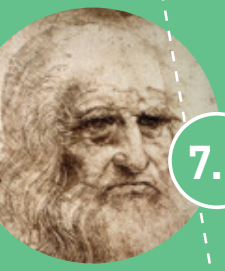


SURVIVING 7

What if?

Heartbeats

What you need:

a stopwatch

What to do:

1. Sit down for 2 minutes.
2. Measure the number of times you breathe in every minute.
3. Measure the number of times your heart beats every minute.
4. Record your measurements in a table.

What if?

- What if you ran around the oval for 5 minutes? How would your heart rate and breathing rate change?
- What if you listened to music with a slow beat for 5 minutes?
- What if you listened to music with a fast beat for 5 minutes?

7.1 The human body is divided into systems

Like all living things, we are made of different types of cells. Groups of cells that do a similar task are called **tissues**. Groups of tissues that work together are called **organs**. The liver, heart, eyes, brain and intestines are all examples of organs. When groups of different organs work together, they are called a **body system**.

Figure 7.1 The process of mummification required organs to be removed. They were sealed in 'canopic' jars.

How did the first scientists learn about the body?

The very first anatomists in the ancient Egyptian city of Alexandria performed dissections in the 3rd century BCE to investigate how the human body worked.

The Egyptians were very clean and quite fearful of illness; they believed that illness was caused partly by evil spirits and so doctors were also part *shaman* (spiritualists).

Perhaps because of this fear of illness, the Egyptians made many medical advances and learned a lot about the human body. Much of this knowledge about human body systems and organs likely came about from observations made during the mummification process. As part of this process, the Egyptians removed key organs from the body because they contained so much liquid that they interfered with mummification. (These organs were subsequently placed in 'canopic' jars to journey separately into the afterlife.)

Leonardo da Vinci

Leonardo da Vinci is famous as a painter, sculptor, architect, musician, engineer and cartographer (map drawer), but he also studied the human body in the late 1400s and early 1500s. He was involved in human and animal dissections and, from these, he drew beautiful and highly accurate drawings. Da Vinci was endlessly curious about the way things worked; he left hundreds of papers on the human body.

Many of Leonardo's illustrations of the heart were based on his studies of the organs of pigs and oxen. Leonardo began studying the human body through life drawing and by attending the public dissections that were occasionally held by the medical schools. He started drawing skeletons and then other body systems when he gained access to corpses from a local hospital.

Leonardo also studied the human heart and even constructed a model of the aortic valve, the one-way valve in the main artery of the heart, using glass. Leonardo was on the verge of discovering how blood circulates, but he never finished his work.

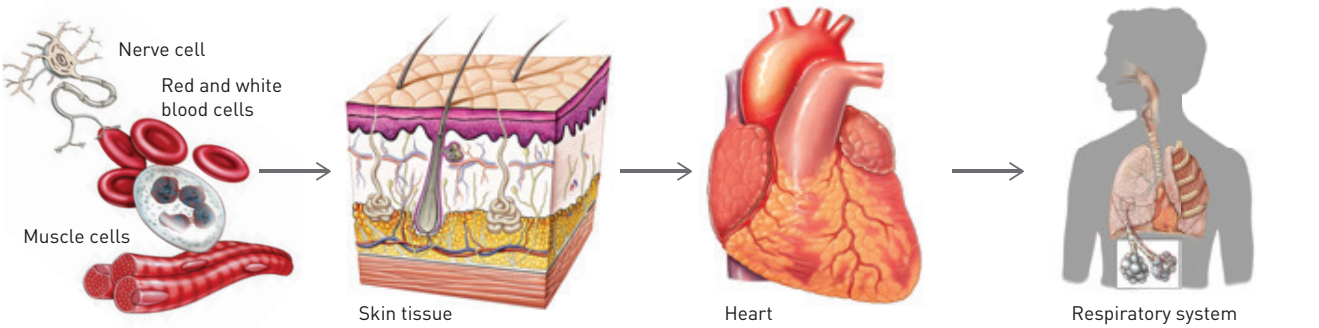


Figure 7.2 The different levels of organisation in the body.

CHALLENGE 7.1: BROWN PAPER BODY BRAINSTORM
GO TO PAGE 203.

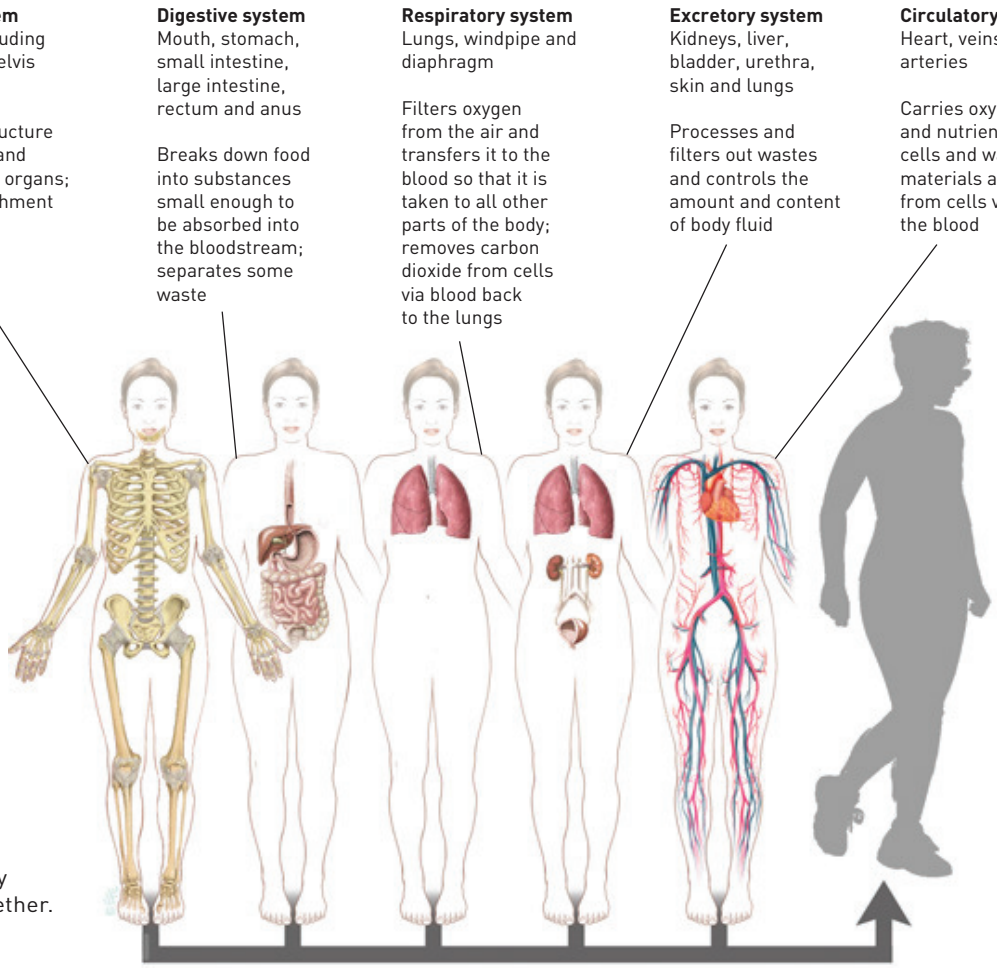


Figure 7.3 Our body systems work together.

The body snatchers

In 18th-century Britain (1700s), the population had grown so rapidly that there was an urgent need for more doctors and surgeons. A number of schools were opened to teach surgical skills – but human bodies were needed to practise on. This was where the 'body snatchers' found a unique moneymaking opportunity.

Anatomists paid gangs to steal bodies from graveyards. Body snatchers were known as 'the Resurrectionists' – giving new life to dead bodies.

Although many people thought the whole practice was a grisly business, without the work of 18th-century anatomists such as William and John Hunter, who established **anatomy** museums for teaching young surgeons, our understanding of the human body would not have progressed so quickly. Some of the great discoveries of medicine took place in the 18th century, including the smallpox vaccine, improvements in childbirth medicine and advances in dental surgery. All these advances were due to a greater understanding of how the human body's systems worked.

Check your learning 7.1

Remember and understand

1. What is the difference between cells, tissues and organs?
2. Why did the Egyptian *shamans* study how the body worked?
3. Why is Leonardo da Vinci (Figure 7.4) so famous?
4. What is, or was, a body snatcher?
5. Why do surgeons need a thorough understanding of anatomy?

Apply and analyse

6. Draw a timeline of when and how the early anatomists studied the body. Use an internet search to help you complete this question.

Figure 7.4 Leonardo da Vinci.

7.2 The digestive system is made up of organs

Digestion is the process by which food (and drink) are broken down and absorbed into your blood for transport to your cells. The food we eat provides us with the energy to stay alive and the building materials for growth and repair.

Digestion

Your digestive tract is made up of a group of organs in the digestive system that form a tube travelling from your mouth to your anus. Along the way, food is broken down and absorbed across the intestinal walls into the blood. The internal walls of the intestines are wrinkly to increase their surface area for absorption into the blood. Food that is not required by the body remains in the digestive tract until the end, where it is released into the toilet.

Physical digestion

Your teeth are responsible for the physical breakdown of your food. There are three main types of teeth in your mouth that do this process. The front ones are called incisors, the pointy teeth next to the incisors are called canines and the rest of your teeth, which are flatter, are called molars. You also have a large muscular organ called a tongue that can push upwards, sideways and backwards. When you swallow your food, the muscles behind the food squeeze tight, and the muscles in front of the food relax. This forces the food to move in a process called **peristalsis**.

Chemical digestion

The mouth is also where saliva is found. Saliva is mostly water, but also contains different types of enzymes. Enzymes are chemicals that can speed up a reaction. In the digestive system, enzymes encourage the lumps of food to break up into nutrients that are small enough to be absorbed by the body.

The stomach contains a mixture of gastric juices to help digest the food you have eaten.

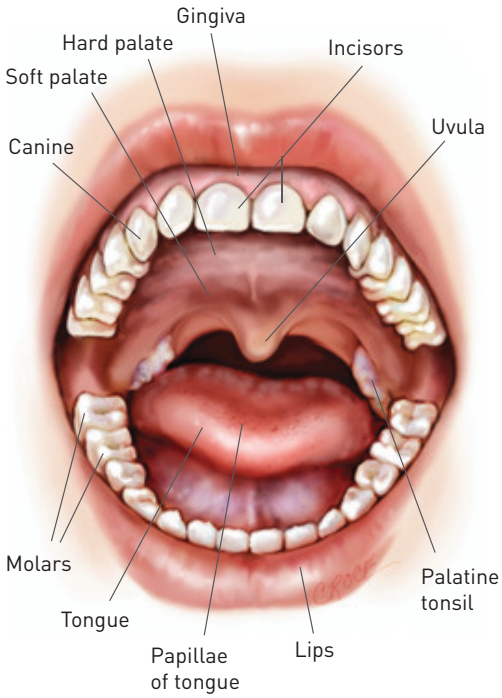


Figure 7.5 The teeth and mouth physically break down food.

These juices include acid that kills any bacteria that may be in the food, and an enzyme that digests the protein (found in meat) in your meal. The cells lining the inside of the stomach produce mucus to stop the acid burning the stomach walls. The resulting mixture of acid, enzymes and digested food is called **chyme**.

Absorbing nutrients

Most nutrients are absorbed in the small intestine. The inside of the small intestine is full of ridges called **villi**. These ridges increase the surface area that the nutrients pass over. This allows more time for all the nutrients to be absorbed from the chyme.

EXPERIMENT 7.2A: DIGESTING PROTEIN
GO TO PAGE 204.

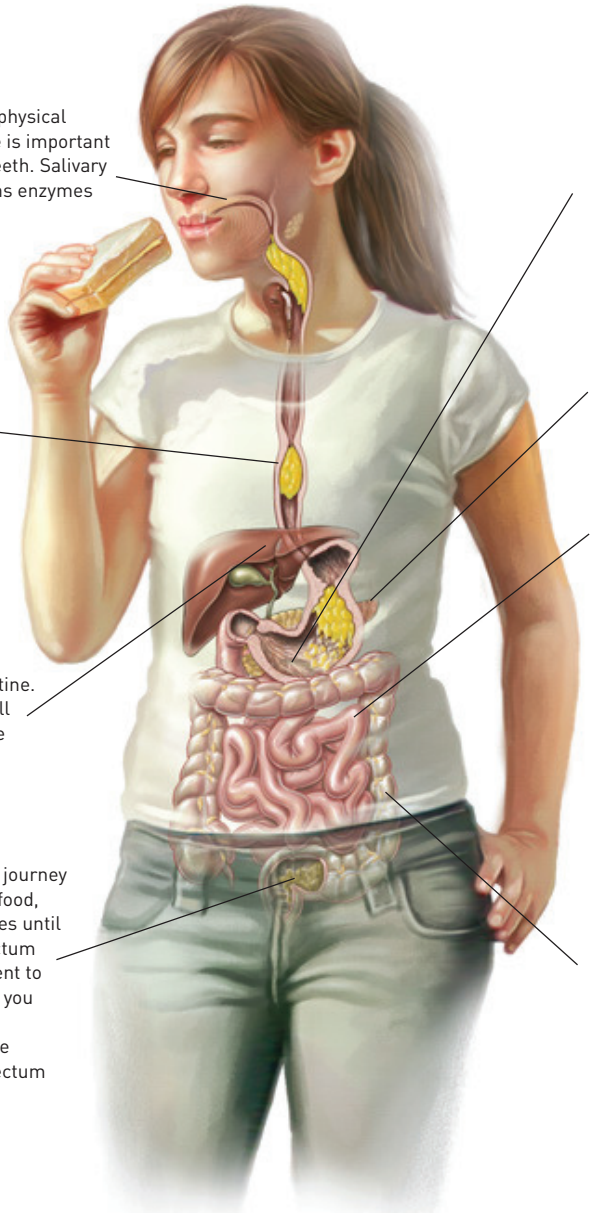
EXPERIMENT 7.2B: WHAT IF AN ENZYME WAS BOILED?
GO TO PAGE 205.

Teeth and mouth
The teeth are responsible for the physical breakdown of food and the tongue is important in pushing the food towards the teeth. Salivary glands make saliva, which contains enzymes to start chemical digestion.

Oesophagus
The oesophagus is a tubular muscle that forces food down to your stomach in a process called peristalsis.

Liver and gall bladder
The liver makes a mixture of chemicals called bile, which is used to digest fat and neutralise (deactivate) stomach acid. The bile is stored in the gall bladder until food reaches the small intestine. Bile is then released into the small intestine through a tube called the bile duct. Food does not travel through the liver.

Rectum and anus
The rectum is the final part of the journey for what is now solid, undigested food, or faeces. The rectum stores faeces until it starts to become full. As the rectum starts to stretch, messages are sent to the brain to make you realise that you need to go to the toilet. Rectal muscles push the faeces out of the ring of muscle at the end of the rectum called the anus.



Stomach
The stomach stores food for about 3 hours while it uses gastric juice (stomach acid) to help digest the food. The food in your stomach looks nothing like what you ate for dinner. It is very runny, warm and smelly and has a totally different taste. This mixture is called chyme.

Pancreas
The pancreas makes pancreatic juice, which contains a mixture of digestive enzymes and also neutralises stomach acid. Food does not travel through the pancreas.

Small intestine
The small intestine is called 'small' because it is quite narrow. If you laid a small intestine out in a straight line, it would be approximately 5 m long. The intestines are really important because they absorb the nutrients that all the cells of the body require. The ability to absorb nutrients is increased by projections, called villi, along the inner wall of the intestine that increase the surface area for absorption. Bacteria in the small intestine also help with digestion. Chyme takes about 5 or 6 hours to pass through the small intestine.

Large intestine
The large intestine is also called the colon and is wider but shorter than the small intestine. The large intestine is approximately 1.5 m long. By the time the chyme reaches the large intestine, most nutrients have been absorbed into the bloodstream. However, some vitamins are absorbed from the large intestine. Water is also absorbed into the bloodstream from the large intestine. Chyme stays in the large intestine for up to 14 hours, or sometimes longer.

Figure 7.6 The structure of the digestive system is shown here with key parts labelled.

Check your learning 7.2

Remember and understand

1 List, in order, the organs of the digestive system that food moves through, from the mouth to the anus.
2 How does saliva make it easier to eat dry biscuits?
3 What is the difference between mechanical and chemical digestion? Which occurs in the stomach?
4 What is the difference between the digestive system and the digestive tract?
5 Which organs are involved in digestion but do not have food pass through them?

Apply and analyse

6 Teeth would look very nice if they were all the same size and shape. What is the advantage of having different types of teeth in your mouth?
7 Can you think of any tools that may work the same way as incisors, canines or molars?
8 What are villi? What is their function?

7.3 The digestive system varies between animals

There are a large number of different types of animals in the world that have a varied diet. Herbivores eat plants. Carnivores eat meat. Omnivores, including us, eat a variety of foods. Although we all need the same basic nutrients, how we obtain those nutrients from our food varies.

Teeth tell a story

Figure 7.7 The teeth on this dinosaur show it was a carnivore.

Before the invention of knives and forks, we used to tear our food apart with our fingers and teeth. Each type of tooth has a specialised function. Incisors have a sharp knifelike structure, and animals such as rats and mice use their incisors to cut their way through food. Canine teeth are pointed and are useful in ripping lumps of meat apart. This is why many meat eaters (carnivores) have large canine teeth. Molars are flatter and are especially good at grinding the plant food of herbivores into small pieces so that it can be digested more effectively by enzymes.

Palaeontologists are scientists who study fossils, including the skulls and teeth of extinct animals. Palaeontologists use the teeth to predict what the animal ate when it was alive.

Herbivore hindgut

Some plants, such as sugar cane, have a ready supply of the sugar that we need for energy. Other plants, such as potatoes, contain starch that our enzymes can break up for nutrients. Not all plants make it this easy to obtain the nutrients that herbivores need. The outside of a plant cell is surrounded by a cell wall made of cellulose. Few animals have the enzyme (cellulase) that can break up this solid nutrient. Instead they rely on bacteria to break it up for them. These bacteria live in the **caecum**, a dead-end pouch where food is stored until the bacteria can digest it. In many animals the caecum is found between the small intestine

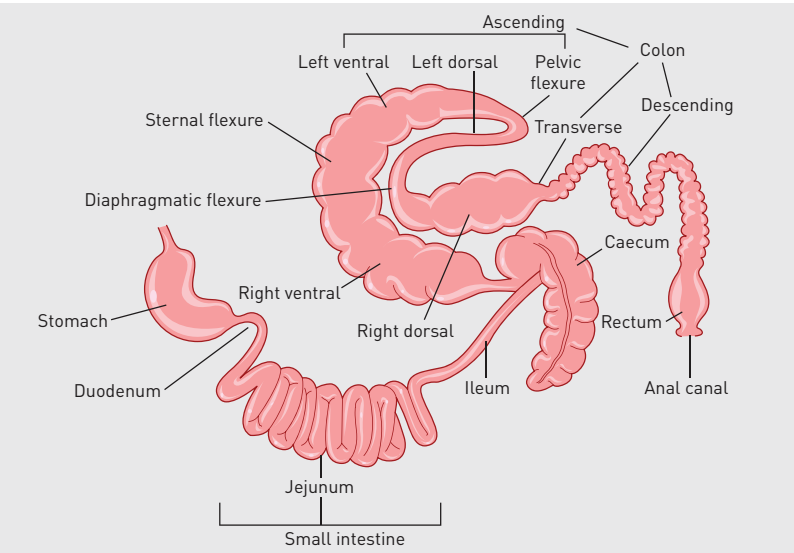


Figure 7.8 The caecum of a horse is found between the small intestine and the large intestine.

Figure 7.9 This fossil has a lot of molars and a few incisors. This suggests that it belonged to a herbivore.

and the large intestine. This is a problem for the animal as it means the plant matter is digested after it passes through the place where the nutrients can be absorbed, in the small intestine. This means some animals, such as possums, rabbits, rodents and termites, eat their own faeces to get the extra nutrients that may have been missed the first time through.

Ruminants

Ruminants are animals with hooves that have four chambers in their stomachs. A cow is an example of a ruminant. When the cow first swallows its food, the grass goes to the first stomach, which is called the **rumen**. This allows the grass to mix with different types of bacteria that can break up the cellulose in the plant's cell wall. The cow regurgitates the grass and chews it over and over again to help the bacteria break down the nutrients. The second stomach (**reticulum**) is involved in trapping any unwanted things the cow might have swallowed, such as rocks or wire. The third stomach, the **omasum**, has many leaf-like folds that filter the fine particles and water into the **abomasum** (the fourth stomach). It is this last section that contains the acid and enzymes just like a human stomach.

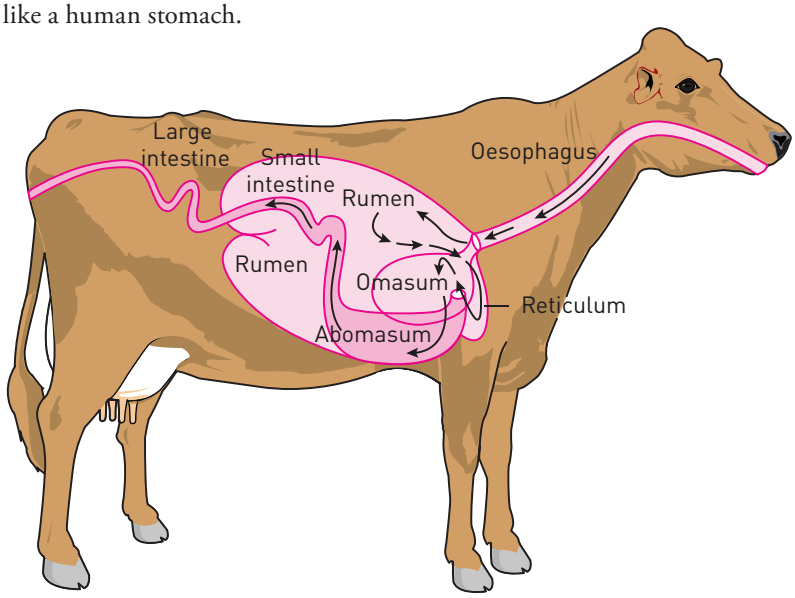


Figure 7.10 The four stomachs of a cow allow it to digest grass.

Check your learning 7.3

Remember and understand

1 How many stomachs does a cow have?

2 Are digestive systems the same in all animals? Explain.

Apply and analyse

3 Examine the images in Figure 7.11 of the digestive systems of a carnivore, a herbivore and an omnivore. Correctly label each digestive system according to the animal's diet. Provide evidence from the diagrams to support each of your answers.

4 Identify the possible diet of the fossils in Figure 7.12. Provide evidence from the photographs to support each of your answers.

Evaluate and create

5 Research the digestive system of an animal of your choice. In what way is it similar, and different, to the digestive system of humans? How does the structure of your animal's digestive system relate to the food it eats?

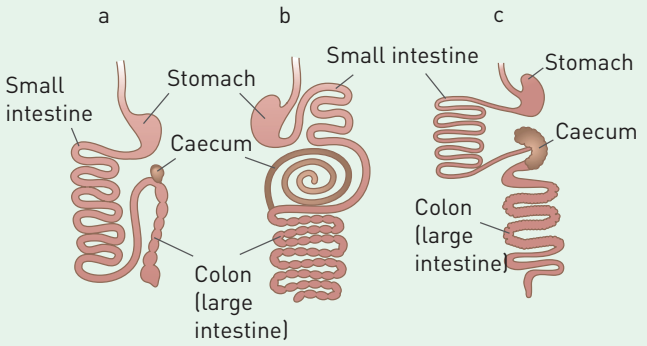


Figure 7.11

Figure 7.12

//SCIENCE AS A HUMAN ENDEAVOUR//

7.4 Things sometimes go wrong in the digestive system

The digestive system is just like a production line in a factory. Each organ relies on the previous section working effectively. This does not always occur. The stomach can get **ulcers**. Gall bladders can get **gallstones**. The small intestine may not be able to absorb a nutrient such as gluten and cause **gluten intolerance**. The large intestine may become blocked causing **constipation**.

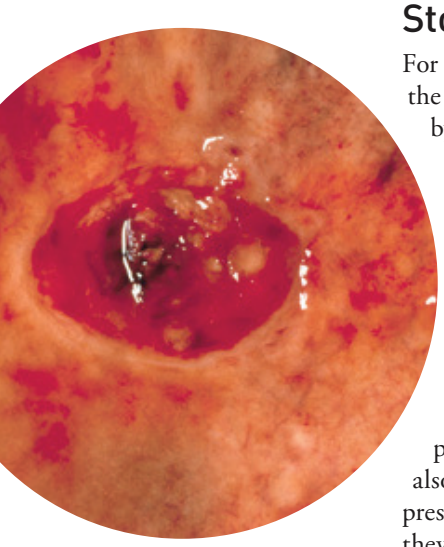


Figure 7.13 A stomach ulcer.

Stomach ulcers

For many years ulcers (small open sores) in the stomach lining were thought to be caused by too much rich, spicy food and stress. Patients would come to hospital in a lot of pain from the stomach acid burning the other tissues around the ulcer. Because it was thought no bacteria could survive in the stomach's acid environment, no one considered that a bacteria could be the cause of the ulcers. Two Australian scientists, Barry Marshall and Robin Warren, noticed that every patient who presented with symptoms of a stomach ulcer also had the bacterium *Helicobacter pylori* present in their stomach. In the early 1980s they did a series of experiments to show that the spiral-shaped bacteria caused damage to the cells lining the stomach, forming an ulcer. These bacteria can be killed by antibiotics. In 2005, Marshall and Warren were awarded the Nobel Prize for medicine (the highest prize in science).

Gallstones

The gall bladder is a small pouch-like structure that stores the bile from the liver. Bile contains many things, including a detergent-like substance that helps to physically break up the fat that leaves the stomach in the chyme. Occasionally, parts of the bile harden into a small stone that stops the bile leaving the gall bladder. The amount of bile in the pouch increases, causing the gall bladder to swell up. This causes severe stomach pains. If the stone cannot be shattered by **ultrasound**, or removed by surgery, the gall bladder may have to be removed. This means the person will have difficulty digesting fatty foods because of the lack of bile to break up the fats.

Figure 7.14 Robin Warren (left) and Barry Marshall (right).

Gluten intolerance

Gluten is a small molecule found in many cereals and grains. Our body uses enzymes to chemically digest the gluten so that we can use the nutrients it contains. Some people do not have this enzyme. This means they cannot digest the gluten and that they are gluten intolerant. It can cause a range of different symptoms, from blockages of the intestines to **diarrhoea** (watery faeces). Gluten intolerance is different to gluten allergies. If a person is allergic to gluten, their body's immune system fights against the gluten. This can affect their whole body, not just their faeces.

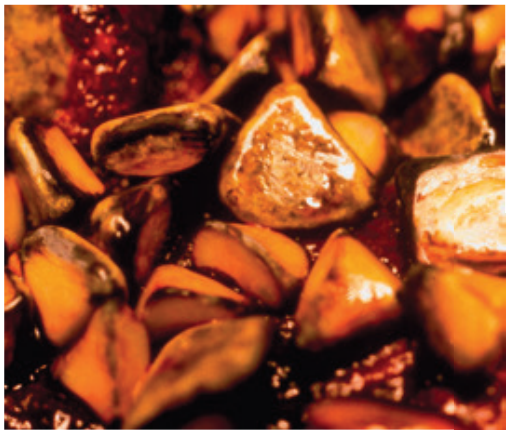


Figure 7.15 Gallstones.

Figure 7.16 A number of grains contain gluten.

Constipation

Sometimes the large intestine becomes blocked. This can be caused by a poor diet (not enough fruit and vegetables), or by an infection. It usually starts with a small blockage, but as more food moves down the digestive system, it gets caught behind the blockage and gradually fills the large intestine. This causes pain and discomfort. Sometimes medication is needed to help the large intestine move the blockage. If it is not treated, the person may die.

Figure 7.17 Constipation may cause pain and discomfort.

Extend your understanding

1. What causes stomach ulcers?
2. What role does bile play in the digestive system?
3. What is the difference between gluten intolerance and gluten allergy?
4. Why does a person with constipation experience pain?
5. Research the extreme measures that Barry Marshall took to show his colleagues that the spiral bacteria caused stomach ulcers.

7.5 The respiratory system exchanges gases

The respiratory system is the body system responsible for breathing – getting oxygen from the air we inhale down the **trachea**, the **bronchi** and the bronchioles into the alveolar sacs and eventually into our blood. We need oxygen to produce the energy for staying alive. As a result, our cells produce carbon dioxide. Our **lungs** breathe out to help us remove the carbon dioxide from our blood.

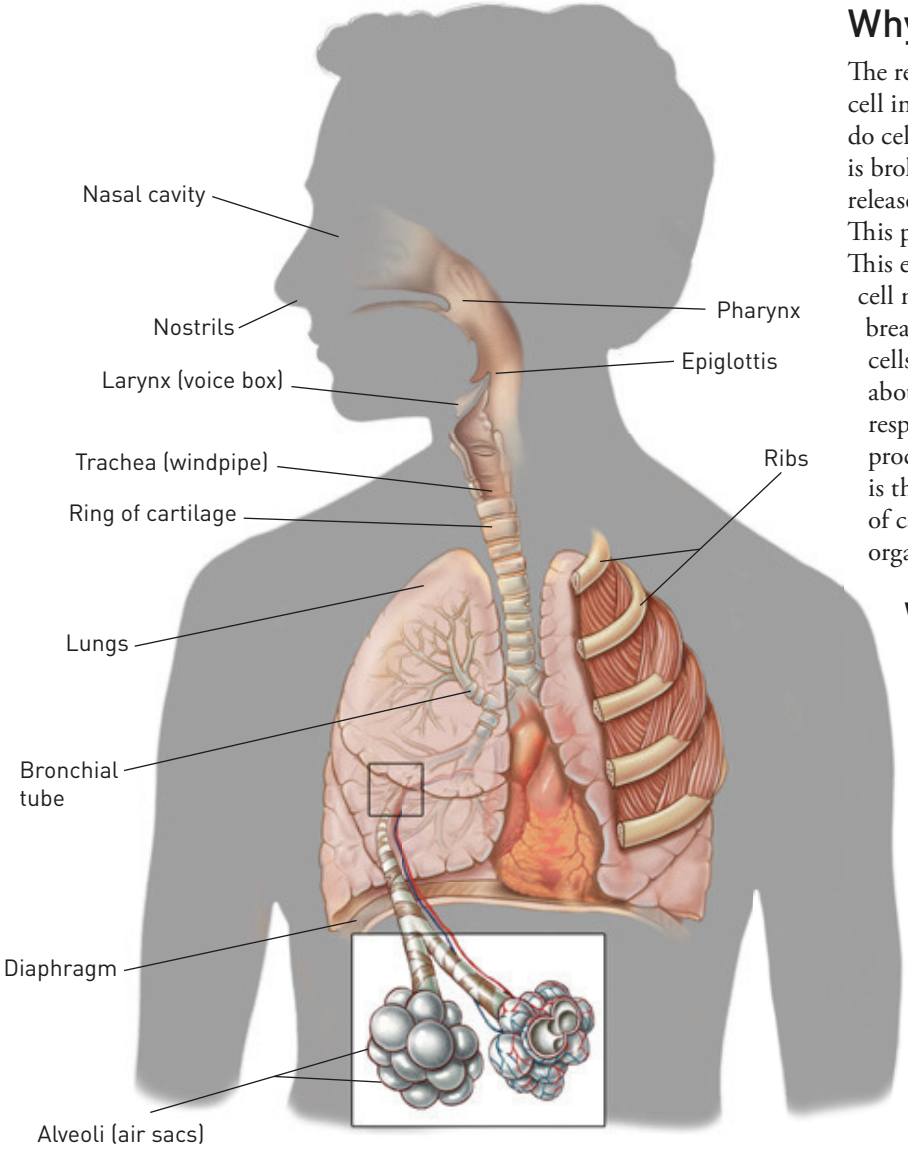


Figure 7.18 The structure of the respiratory system.

Why do we need oxygen?

The respiratory system makes sure that every cell in your body gets the oxygen it needs. Why do cells need oxygen? Most of the food we eat is broken down to glucose, a simple sugar. To release energy from glucose, oxygen is required. This process is called **cellular respiration**. This energy is then used for all the jobs the cell needs to perform, from making and breaking down substances to making new cells. You can see why people get confused about the difference between breathing and respiration. 'Cellular respiration' is the actual process that happens in cells and 'breathing' is the inhalation of oxygen and exhalation of carbon dioxide by your lungs and other organs in the respiratory system.

Where does the air go?

We breathe air in through our nose and mouth, trapping all the dust and pollens with hairs and wet surfaces as it travels to our throat or **pharynx**. At the bottom of the pharynx is a trapdoor called the **epiglottis** that controls the passage of food and air. Food goes down the oesophagus to the stomach. Air needs to go down the trachea to the lungs.

The lungs

There are *two* lungs in our chest, changing in size every time we take a breath and they fill with air. The trachea branches into two to carry air into

CHALLENGE 7.5A: MEASURE YOUR LUNG CAPACITY
GO TO PAGE 206.

CHALLENGE 7.5B: FISH DISSECTION
GO TO PAGE 206.

each lung. These branches are called bronchi. The lungs feel spongy to touch because they are home to millions of tiny air sacs called **alveoli**. If these air sacs were unravelled and flattened, they would have a surface area of approximately half the size of a tennis court. Each tiny alveolus is covered by a mesh of even smaller blood vessels called capillaries. The lungs are structured to have as many air sacs as close to as many blood vessels as possible. Oxygen moves into the blood, whereas carbon dioxide (the waste product of cellular respiration) moves out of the blood.

The diaphragm

The **diaphragm** is a dome-shaped muscle that is attached to your ribs and moves up and down beneath your lungs. The muscle contracts down and relaxes up. The diaphragm also separates the heart and lungs from the stomach and digestive system. The lungs have no muscle tissue, so they can't move on their own. Every time you breathe in, the muscles in the diaphragm and between the ribs work together to expand your chest. This creates suction that opens the lungs, pulling air in. Then the muscles relax, allowing the air to move out again.

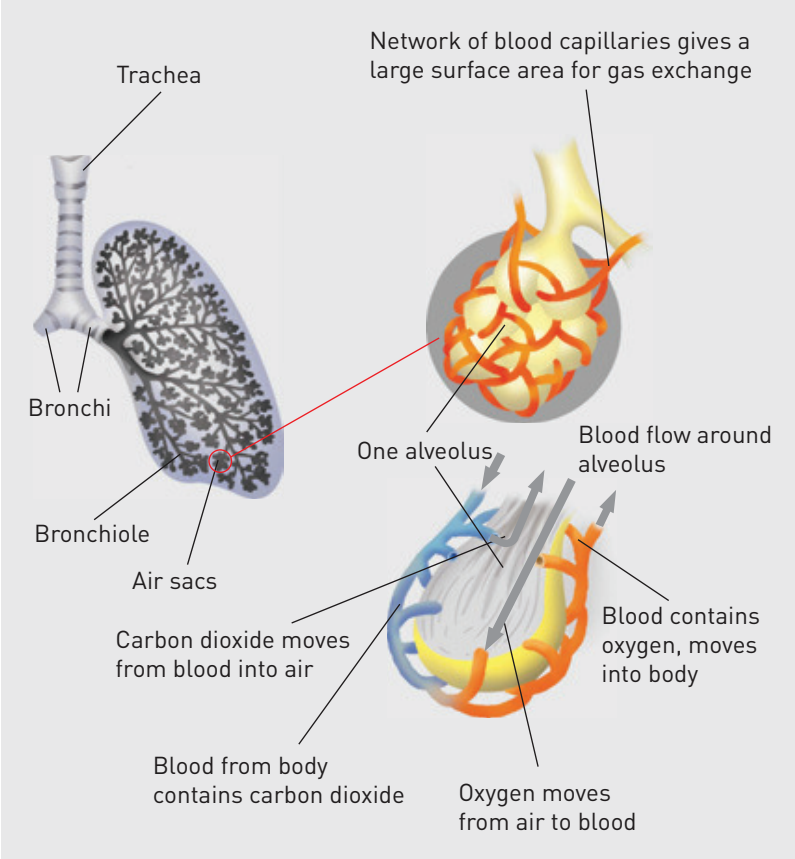


Figure 7.19 Gas exchange takes place in the alveoli.

Check your learning 7.5

Remember and understand

1. Draw a simple diagram showing how air travels down from the mouth and nose to the alveoli at the end of the branches of the bronchioles.
2. Explain the term 'gas exchange'.
3. At the same time that oxygen is passing into the blood, what gas is passing out of the blood back into the lungs?
4. Write the sequence of steps in breathing in and breathing out.
5. What role does the epiglottis play?
6. What advantage does the large surface area of the alveoli give in allowing oxygen to pass into the blood?

Apply and analyse

7. In your own words, explain why we need to breathe.

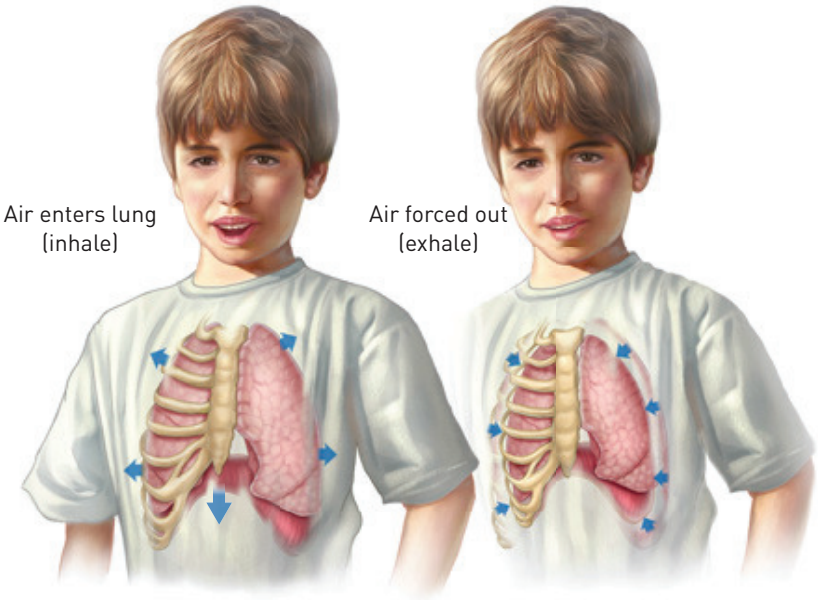


Figure 7.20 Breathing consists of inhalation and exhalation.

//SCIENCE AS A HUMAN ENDEAVOUR//

7.6 Things sometimes go wrong in the respiratory system

Our respiratory system is responsible for supplying the oxygen we need for energy. When things go wrong, our body struggles to survive. Small irritations make us cough. **Asthma** causes the airways to become smaller. **Emphysema** prevents the oxygen from entering our blood. **Pneumonia** is an infection that fills our lungs with fluid.

Coughing and sneezing

Every time you breathe in, you also take in small particles of dust, pollen and other particles. These particles are trapped by the cells lining our upper airways. Small **cilia** (hair-like structures) on the surface of the cells trap these particles and push them back to the top of the throat where they are swallowed. Larger particles trigger the diaphragm to contract quickly, making us cough. This pushes up the large particle before it enters the bronchioles.

Sometimes the particles get trapped by the hairs in our nose. This causes a message to go to our brain, which coordinates the muscles in the eyes, chest, stomach and diaphragm, making us sneeze. Some sneezes have been recorded at over 120 kilometres per hour.

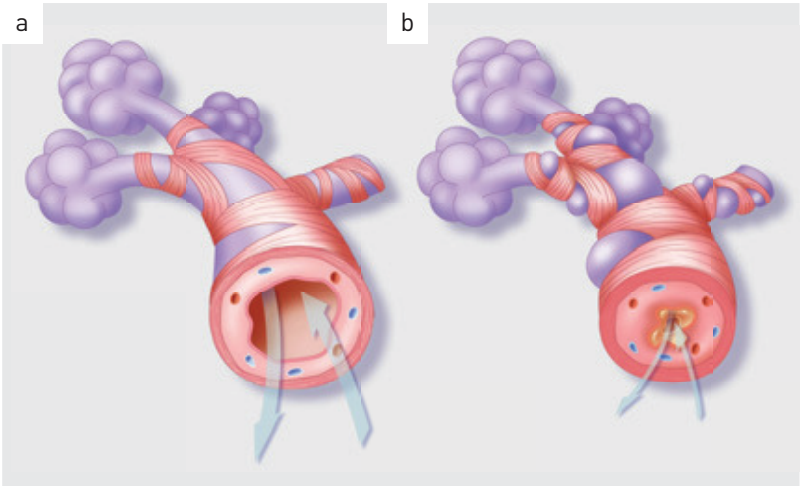


Figure 7.22 Asthma causes the bronchioles to become narrow: (a) normal airway and (b) asthmatic airway.

Figure 7.21 We cough or sneeze to clear small particles from our airways.

Asthma

Asthma is quite common in our population, affecting more than one in ten Australians. Asthma usually starts when something in the environment irritates the airways. This causes the bronchi and bronchioles to narrow, making it harder for air to move into the lungs. This makes it hard to breathe. Asthma attacks can be reversed by drugs, such as Ventolin, that relax the airways.

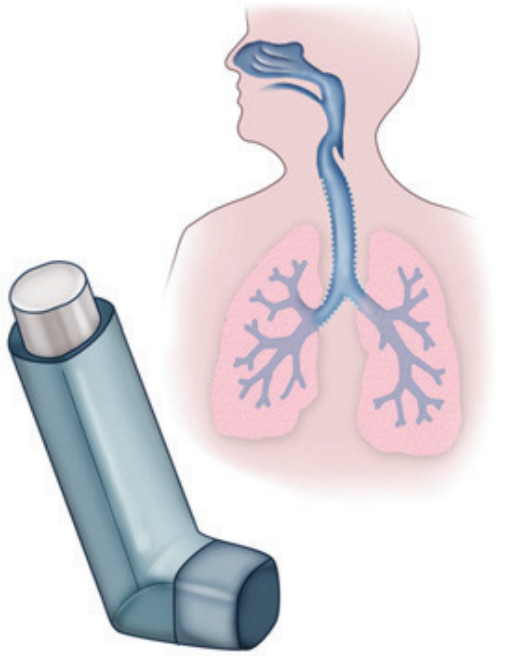


Figure 7.23 Ventolin is commonly used to control asthma attacks.

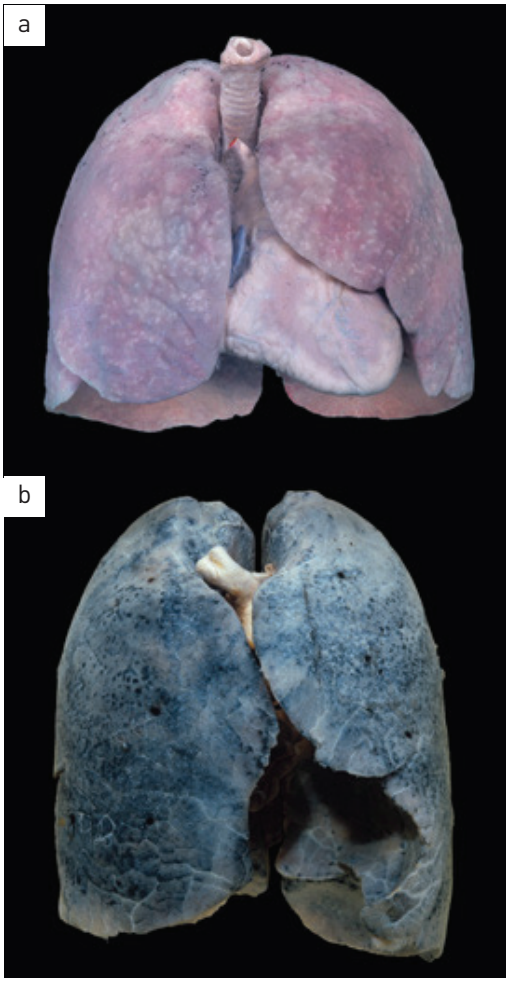


Figure 7.24 (a) Healthy lungs. (b) A smoker's lungs.

Emphysema

Smoking involves breathing toxic chemicals and tar into your lungs. The tar is like honey, covering the inside of the alveoli and stopping oxygen from moving into the blood. The toxic chemicals in the smoke kill the cells, destroying the alveolar sacs, and travel through the blood to cause trouble all over your body. Emphysema is a disease that is caused by the inability of the collapsed alveoli to move air in and out. A person with emphysema struggles to breathe in enough oxygen to walk even 20 metres.

Pneumonia

Pneumonia is caused by a bacterial or viral infection in the lungs. The alveoli in the lungs fill up with bacteria, pus and fluid. This prevents air moving into the lungs. Anyone can contract pneumonia, but it tends to be most common in young children and the elderly. A short course of antibiotics (special drugs that kill bacteria) can clear the lungs again.

Extend your understanding

1 What causes each of the following?
   a a cough
   b a sneeze.
2 What is asthma?
3 Why do people with pneumonia feel tired all the time?
4 It is physically impossible to keep your eyes open during a sneeze. Can you explain why?
5 Describe some health risks people take with their lungs. What can be done to avoid these risks?

7.7 The circulatory system carries substances around the body

The circulatory system is the body system responsible for moving blood around your body. Many different substances, including nutrients and wastes, are transported in the blood, picked up from and dropped off at different locations.

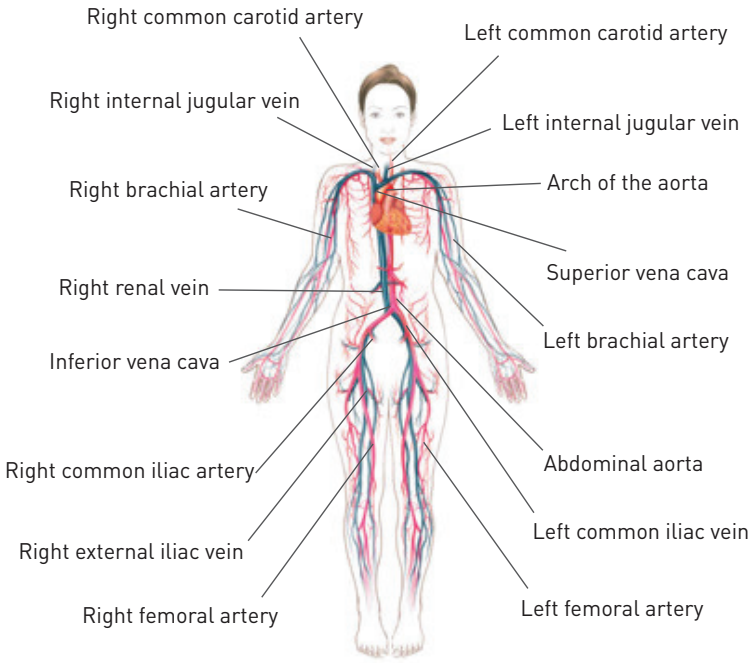


Figure 7.25 The structure of the circulatory system with key parts labelled.

The heart

The heart is a large two-part pump about the size of your fist. It is made of four chambers: two **atria** at the top and two **ventricles** at the bottom. The ventricle on the right side of the heart pumps blood to the lungs to 'drop off' carbon dioxide and 'pick up' oxygen. This oxygenated blood moves back to the left atrium and on to the left ventricle. The more muscular left ventricle pumps blood out through the **aorta** at the top of the heart and around the body. Valves keep the blood moving in the right direction until it gets back to the right atrium of the heart.

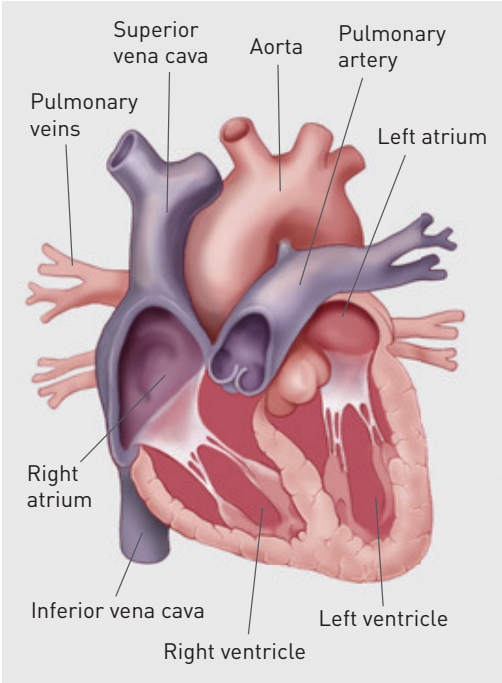


Figure 7.26 This diagram shows your heart, as well as some of the major blood vessels that travel to and from the heart. The diagram uses a common convention that shows the arteries in red and the veins in blue.

Blood is a combination of cells, cell fragments, liquid and dissolved substances and each aspect is absolutely necessary.

- Oxygen is carried by the **red blood cells** from the lungs to all the cells of the body. Carbon dioxide is dissolved in the **plasma** (the straw-coloured liquid at the top of centrifuged blood).
- Nutrients and wastes are also dissolved in the plasma for transport to and from cells.

EXPERIMENT 7.7: HEART DISSECTION
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- **White blood cells** use the blood to travel to places where bacterial cells that cause infection are growing. The white blood cells then kill the bacterial cells.
- **Platelets** are cell fragments that burst when exposed to breaks in the blood vessels. They fill the hole and glue the edges together.

Blood vessels

Blood travels through tubes called **blood vessels**. Just like our roads, blood vessels have different sizes and structures depending on the amount of blood they need to carry, as well as the speed of the blood and whether it is picking up or dropping off substances.

Arteries are the largest blood vessels. Arteries have thick, muscular walls to cope with high pressure and to help pass the blood along. Arteries carry blood away from the heart. The blood is at a higher pressure here because it has just been pumped. Arteries branch into **arterioles** (smaller arteries).

Capillaries are possibly the most important of the blood vessels. Their walls are only one cell thick to allow substances to easily pass in and out of the blood. Capillaries are the vessels connecting the arteries and veins; they are sometimes referred to as a capillary bed when they are in large numbers surrounding an organ.

Veins carry blood back to the heart to be pumped elsewhere. These vessels are similar in size to the arteries, but only have a small amount of muscle in their walls. To avoid any blood going backwards due to a lack of pressure, veins have one-way valves in them.

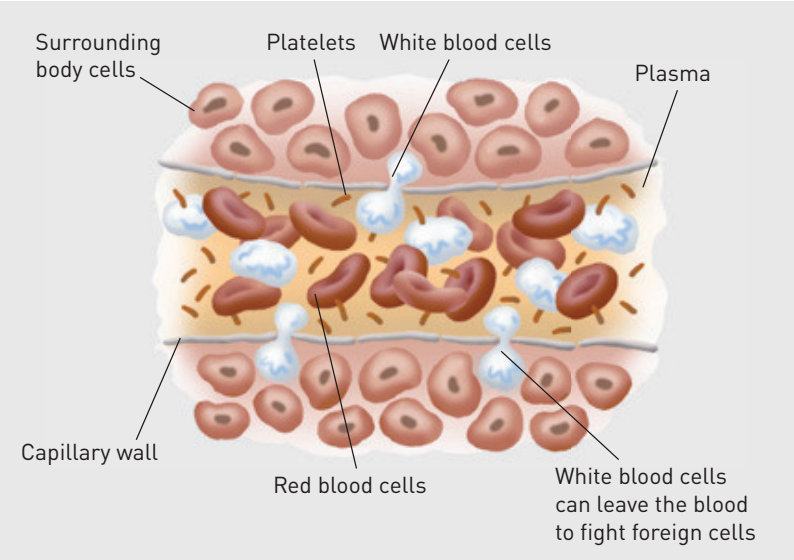

Figure 7.27 A cross-section of a blood vessel.

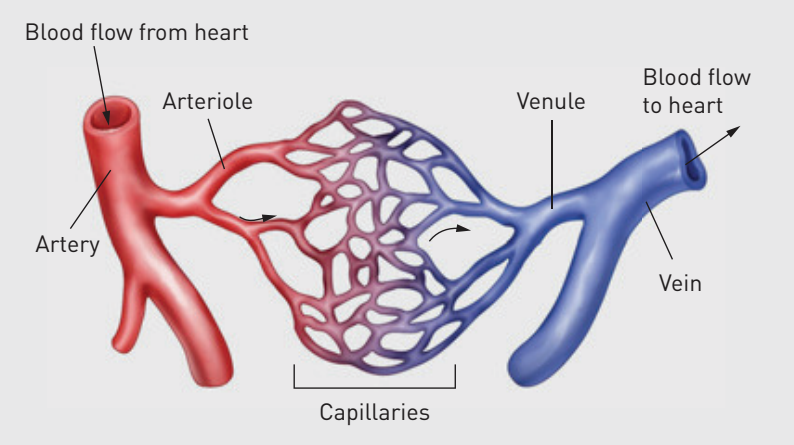

Figure 7.28 Capillary bed, showing the relationship between arteries, veins and capillaries.

Check your learning 7.7

Remember and understand

1. Copy and complete: The circulatory system is the transport system for the body, delivering _____ and other _____ to the cells and carrying wastes away for removal. _____ blood cells are responsible for carrying oxygen, _____ blood cells fight germs, _____ block cuts and _____ is the liquid carrying them all.
2. Explain how the three blood vessel types differ in their structure, jobs and locations. Use diagrams in your answer.
3. How many chambers are there in your heart? Name them.
4. Use Figure 7.26 showing the structure of the heart to complete the following for the path of blood through the chambers of the heart:
   body → _____ → _____ → lungs → _____ → _____ → body.
5. Rewrite your answer to question 4, adding the names of the veins and the arteries involved.
6. From which body system does the circulatory system absorb nutrients?
7. Why would muscles need the heart to pump faster during exercise? What chemical reaction does this include?
8. Instead of the blood travelling directly from the lungs to the rest of the body, the blood returns to the heart first. What is the advantage of doing this?

//SCIENCE AS A HUMAN ENDEAVOUR//

7.8 Things sometimes go wrong in the circulatory system

Blood vessels carry oxygen and nutrients around the body. When something goes wrong, the body is unable to make the energy it needs to survive. Valves in the heart can leak (valve disease), the vessels can narrow (atherosclerosis) and the cells in the heart can die in a heart attack. Healthy eating and regular exercise all help to keep your heart healthy.

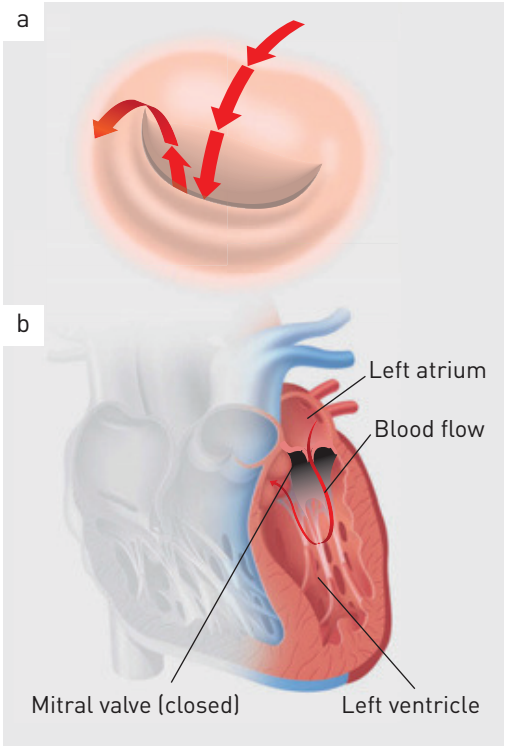

Figure 7.29 (a) The heart valve opens to allow blood to flow from the atrium to the ventricle. (b) Closing of the valve prevents the backflow of blood so that it can be pumped effectively around the body.

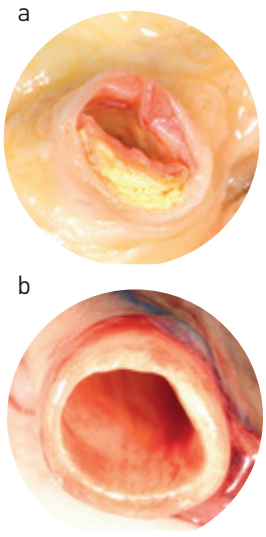

Figure 7.30 (a) A blocked artery and (b) an unblocked artery.

Valve disease

The heart has a series of valves that prevent the blood flowing backwards. This means when the ventricle fills with blood from the atrium, the valve between the atrium and ventricle closes (lub), forcing the blood to flow out of the heart when the ventricle contracts. The valve between the ventricle and the aorta then closes (dub) allowing the ventricle to fill once again. This is what creates the lub-dub sound you hear when you listen to your heart.

Sometimes these valves become damaged. They may become narrowed from scarring (stenosis), they may leak (regurgitation or insufficiency) or not close properly (prolapse). This prevents the blood from flowing properly around the body. As a result, less oxygen and nutrients get carried to the cells. This makes the person very tired all the time.

Atherosclerosis

Atherosclerosis is a disease that results from the narrowing of the blood vessels. This narrowing is caused by a build-up of plaque on the inside of the arteries and veins. Plaque consists of fat, cholesterol and other substances normally found in the blood. Layers of plaque are laid down over time, eventually

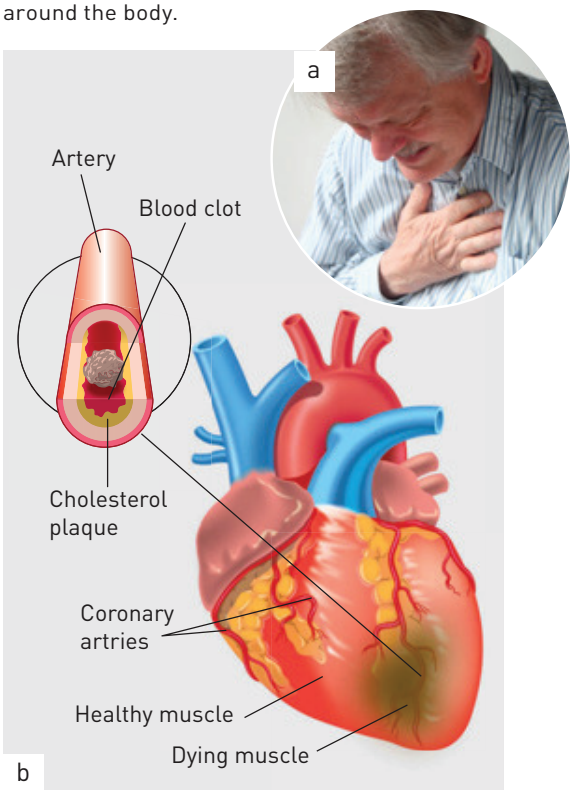

Figure 7.31 (a) Chest pain is often caused by a (b) blockage in the heart's own blood vessels.

CHALLENGE 7.8: MODELLING BLOOD FLOW
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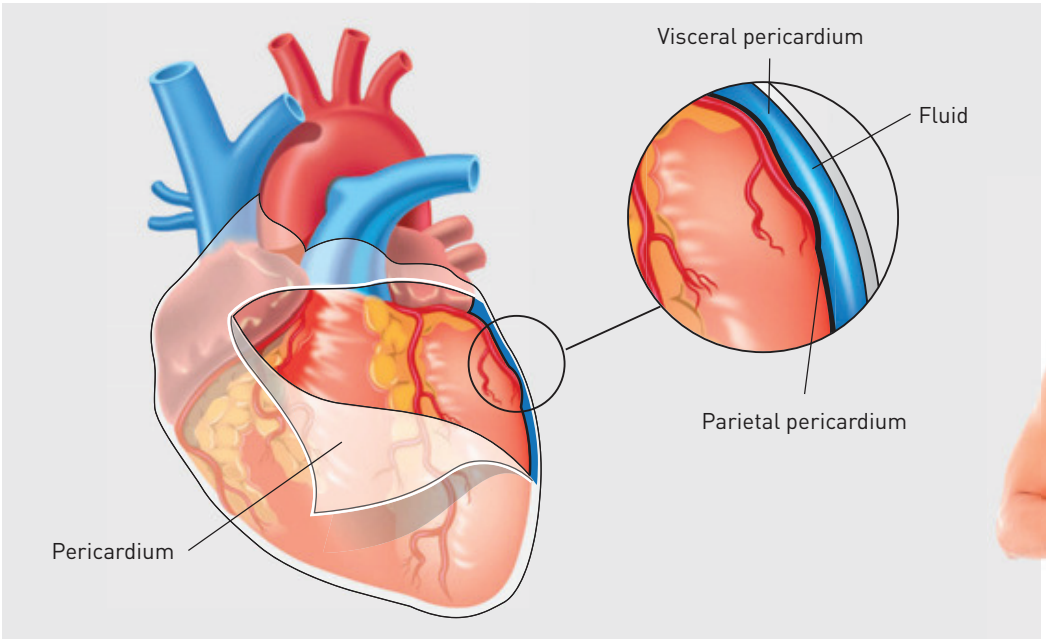

Figure 7.32 The pericardium reduces friction in a beating heart.

hardening and restricting the blood flow. The symptoms depend on the part of the body affected by the narrowed blood vessel. If the blood vessel is in the heart, then a heart attack will follow.

Coronary heart disease

A heart attack is usually caused by coronary heart disease (CHD), which is basically fatty deposits blocking important blood vessels in the heart. 'Coronary' refers to the heart's own blood vessels. The 'attack' occurs when the vessels become completely blocked or when a bit of the fatty deposit breaks off and travels into the heart. Heart muscle cells may be killed in the process.

So how can you keep your heart healthy? Eating less fatty food is a really good start, but it's not the only thing you can do.

The heart is a muscle and, like all muscles, it needs exercise to keep it strong. Regular exercise is all it needs. In people who are overweight or who smoke cigarettes, the heart needs to work much harder to do the same job. This is actually stressful for your heart. Elite athletes work their bodies very hard, so they need to make sure they have their hearts checked regularly by a doctor.

Pericarditis

The pericardium is the thin sac that surrounds the heart and helps it move easily when it beats. It reduces the friction when the heart beats. Sometimes this thin layer of cells can become infected by bacteria, causing the sac to fill with fluid– a condition known as pericarditis. As a result the heart cannot beat properly. This restricts the heart from filling properly with blood. Antibiotics are needed to help kill the bacteria.

Extend your understanding

1 What causes the lub-dub sound you hear when you listen to your heart?
2 What is the cause of the following valve conditions?
   a stenosis
   b regurgitation or insufficiency
   c prolapse.
3 What is the purpose of the heart having a pericardium?
4 What is the link between atherosclerosis and cardiovascular disease?
5 What things could you do to ensure your circulatory system stays healthy?
6 How does the heart muscle become damaged during a heart attack?
7 How does the function of the pericardium become affected when it fills with fluid during an infection?

7.9 The excretory system removes waste

Our cells and our bodies create a number of waste products. If we are to keep functioning correctly, these wastes need to be removed. The process of removing wastes is called **excretion**. The organs of excretion are the kidneys, liver, lungs and skin. These organs make up the **excretory system**.

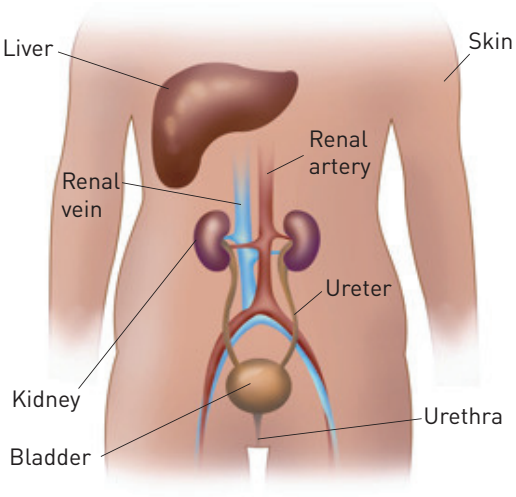

Figure 7.33 The structure of the excretory system with key parts labelled.

Figure 7.35 Ammonia is a strong cleaning solution. Liquid ammonia can dissolve some metals, so you can imagine why it's not a good thing to have too much of it in your body.

What is waste?

Our bodies produce a number of substances that need to be removed to avoid damage to our bodies. The human body, like all organisms, relies on a careful balance of inputs and outputs to work properly. Water is really important in controlling wastes because it can dilute harmful substances, diluting their impact at the same time. Water is also great for moving substances quickly and is essential for keeping our body temperature just right.

When your body digests proteins, it breaks them down into smaller molecules called **amino acids**. However, it cannot store the amino acids that it doesn't use immediately. Your liver breaks down these amino acids into other substances for energy. When it does this, it produces a very toxic substance called **ammonia**. The liver then uses energy to change the ammonia into a safer substance called **urea**, which is also filtered by the kidneys for removal.

Figure 7.34 The salt that you eat helps substances move in and out of cells. However, if there is too much salt in your body, things get out of balance. Your body gets rid of the excess salt by filtering it out through the kidneys.

The kidneys

You have two kidneys, one on each side of your lower back. They are approximately 10 cm long. Blood carrying waste products enters your kidneys to be filtered by the million tiny structures in the kidney called **nephrons**. At the end of this filtering process there are two main outputs: clean blood and urine.

EXPERIMENT 7.9: KIDNEY DISSECTION
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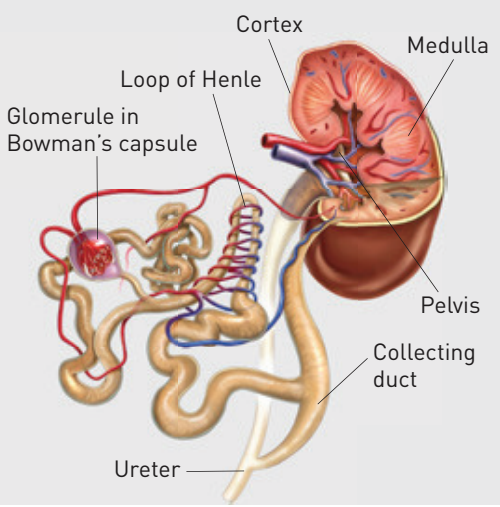

Figure 7.36 The structure of the kidneys. The nephron, shown in greater detail on the left, is the filtering unit of the kidney.

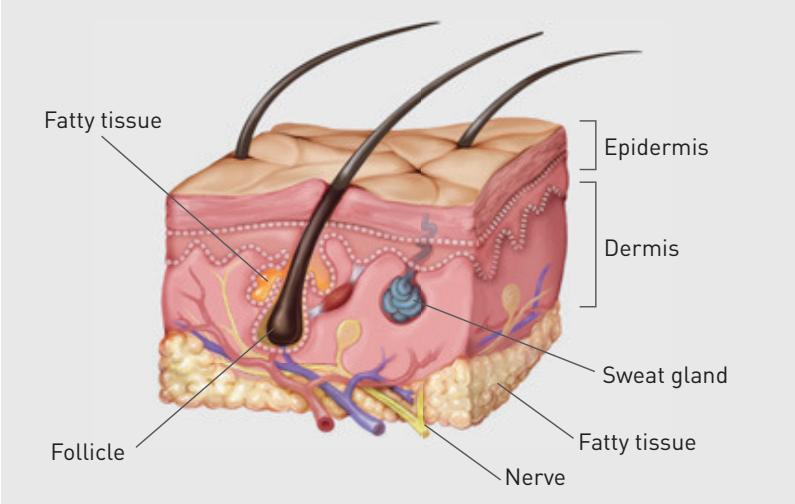

Figure 7.37 The structure of skin.

The skin

The skin plays a very important role in releasing waste heat by evaporation from wet skin. If you've ever licked your upper lip after exercise, you will know that your sweat is very salty. Sweat also contains waste products such as urea.

The liver

All our food has to be metabolised, or processed. **Metabolism** is the name given to the chemical reactions that occur in the body. These reactions can break down substances or build new substances. The liver is responsible for the metabolism of many substances, especially waste substances. Dangerous substances are often changed into less dangerous forms by the liver before their removal from the body.

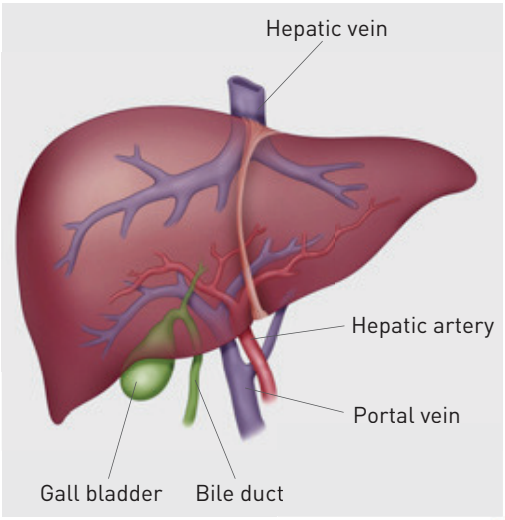

Figure 7.38 The structure of the liver with key parts labelled.

Figure 7.39 Protein digestion produces toxic ammonia.

Check your learning 7.9

Remember and understand

1 What does the word 'excretion' mean?
2 Can you think of any similarities between your excretory system and your respiratory system?
3 What are four organs involved in excretion?
4 Why does urine tend to be more concentrated in hot weather?
5 How does your body get rid of the following wastes?
   a salt
   b water
   c urea.

Apply and analyse

6 What effect would running a marathon have on the quantity and concentration of the urine?
7 If someone passes blood in their urine, it is a likely sign of kidney damage. Can you think of why?

CHALLENGE 7.10A: LOCATING THE STOMATA OF A LEAF
GO TO PAGE 209.

CHALLENGE 7.10B: LOCATING THE XYLEM AND PHLOEM IN A STEM
GO TO PAGE 209.

7.10 Plants have tissues and organs

Plants are multicellular organisms that have specialised organs to help move water and nutrients around the body. **Roots** use **osmosis** to absorb water from the soil. **Stems** transport the water and nutrients around the plant. **Leaves** exchange gases and produce the sugars needed for energy.

Roots

Roots help anchor a plant to the soil and help it absorb nutrients and water. Most root cells have a series of small hairs to increase the amount of surface area that can take in the water. First the roots take mineral salts from the soil and store them in their cells. This makes the inside of the roots more 'salty' than the soil. Water molecules are attracted to the mineral salts in the root cells. As a result, water moves through the root cell membrane and into the plant. This process is called osmosis.

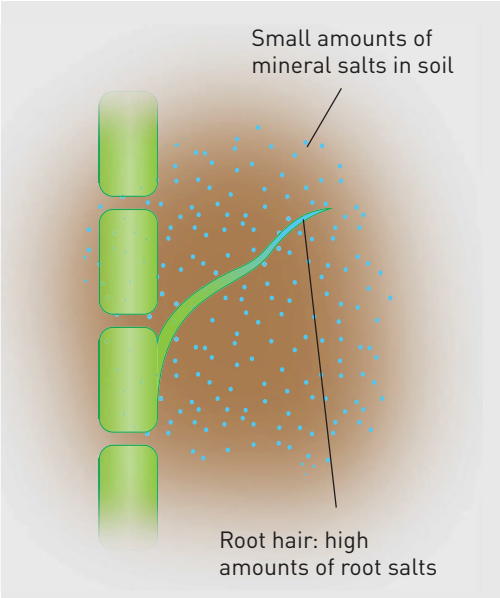

Figure 7.40 Osmosis into a root hair.

Stem

The stem of a plant is the organ responsible for the transport of water and nutrients between the leaves and roots. There are two main structures in the **vascular bundle** of the stem.

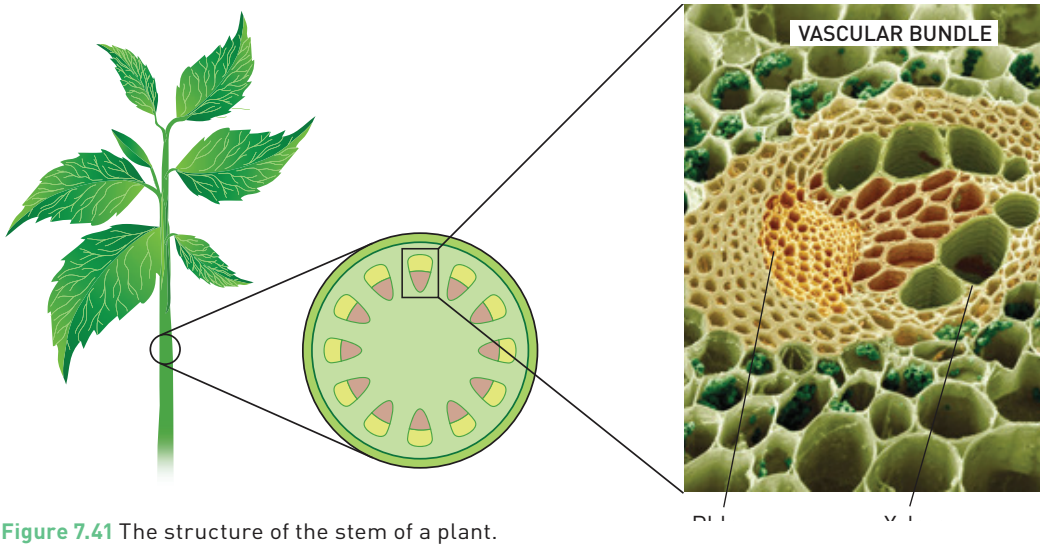

Figure 7.41 The structure of the stem of a plant.

CHALLENGE 7.10C: MODELLING ROOT CELLS
GO TO PAGE 210.

EXPERIMENT 7.10: FACTORS THAT AFFECT TRANSPIRATION
GO TO PAGE 210.

The **xylem** (*zi-lem*) is a straw-like structure that moves the water from the roots to the top of the plant. Water molecules like to stick together; you can see this in the way a drop of water forms a spherical shape. When water evaporates from the leaves at the top of a plant (**transpiration**), other water molecules move up to replace it. This can pull water molecules from the roots to the top of a 10 metre tree.

The **phloem** (*flo-em*) is another network of cells in the plant stem that transport the glucose produced in the leaves to other parts of the plant. These sugars are needed for all cells in the plant to produce the energy they need to stay alive.

Leaves

The leaves of a plant are involved in exchanging gases. In sunlight, a plant needs carbon dioxide to produce the sugars it needs for energy. The carbon dioxide moves in and out of cells through a small opening called a stoma (plural stomata). A plant stoma has two specialised guard cells that can grow longer, forcing a hole to appear between them. This allows air to move in and out. When it is too hot, the plant loses more water than the roots can replace. This causes the guard cells to become smaller, closing the pores in the plant's stomata.

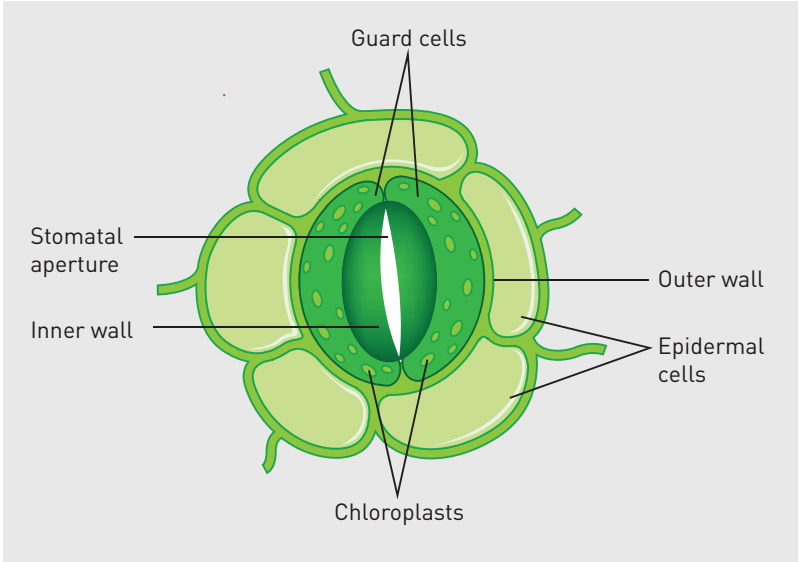

Figure 7.42 The structure of a plant stoma.

When the sun is shining, the leaves convert the water from the roots and the carbon dioxide from the stomata into glucose (sugar) and oxygen in a process called photosynthesis. Photosynthesis cannot happen without the help of **chlorophyll**. This is the reason most leaves are green.

During autumn, some leave lose their green chlorophyll. This allows the other colours present in the leaves (reds, oranges and yellows) to appear.

Figure 7.43 Autumn leaves come in a range of colours.

Check your learning 7.10

Remember and understand

1. Name three organs found in most plants and describe their function (what they do).
2. What is osmosis?
3. What is the difference between xylem and phloem?
4. Why do leaves become red and yellow in autumn?
5. What system in humans provides the same function as a plant stem?

Apply and analyse

6. Some florists sell blue orchids that are artificially coloured. Use your knowledge of plant systems to explain how these orchids may have become blue.

Figure 7.44 Artificially coloured orchids.

* REVIEW

7

Remember and understand

1 What was Leonardo da Vinci famous for?
2 What do you think motivated the earliest studies of the human body?
3 Name four things that the circulatory system transports around your body.
4 What is the gaseous waste product removed by the lungs?
5 Describe how the respiratory system and circulatory system work together.
6 What is the difference between respiration and breathing?

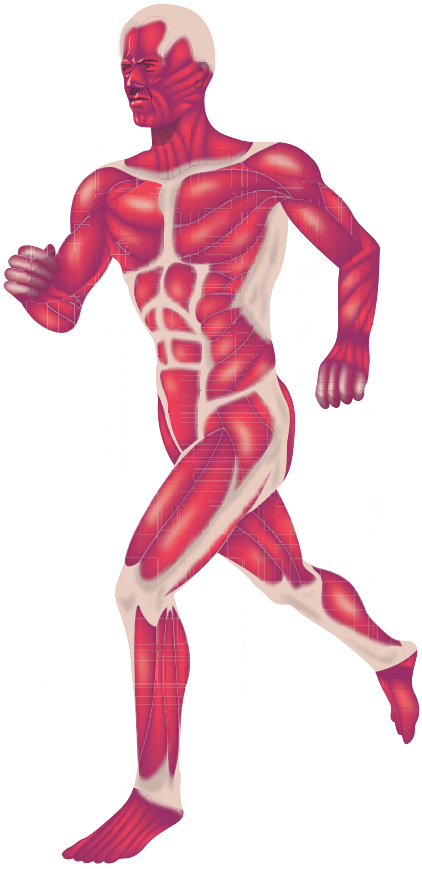

Figure 7.45 The respiratory system and circulatory system must work together to supply oxygen to the muscles.

7 Where does chemical digestion occur in the body?
8 Where does peristalsis occur in the body? Explain how it causes food to move.
9 Plants do not have a digestive system. What organ helps the plant supply all its energy needs?

Apply and analyse

10 How does the human digestive system 'feed' all the other systems?
11 Why would muscles need more blood during exercise?

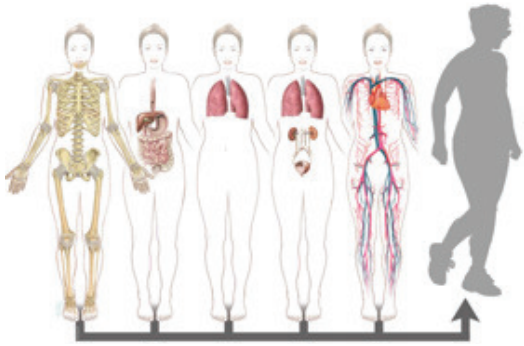

Figure 7.46 Each system in the human body is made up of organs that must work together.

12 Would you expect to find chloroplasts in the roots of a plant? Why or why not?
13 Sweating is often considered to be a bad thing. What is your perspective? Put forward an argument for your point of view. What do you think would happen if you didn't sweat?
14 Imagine it is your job to construct a 'user's manual' for one of the systems covered in this chapter. Write a list of ten 'Frequently Asked Questions' (FAQ) to go at the front of the manual. Write an answer to as many of your questions as you can. If you don't know the answer, write down where you could find the answer or who you could ask.
15 Some people have had the valves in their heart replaced with prosthetic valves, either made from synthetic materials or transplanted directly from a pig or cow heart. Why is it so important that the valves in a heart are functioning properly?
16 Mangrove trees get rid of excess salt through their leaves. This salt is often seen as white crystals on the underside of the leaves. Which system does this represent for the plant? How is this similar to humans? Which organ(s) is responsible for this in humans?

17 Human dissections sound like grisly work, so why do you think it was so important that they happened?

Evaluate and create

18 Use your understanding of the different systems of the human body to create a concept map detailing the connections between the systems. An example has been provided to help you get started.

Figure 7.47 There are many different systems in your body that must work together to keep you alive.

19 Revisit Challenge 7.1, the brown paper body brainstorm that you did at the start of this unit. Look at the body you and your group created. Evaluate your own work by writing a short paragraph about how your knowledge of your major body systems has changed after completing this unit. Give yourself a score out of 5 for *then* and a score out of 5 for *now*.

Ethical understanding

20 There are many diseases that affect the different organs in the body. Sometimes the only treatment available is an organ transplant. Replacement hearts and lungs can only be obtained from critically injured patients who have been certified brain dead. Discuss the advantages and disadvantages of organ donation with a partner. Would you want your organs donated if you were brain dead? Explain the reasoning behind your decision.

Research

21 Choose one of the following topics for a research project. A few guiding questions have been provided for you, but you should add more questions that you want to investigate. Present your research in a format of your own choosing, giving careful consideration to the information you are presenting.

a **Smoking bans**

Many smoking bans, such as bans in workplaces, are related to the issue of secondhand smoke. This refers to how smoke affects people standing near a person who is smoking. Find out some facts about the impacts of secondhand smoke. Do you think the rules are required? Argue your position on whether smoking bans should be extended, removed or are fine as they are now.

b **Getting rid of nitrogen**

Animals need to get rid of nitrogen. Some animals produce ammonia, some produce uric acid, some produce urea and others produce guanine. Find out which types of animals produce these different substances to remove nitrogen. In which environments do animals that produce ammonia live? In which environments do animals that produce urea live? What are the advantages for animals of producing the different forms of nitrogenous wastes?

c **Omega-3 fatty acids**

What are omega-3 fatty acids? What foods should be eaten to include them in your diet? How do omega-3 fatty acids help reduce heart disease? What other diseases are helped by omega-3 fatty acids? Why is this sort of fat good for you to eat?

d **Rh factor**

What is the Rh factor? How is the Rh factor written with blood groups? What percentage of the population is Rh negative and what percentage is Rh positive? What affect does the Rh factor have in pregnancy?

* KEY WORDS

7

abomasum
the fourth stomach of a cow

alveoli
tiny air sacs in the lungs where gas exchange occurs

aorta
the major artery that carries oxygenated blood from the heart and divides into smaller arteries around the body

arterioles
smaller arteries

artery
thick, muscular-walled blood vessel that carries blood away from the heart under pressure

atria
the smaller upper chambers of the heart

bronchi
the air passages that carry air in and out of the lungs; airways

caecum
a small dead-end pouch that connects the small and large intestines

capillary
blood vessel with a wall only one cell thick, allowing substances to easily pass into and out of the blood

diaphragm
the dome-shaped muscle that is attached to ribs and moves up and down beneath the lungs

epiglottis
a flap of skin that controls the passage of food and air

excretory system
a group of organs that are involved in excretion

lungs
organs found in the ribcage that are part of the respiratory system

nephron
tiny structure in the kidneys that filters the blood

omasum
the third stomach of a cow

osmosis
the movement of water through a selective membrane from an area of low 'salt' concentration to an area of high 'salt' concentration; occurs in root cells

peristalsis
when muscles behind the food squeeze tight, and the muscles in front of the food relax, causing the food to move along the throat or intestines

pharynx
the throat; connects the mouth to the oesophagus

phloem
the vascular tissue found in plant stems that carries the sugars around the plant

plasma
the straw-colour fluid that forms part of the blood

platelets
small disc-like cells found in blood that are involved with forming clots

red blood cells
cells found in the blood that carry oxygen around the body

reticulum
the second stomach of a cow

rumen
the first stomach of a cow

trachea
the large tube that connects the throat to the bronchi; carries air in and out of the body

transpiration
the process of water evaporation from plant leaves that causes water to move up from the roots

vascular bundle
groups of tubes found in plant stems that carry water and nutrients around the plant

vein
thin-walled blood vessel that carries blood back to the heart

ventricles
the large lower chambers of the heart

villi
small ridges found in the small intestine that absorb nutrients from the digestive system

white blood cells
cells found in the blood that help fight infections

xylem
the tissue in plants that carries water from the roots to the rest of the plant