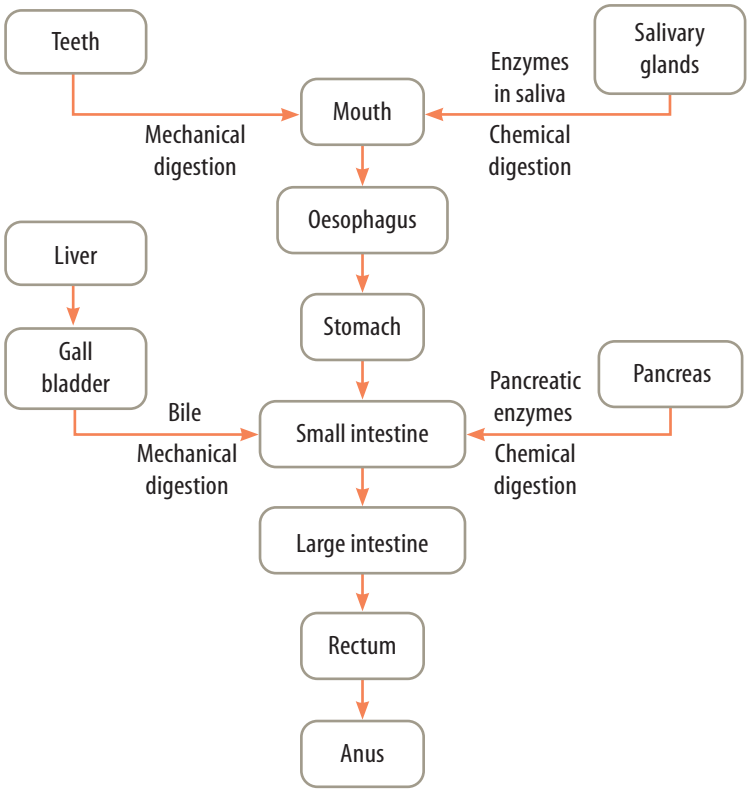
8 Construct a Venn diagram to show similarities and differences between mechanical and chemical digestion.

9 Label this diagram of the human digestive tract.

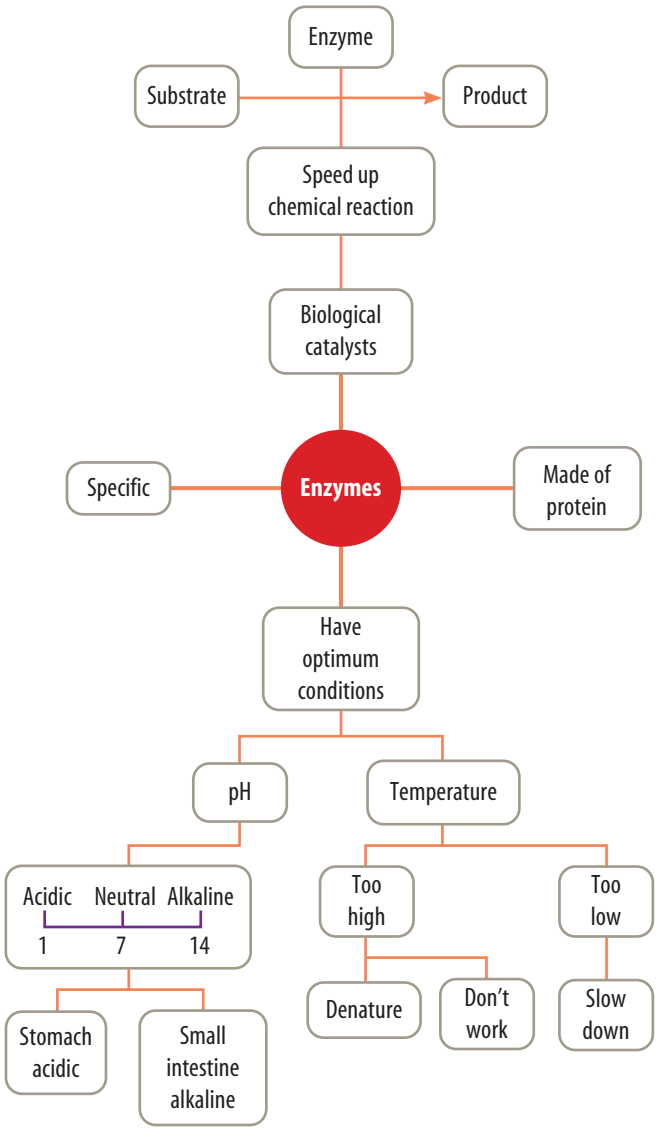


The human digestive tract

10 (a) Using the links and ideas in the two visual thinking maps on this and the next page (as well as your own), construct a board for the game 'Nutridigest', which you will create.
(b) In a team of four, brainstorm as many questions as you can that could be placed on each of the squares. Creatively write these onto your Nutridigest cards.
(c) As a team, discuss the rules for your Nutridigest game. Write down those you agree on.
(d) Make a brochure that explains how to play your game.
(e) Trial playing the game with your team.
(f) Make any alterations to your game that you think would improve it.
(g) Play the game that has been created by another team.
(h) In a team of eight, discuss the good things (strengths) and not-so-good things (limitations) of each game. Also, suggest ways that they could be improved in the next 'edition'.



What happens to food in each part of the digestive system?



What other points about enzymes could you add to this map? Can you suggest any more links between points already on the map?

11 (a) Have a lucky dip with names of parts of the digestive system and three different nutrients inside.
(b) As a class, make your selections from the lucky dip.
(c) Think about the function of your selection. Also, think about what sorts of actions or sounds it might have.
(d) As a class, act out your roles in digestion.

12 (a) Construct a mind or concept map to summarise what you have learned during your study of 'living connections'.
(b) Share your map with others in your team.
(c) Create another mind or concept map that incorporates the learning of all of your team members.

13 As a team, create a song, poem, cartoon or play about something that you have learned.

14 (a) Discuss in your team what you have learned or found interesting in this chapter.
(b) On sticky notes, write down other questions that you or your team may have about areas related to those in this chapter. Place the questions on a class question gallery board with those of other class members.
(c) Once all of the questions are on the board, organise them into groups or themes.
(d) In pairs, select one of the questions in the gallery.
(e) Research the question and report your findings to the class.

15 The process of replacing oxygen with carbon dioxide is called gas exchange. Some animals exchange gases through lungs or gills. Some other animals exchange gases though their skin, and yet others through rows of air holes along both sides of their bodies.
Investigate how animals and insects exchange gases to create a mind map and answer the following questions.
(a) Construct a mind map, poster or PowerPoint presentation that summarises your findings on how at least five different animals achieve their exchange of gases.
(b) Why do frogs need lungs when they can exchange gases through their skin?
(c) Why can't fish survive in the air?
(d) Why can't humans breathe under water without air tanks?
(e) How is gas exchange in insects similar to that in humans?
(f) What are two major differences between gas exchange in insects and humans?

16 (a) In teams, construct mind maps about each of the circulatory, respiratory and excretory systems.
(b) Use the information in these mind maps to construct matrix grids (see page 340) to summarise the key information for each system.

17 (a) Name the organs in each of the following systems.
(i) Circulatory system
(ii) Respiratory system
(iii) Excretory system
(b) Create a word-find with these terms and then swap it with another team member to see how many words each of you can find.

work sheet 4.8 Summing up