3 Control and coordination

You are a multicellular organism made up of a number of body systems that work together to keep you alive. Your body systems are made up of organs, which are made up of tissues, which are made up of particular types of cells. Your cells communicate with each other using electrical impulses and chemicals such as neurotransmitters and hormones. The coordination of this communication is essential so that the requirements of your cells are met and a stable internal environment is maintained.

OVERARCHING IDEA

- Systems

SCIENCE UNDERSTANDING

Multicellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment.

Elaborations

Describing how the requirements for life (for example oxygen, nutrients, water and removal of waste) are provided through the coordinated function of body systems such as the respiratory, circulatory, digestive, nervous and excretory systems

Explaining how body systems work together to maintain a functioning body using models, flow diagrams or simulations

Identifying responses using nervous and endocrine systems

THINK ABOUT BODY SYSTEMS

- Why did doctors think for thousands of years that the human heart was made up of only two chambers?
- Whose observations of dissected human bodies and bones stolen from graves helped establish surgery as a separate medical profession?
- Is it the amount of oxygen or carbon dioxide in your blood that influences your breathing rate?
- In what form are old red blood cells excreted in faeces?
- Which nerve plays a key role in giving the sensation of smelling stinky garbage?
- Which part of your brain acts as a thermostat to regulate your body temperature?
- Which hormone is involved in lowering your blood glucose levels?
- How can reflex actions increase your chances of survival?

This scanning electron micrograph of the tongue surface shows the papillae that give the tongue its texture. The papillae also contain the tastebuds, part of the sensory system that sends information to the brain.

YOUR QUEST

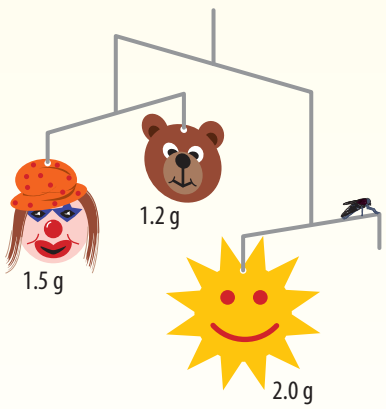
Speedy reactions?

How speedily can you react to a potentially threatening situation? Imagine you are in the situation below. How would you feel? How would you react? Would everything start to happen in slow motion and then quickly speed up? Can an accident be avoided?

When you first see the danger, you detect it using receptors in your eyes. This message is then sent to your nervous system, which will tell your body what to do. As there is potential danger in this situation, your endocrine system may also react by producing hormones such as adrenaline to trigger your body to 'get up and go'. Hopefully this all happens fast enough to avoid a collision!

FAST OR SLOW

1 A mobile has lost a piece and is hanging crooked. When a fly lands on the mobile, it becomes balanced again. Given the masses in the diagram, what is the mass of the fly?
Response: Solving the puzzle



2 Ouch! You step on a sharp object.
Response: You lift your foot quickly.

3 You have been in three classes before lunch. You had very little breakfast and you feel that you have no energy. Your friend Janine, who knows everything, tells you that you have low blood sugar and must eat your lunch so that your blood sugar level can get back to normal. The bell rings, and you rush to the canteen to get lunch.
Response: Getting your blood sugar back to normal

THINK

Carefully observe each situation above and then complete the following.

1 Order the responses from fastest to shortest response time.

2 Using your current understanding of how you respond to your environment, suggest reasons for the different types of responses and how your body processes the information to bring about the response.

3 Suggest a question or hypothesis for each scenario that you could investigate.

4 Propose another scenario and predict what your body's response would be. Suggest why and how it would respond in this way.

INVESTIGATE, THINK AND CREATE

5 (a) Find out how seeing danger quickly approaching can result in a change of behaviour (such as running faster, stopping or screaming). Outline the involvement of both nerves and hormones.
(b) Construct a cartoon or comic strip to summarise your findings.

6 Find some activities that can be used to determine your reaction time. Test your classmates and record times to see who is the fastest.

3.1 SCIENCE UNDERSTANDING

Respiratory and circulatory systems

Although you don't have to think about breathing, it is essential for your survival. It is a necessary function so that you can meet oxygen requirements for cellular respiration and for the removal of waste products such as carbon dioxide.

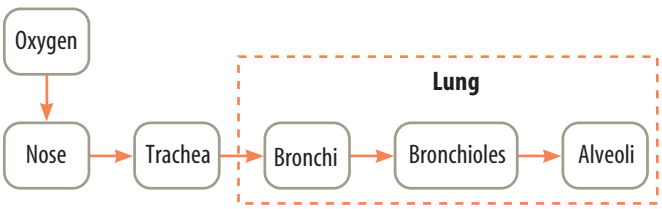
Cells need energy!

Your circulatory and respiratory systems work together to provide your cells with **oxygen** which is essential for **cellular respiration**. This process involves the breaking down of **glucose** so that energy is released in a form that your cells can then use. As can be seen in the cellular respiration equation below, **carbon dioxide** is produced as a waste product. The carbon dioxide then needs to be removed from your cells or it would cause damage or death to them.

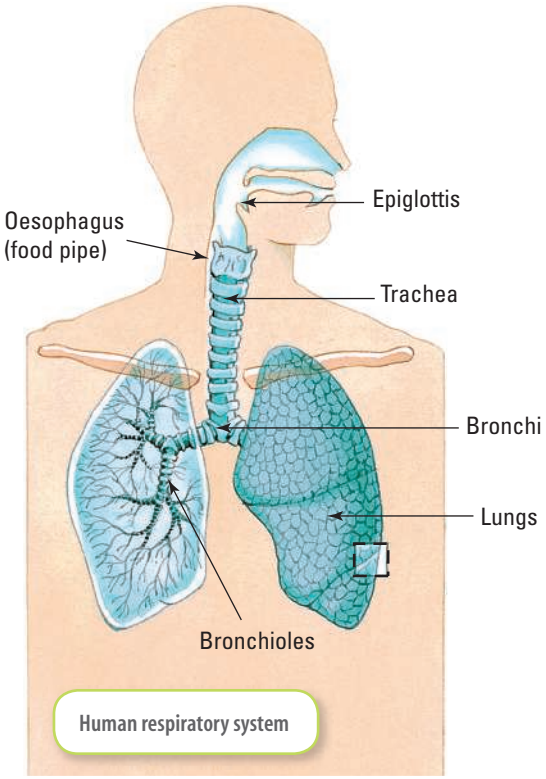
Glucose + oxygen ⟶ carbon dioxide + water + energy

GETTING OXYGEN INTO YOUR RESPIRATORY SYSTEM

Your **respiratory system** is responsible for getting oxygen into your body and carbon dioxide out. This occurs when you inhale (breathe in) and exhale (breathe out).

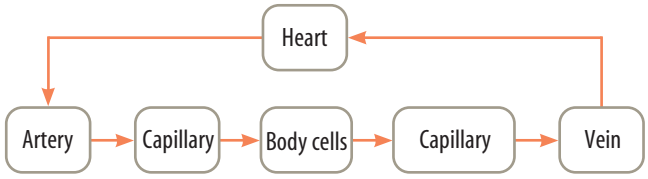


When you breathe in, you actually take in a mixture of gases (of which about 21 per cent is oxygen) from the air around you. The air moves down your **trachea** (or windpipe), then down into one of two narrower tubes called **bronchi** (bronchus), then into smaller branching tubes called **bronchioles** which end in tiny air sacs called **alveoli** (alveolus).



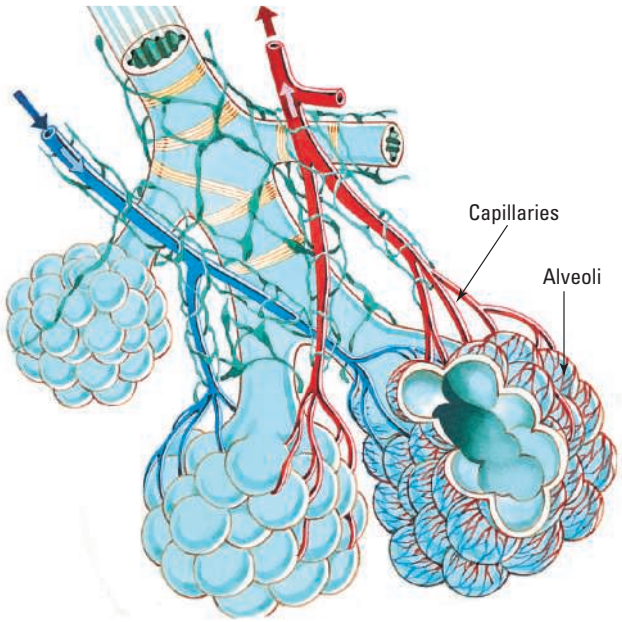
Transporting around

Your **circulatory system** is responsible for transporting oxygen and nutrients to your body's cells, and wastes such as carbon dioxide away from them. This involves blood cells that are transported in your blood vessels and heart. The three major types of blood vessels are **arteries**, which transport blood to the heart, **capillaries**, in which materials are exchanged with cells, and **veins**, which transport blood back to the heart (as shown below).

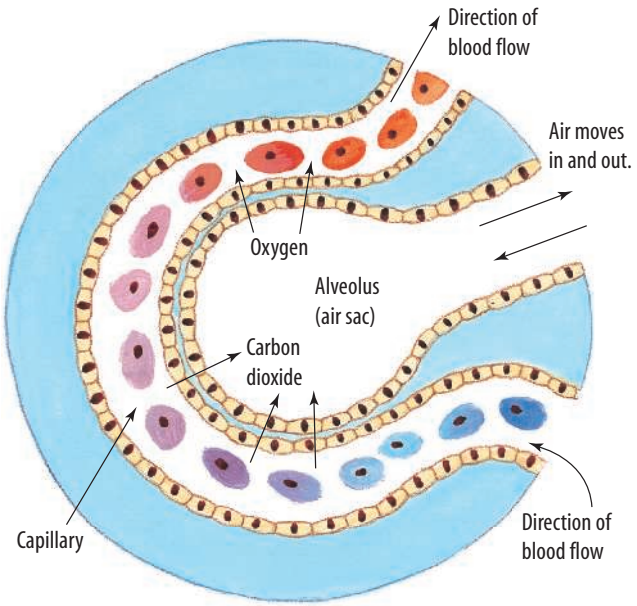


GETTING OXYGEN INTO YOUR CIRCULATORY SYSTEM

Your alveoli are surrounded by a network of capillaries. These capillaries contain **red blood cells** (or **erythrocytes**) that contain **haemoglobin**, an iron-based pigment that gives your blood its red colour. Oxygen moves from the alveoli into the red blood cells in the surrounding capillaries and binds to the haemoglobin to form oxyhaemoglobin. It is in this form that the oxygen is transported to your body cells.



Organs of the respiratory system, expanded to show details



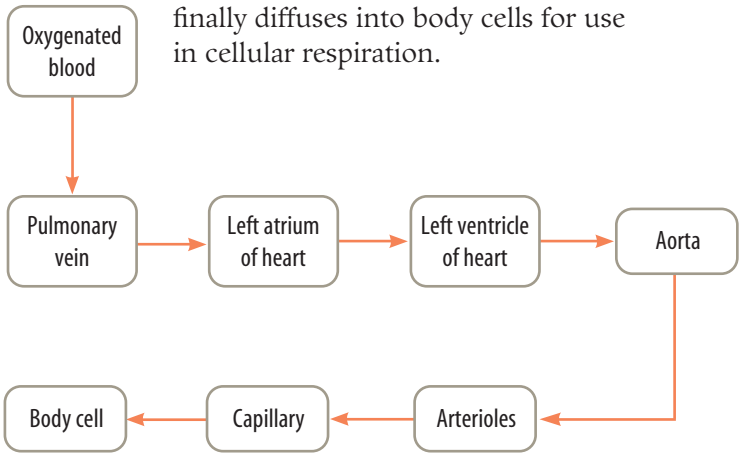
In an alveolus, oxygen diffuses into the blood and carbon dioxide diffuses out of the blood.

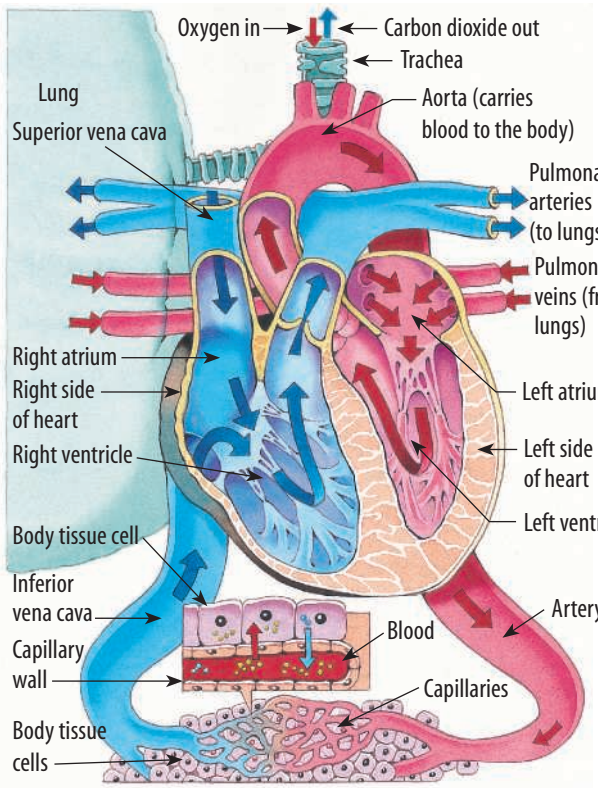
Oxygen → Alveoli → Capillary → Erythrocyte → Haemoglobin

GETTING OXYGEN TO YOUR CELLS

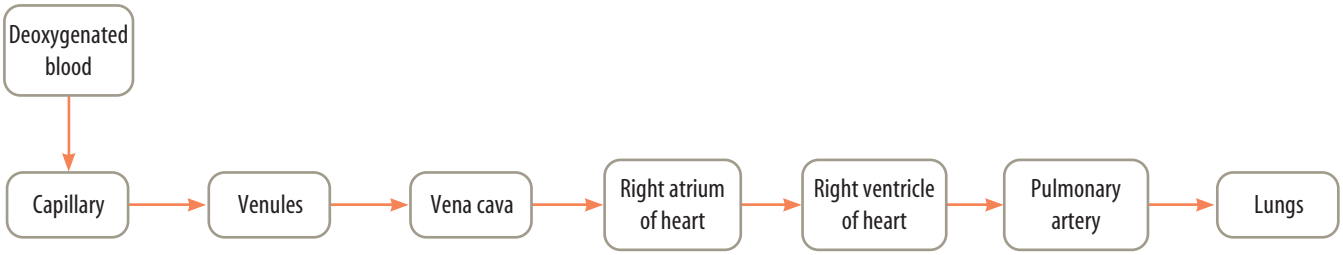
Oxygenated blood travels from your lungs via the **pulmonary vein** to the **left atrium** of your **heart**. From here, it travels to the **left ventricle** where it is pumped under high pressure to your body through a large artery called the **aorta**.

The arteries transport the oxygenated blood to smaller vessels called **arterioles** and finally to capillaries through which oxygen finally diffuses into body cells for use in cellular respiration.





The movement of blood through the heart

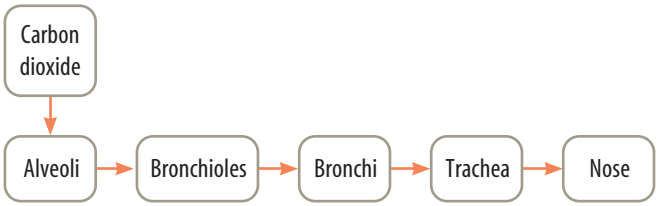


GETTING CARBON DIOXIDE AWAY FROM YOUR CELLS

When oxygen has diffused into the cell and the waste product of cellular respiration, carbon dioxide, has diffused out of the cell into the capillary, the blood in the capillary is referred to as **deoxygenated blood**. This waste-carrying blood is transported via capillaries to **venules** (small veins) to large veins called **vena cava**, then to the **right atrium** of your heart. From here it travels to the **right ventricle** where it is pumped to your lungs through the **pulmonary artery**, so called because it is associated with your lungs. The pulmonary artery is the only artery that does not contain oxygenated blood.

GETTING CARBON DIOXIDE INTO YOUR RESPIRATORY SYSTEM

Carbon dioxide from the deoxygenated blood in your capillaries diffuses into the alveoli in your lungs. It is then transported into your bronchioles, then your bronchi, and then into your trachea. From here, carbon dioxide is exhaled through your nose (or mouth) when you breathe out.

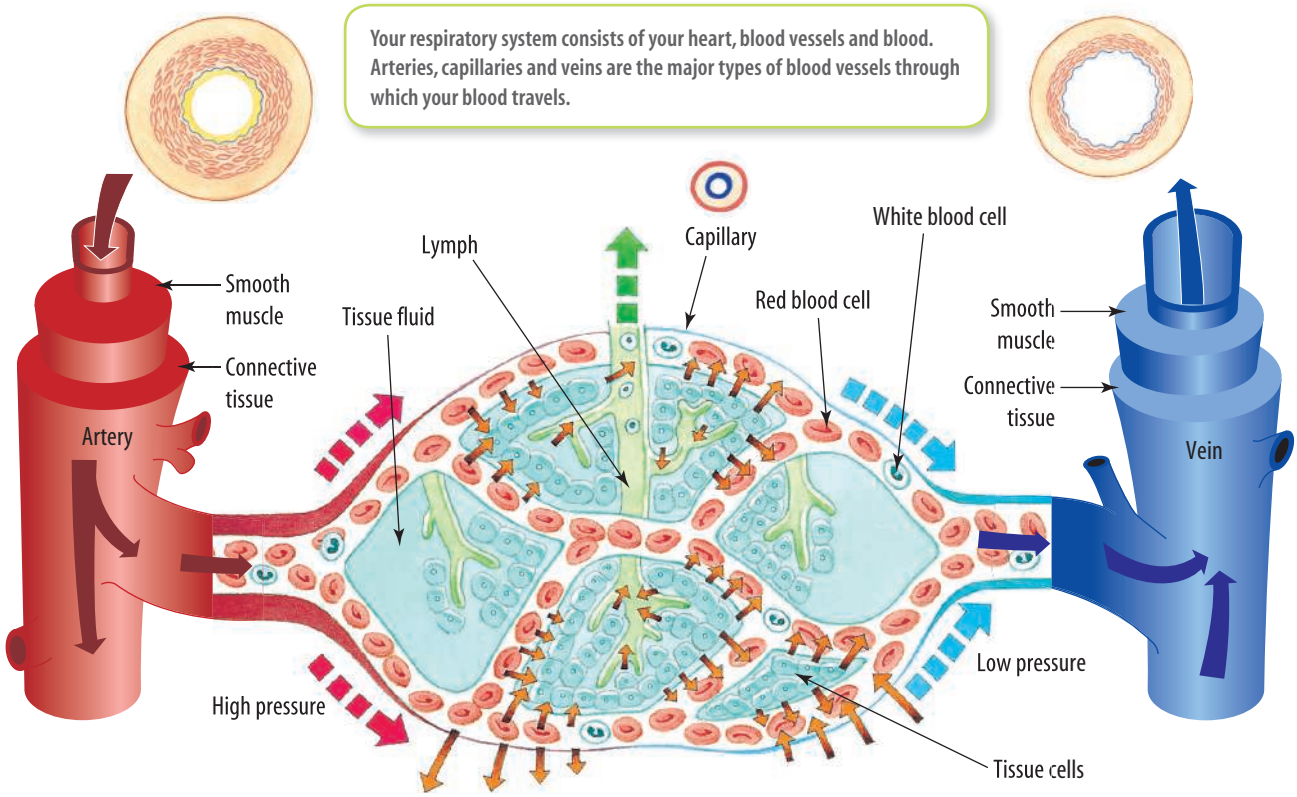


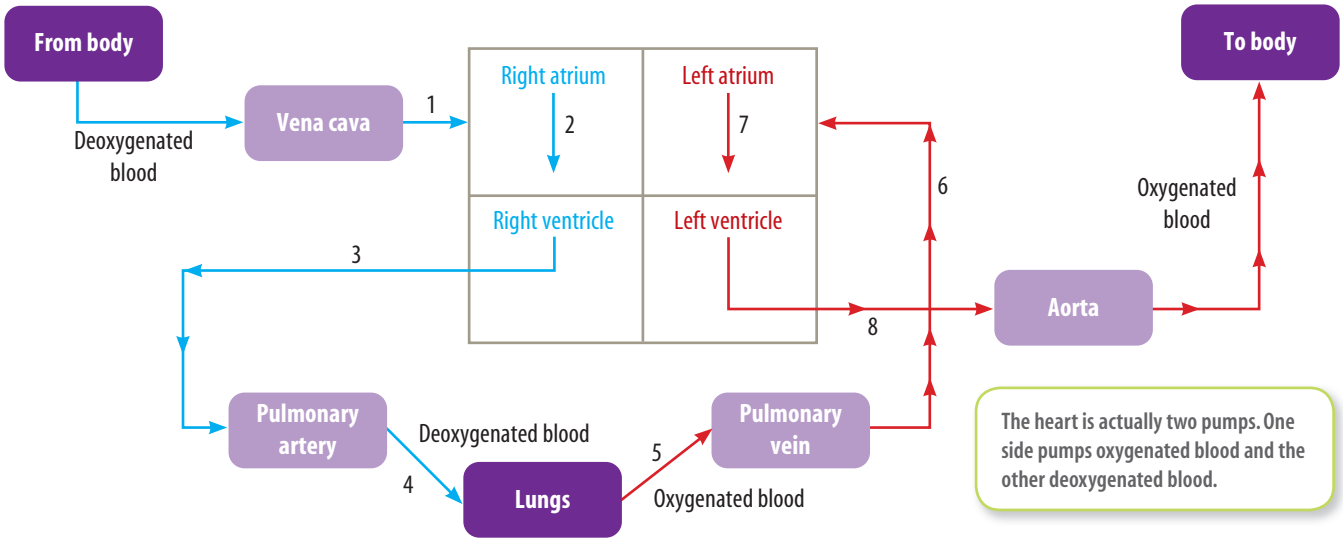
eBookplus **eLesson**

Robotic heart surgery
Watch an ABC *Catalyst* report to find out how the treatment of the heart condition atrial fibrillation is being revolutionised by the use of robotic systems.

eles-1081

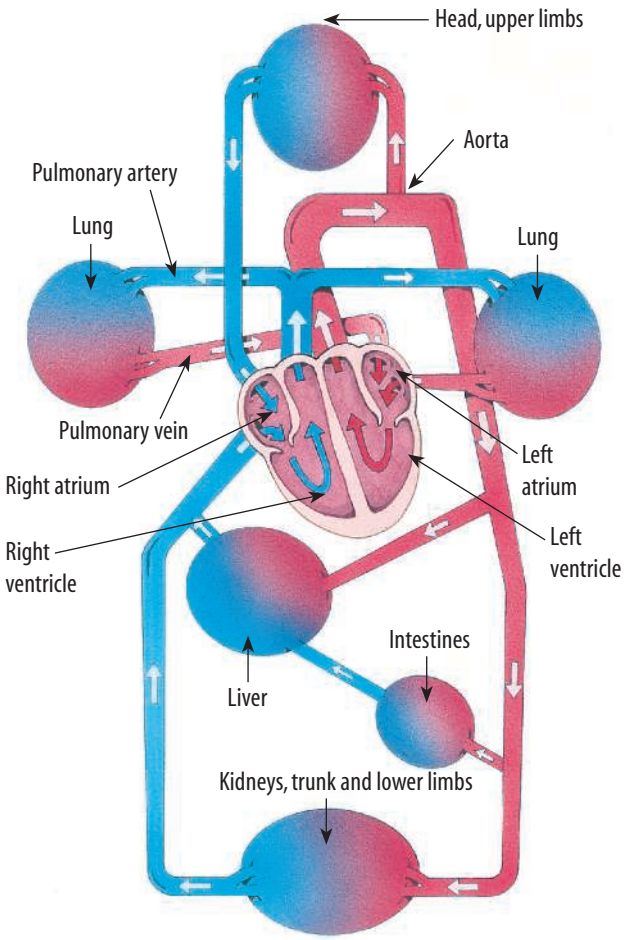
Your respiratory system consists of your heart, blood vessels and blood. Arteries, capillaries and veins are the major types of blood vessels through which your blood travels.





Putting it all together

Your body systems do not work in isolation. They work together to supply your cells with nutrients and to remove waste products that may otherwise be harmful. The transport of oxygen and carbon dioxide described here is merely an outline of the process. It is actually much more complex and is regulated by your nervous and endocrine system. Later in this chapter you will find out more about how these other systems are involved in keeping you alive.



Connected highways — the routes for blood circulations

Scientific theories can change over time

CLAUDIUS GALEN (*c.*129–*c.*199 AD)

For over a thousand years, the key training books used for doctors were based on the ideas of the Greek physician **Claudius Galen**. Galen's ideas were based on his observations of dissections of animals (other than humans). Galen described the human heart as being made up of two chambers and also being the source of the body's heat. He believed that blood was made by the liver and travelled to the right chamber and that the left chamber of the heart made 'vital spirits' which were then transported by arteries to body organs.

ANDREAS VESALIUS (1514–1564)

Another physician in Greece, **Andreas Vesalius**, began to transform medical knowledge — by questioning all previous theories. He believed that it was necessary to dissect bodies to find out how they worked. As the Church did not allow this, he took bones from graves and even stole a body from the gallows. His drawings showed, for the first time, the position and working of the muscles and organs in the body. Vesalius's observations proved that some

of Galen's theories were wrong and he discovered anatomical structures previously unknown. His findings helped establish surgery as a separate medical profession.

A drawing by Vesalius

WILLIAM HARVEY (1578–1657)

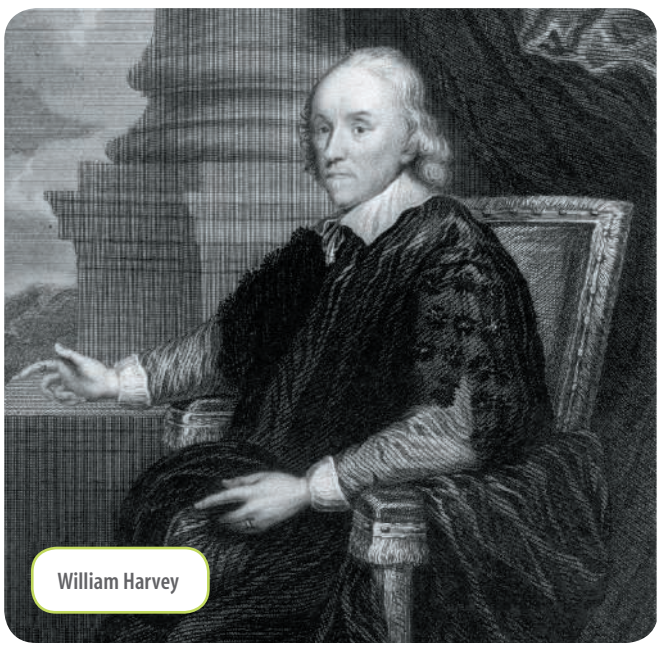
Although Vesalius had assisted in revising the structure of the human heart, there was still confusion about its function. About 100 years later, **William Harvey**, an English physician, published his work on blood circulation which led to another change in how we think about the heart and our circulatory system.

SCIENCE AS A HUMAN ENDEAVOUR (then, now — future?)

Our scientific understanding is continually being refined as advances in science and emerging sciences

Andreas Vesalius

and technologies are made. The development of technologies (for example, imaging technologies) has improved our understanding of the functions and interactions of body systems, such as our circulatory and respiratory systems. Not only do these advances generate new scientific theories and understanding, but they also significantly affect people's lives and generate exciting new scientific career opportunities.



William Harvey

UNDERSTANDING AND INQUIRING

REMEMBER

1 State the word equation for cellular respiration.

2 Identify the molecule that the respiratory system and circulatory system work together to:
   (a) supply to your cells
   (b) remove from your cells.

3 Construct a flowchart to show the transport of:
   (a) oxygen from your nose to your alveoli
   (b) oxygen from your lungs to haemoglobin in your red blood cells
   (c) oxygenated blood from your lungs to your body cells
   (d) deoxygenated blood from your body cells to your lungs
   (e) carbon dioxide from your lungs to your nose.

4 Construct a diagram to show the interactions between your heart, body cells and blood vessels.

THINK AND DISCUSS

5 Use Venn diagrams to compare:
   (a) the right atrium and left atrium of the heart
   (b) the right ventricle and left ventricle of the heart
   (c) the left atrium and left ventricle of the heart
   (d) oxygenated blood and deoxygenated blood
   (e) arteries and veins
   (f) oxygen and carbon dioxide
   (g) the pulmonary artery and pulmonary vein
   (h) the aorta and vena cava.

INVESTIGATE, THINK AND CREATE

6 (a) Search the internet for animations or simulations showing how the circulatory or respiratory systems function.
   (b) Select your favourite animation or simulation.
   (c) Construct a PMI chart that outlines what you liked about the animation, what you didn't like and how it could be improved.
   (d) Create your own multimedia version on the circulatory system and/or respiratory system.
   (e) Share your creation with the class.

Topic/theme/idea

Plus	Minus	Interesting
•	•	•
•	•	•
•	•	•
•	•	•
•	•	•
•	•	•

7 Find out more about the structure and function of either the circulatory or respiratory system and create a model that helps you to explain why the system is so important to survival.

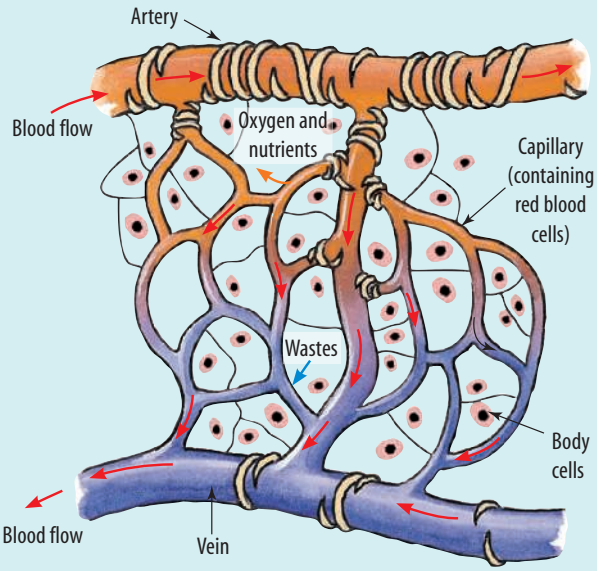
8 Find out more about Galen, Vesalius and Harvey and their work and discoveries. Suggest how they were influenced by the times in which they lived. Why didn't they just accept the ideas of their times? Why did they ask questions? Propose a question or hypothesis that you may have asked if you lived in each of their times.

9 Find examples of how developments in imaging technologies have improved our understanding of the functions and interactions of our body systems. Share your findings with others.

10 Investigate how technologies using electromagnetic radiation are used in medicine; for example, in the detection and treatment of cancer of the circulatory or respiratory system.

11 (a) Find examples of scientific research on either the circulatory or respiratory system.
   (b) Create a poster, PowerPoint presentation or podcast on the research that interests you most and present your findings to the class.

12 (a) Use the internet to identify problems relating to either the circulatory or respiratory system.
   (b) Select one of these problems and construct a model or animation to demonstrate its effect on normal body function.



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

work sheet 3.1 Cells, tissues, organs and systems

Essential intake

Feeling hungry? Tummy rumbling? You need to eat to provide your body with nutrients.

Essential nutrients

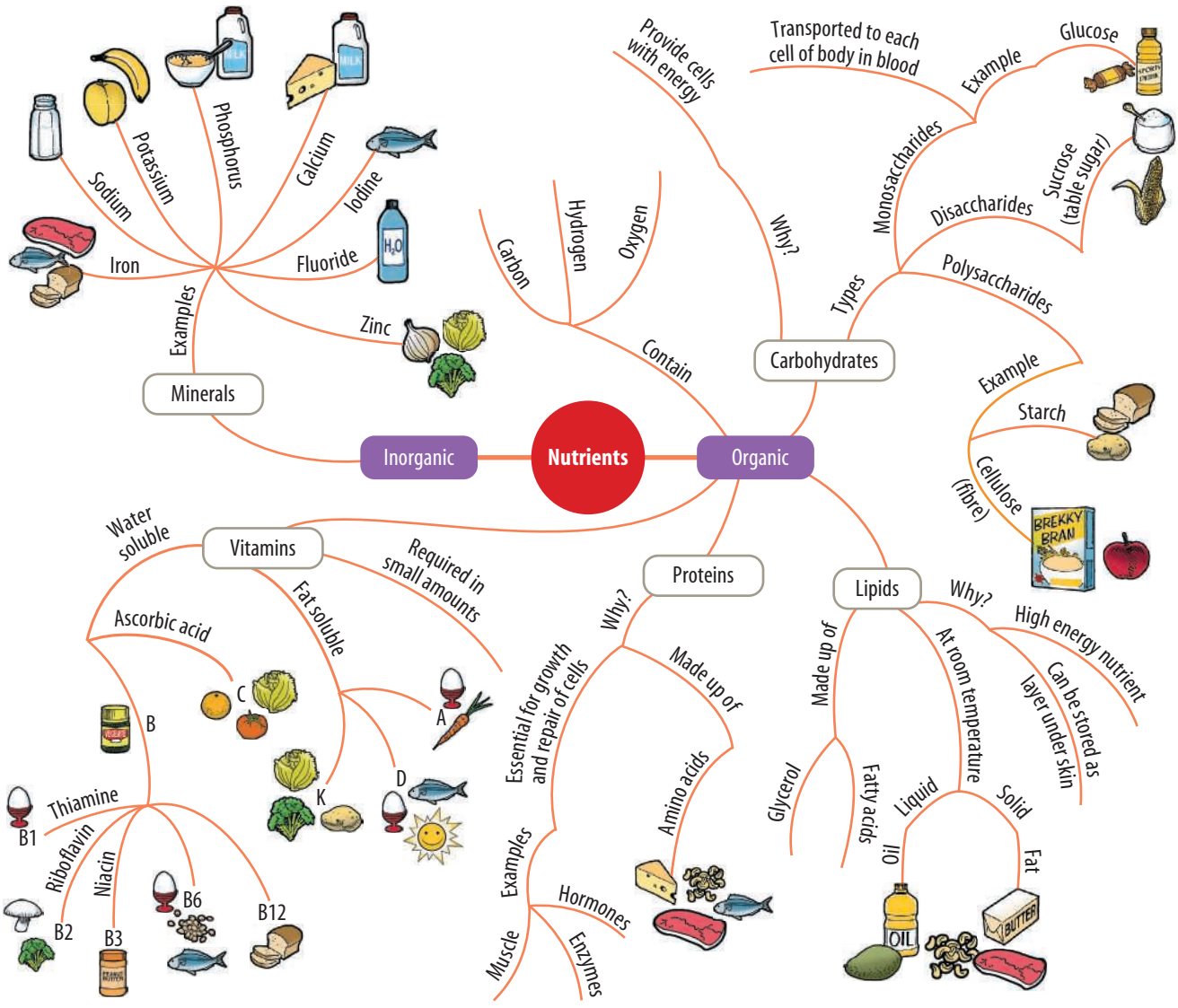
Nutrients are substances needed for energy, cell functioning and for your body's growth and repair. The five main groups of nutrients that your body needs to stay alive are:

- carbohydrates
- proteins
- lipids
- vitamins
- minerals.

All of these except minerals are called organic nutrients because they contain carbon, hydrogen and oxygen.

Carbohydrates and **lipids** are nutrients that provide you with an immediate source of energy and a back-up supply. While **proteins** can supply some energy, their key role is as bodybuilding compounds. They provide the raw materials required for cell growth and the repair of damaged and worn-out tissues. They are also involved in many other activities in your body; important chemicals such as enzymes and hormones are made of protein. Although vitamins have no energy value, they are needed in small amounts to keep you healthy and to speed up a variety of chemical reactions in your body.

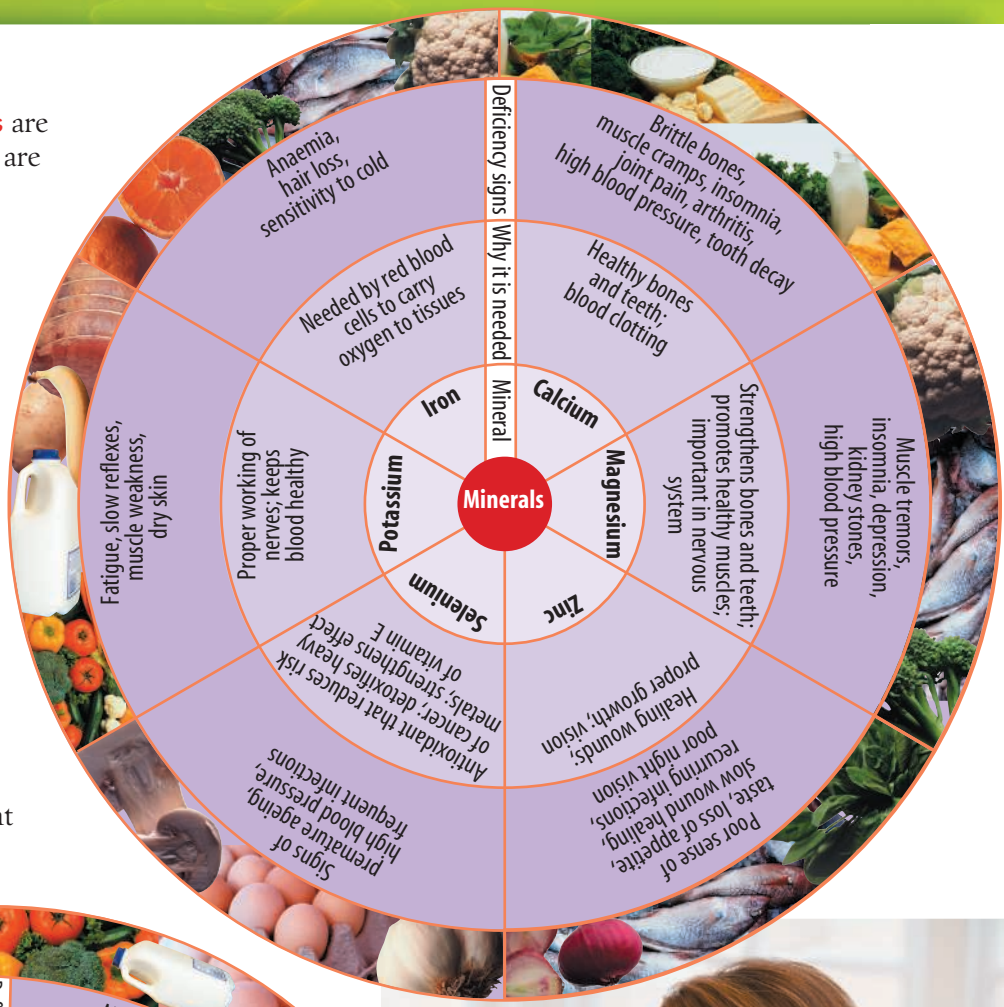
Mind-mapping your essential nutrients



SMALL BUT IMPORTANT

Even though **vitamins** and **minerals** are required in only small amounts, they are very important to your health. They are both needed to control chemical changes in your body. Your **endocrine system** and **nervous system** also require a number of these to be able to effectively function and maintain a healthy environment for your cells.

A lack of any of the 13 vitamins can cause disease. Diseases caused by a lack of vitamins are called **vitamin-deficiency diseases**. Diseases such as scurvy, rickets and beriberi have become less common as people have become more aware of the importance of vitamins. Deficiencies of minerals can also cause a number of significant problems.



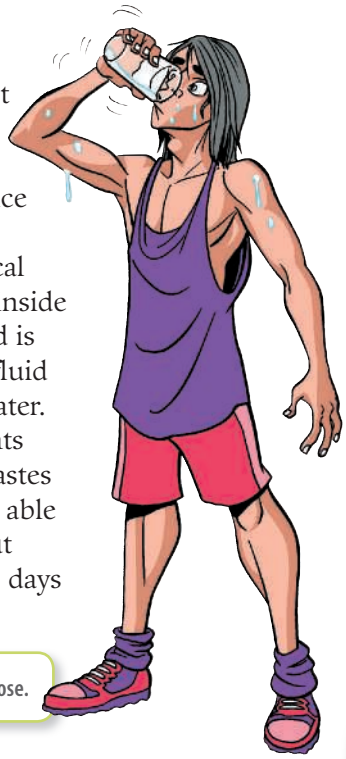
Nutrient requirements change during pregnancy.

Essential non-nutrients

Foods contain other important substances that are not nutrients. They are not used for energy or for growth and repair, but they are still essential to your health. Two of these substances are water and fibre.

ESSENTIAL WATER

Did you realise that about two-thirds of your body is water? Water is another essential substance that you need to stay alive. Many of the chemical reactions that take place inside you use water. Your blood is 90 per cent water — the fluid part (plasma) is mostly water. Blood helps carry nutrients around your body and wastes away from it. You may be able to survive 40 days without food, but no more than 3 days without water.

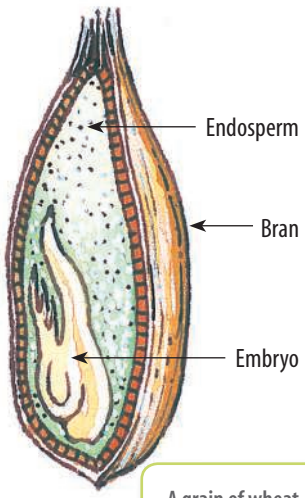


You need to replace the water you lose.

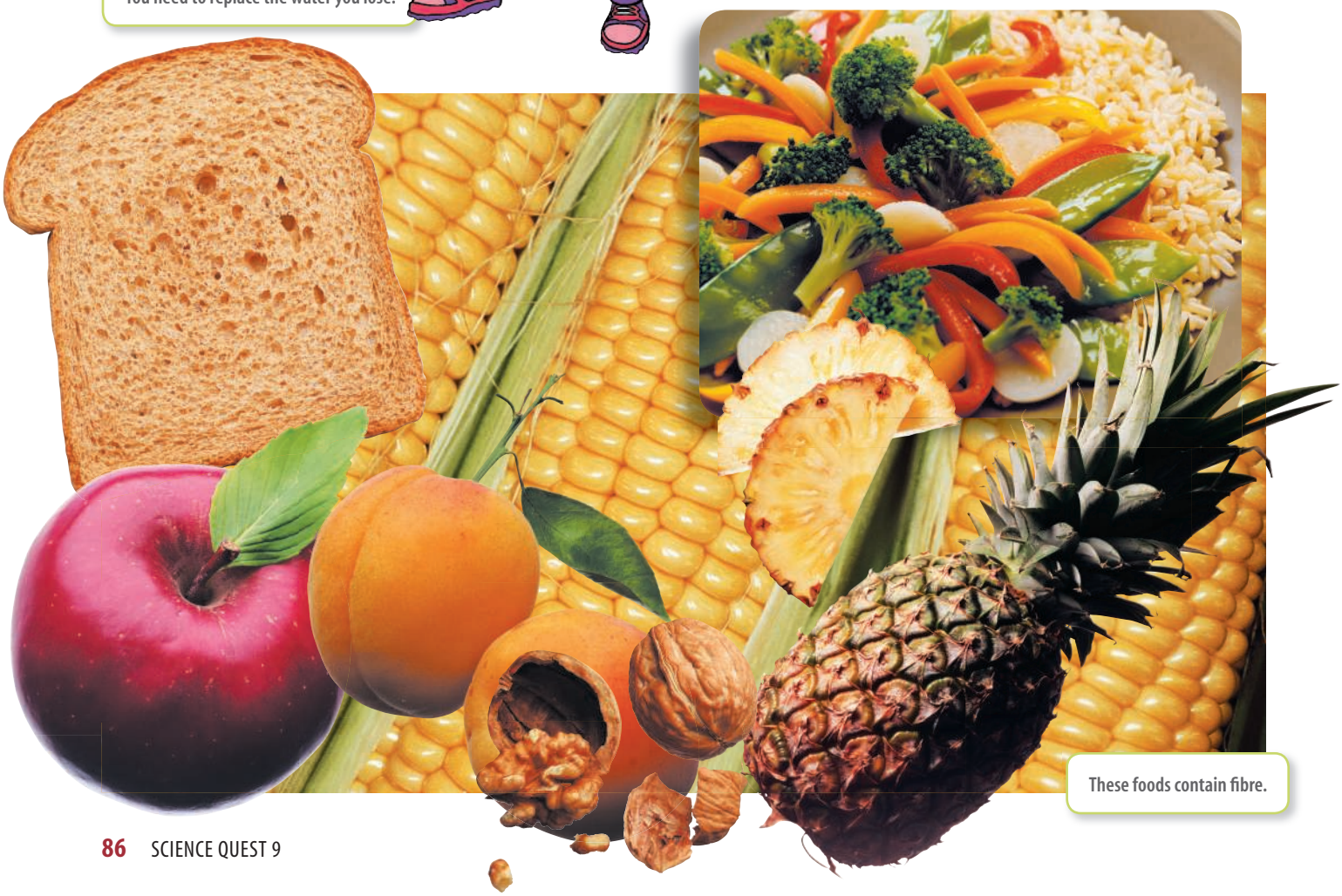
How much water have you drunk today? Each day you lose water when breathing out (0.5 litres), sweating (0.5 litres) and urinating (1.5 litres). Have you replaced water that you have lost today? If you lose too much water, you may become **dehydrated**. A dry throat and mouth and dark-coloured urine are signs of mild dehydration. If you lose more than 20 per cent of your body's water volume, you could die!

IN ONE END AND OUT THE OTHER

Fibre is found in the walls of plant cells. It is only partially broken down by your digestive system. Although it really does go 'in one end and out the other', it serves a very useful purpose and is an essential part of your diet. It provides bulk to your food, allowing it to move properly through your intestines.



A grain of wheat



These foods contain fibre.

INQUIRY: INVESTIGATION 3.1

Essential testing

KEY INQUIRY SKILLS:

- questioning and predicting
- processing information

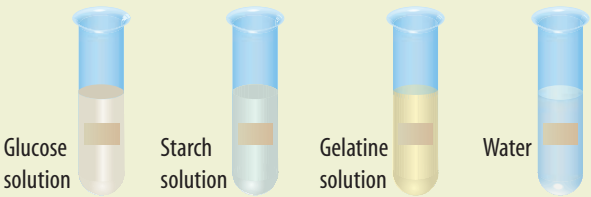
Equipment:

test-tube rack
4 test tubes
safety glasses
glucose solution
starch solution
gelatine solution
distilled water
iodine solution
test-tube holder
Benedict's solution
tongs
candle or Bunsen burner
matches
heatproof mat
0.01 M copper sulfate solution
1.00 M sodium hydroxide solution
food samples

- From your kitchen cupboards, select five foods to test. If they are solid, you may need to use a mortar and pestle to grind them into a 'mash' with a small amount of water before testing.
- Predict which of your food samples will contain starch, glucose and/or protein.

Essential standards

- For each of the tests in this experiment, set up the four test tubes as shown below. After each test, clean the test tubes by rinsing with water. Make sure a fresh sample of each liquid is used for each test.

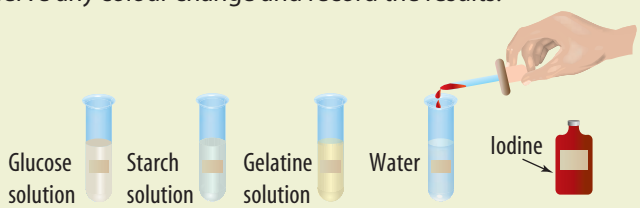


- Copy and complete the table below for recording the test results.

Test results	Water	Glucose solution	Starch solution	Gelatine solution
Starch test				
Glucose test				
Protein test				

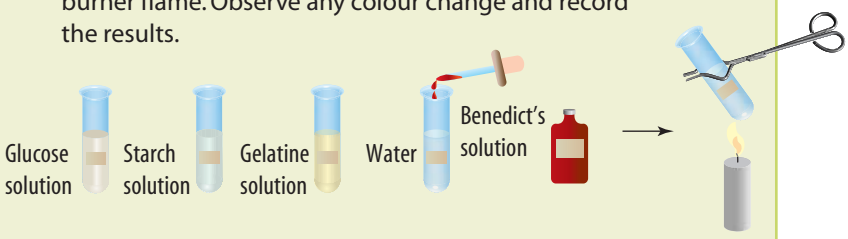
Starch test

- Add two drops of iodine solution to each of the four test tubes. Observe any colour change and record the results.



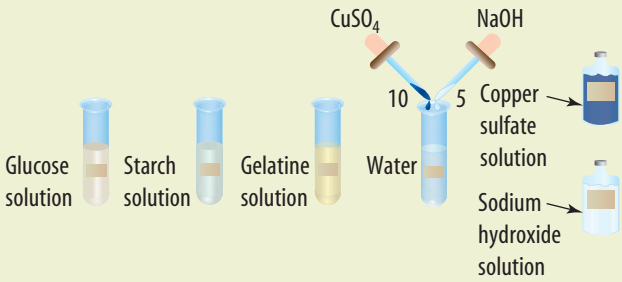
Glucose test

- Add four drops of Benedict's solution to each of the four test tubes. Gently heat each test test over the candle or Bunsen burner flame. Observe any colour change and record the results.



Protein test

- Add ten drops of copper sulfate solution to each of the four test tubes. Then add five drops of sodium hydroxide solution to each test tube. Observe any colour change and record the results.



Essential food tests

- Using the three tests above, investigate the food samples for the presence of starch, glucose and protein. (*Note:* Add *only* your food samples to these tests, *not* the glucose, starch or gelatine solutions.)

DISCUSS AND EXPLAIN

1. Construct a table to record your observations.
2. Suggest why you set up standard tests and added the same volumes of solutions to each test tube.
3. Which foods contain two or more of the nutrients tested for?
4. Were your predictions supported by your results? Comment on your overall findings.
5. If you were to do the food testing again, suggest how you might improve the procedure.

Without fibre, undigested food travels too slowly through the large intestine, losing too much water. The result is difficulty in releasing the solid food waste from the body, a condition called **constipation**. Lack of fibre in the diet can also lead to haemorrhoids (varicose veins around the anal passage, also known as piles), bowel cancer and several other diseases.

Fibre can be found only in foods that come from plants — foods such as fruits and vegetables, wholegrain breads and cereals, nuts and seeds.

Wholegrain products are higher in dietary fibre because they contain the outer covering, or bran, of the grain. When grains are highly processed, as they are in the production of white bread, white flour and many breakfast cereals, the bran is removed.

INQUIRY: INVESTIGATION 3.2

What's in your kitchen cupboard?

KEY INQUIRY SKILLS:

- questioning and predicting
- processing information

1 Find ten food items in your kitchen that have the nutrients listed on the packaging.

2 Draw up a table like the one below to summarise your findings.

3 Which of the foods was highest in:
(a) energy (b) protein (c) fibre (d) sodium?

4 Rank the foods in order from highest to lowest for:
(a) fat (b) fibre (c) energy.
Are your results what you expected? Why?

5 The recommended daily fibre intake is 30–40 g. On the basis of your findings, put together a meal of your packaged foods that would meet this requirement.

6 Draw a bar graph of your results for your foods and their fat content.

7 (a) Compare your results with those of two other students.
(b) How were they similar and how were they different?
(c) Select foods from your group to put together a meal. Using the nutrient tables, calculate the amount of each nutrient in your designed meal.

8 (a) Suggest three questions that you could research on the topics of nutrients or packaging labels.

(b) Collate the questions from the whole class and select one of these questions to research.
(c) Report your findings back to the class.

Name of food	Nutrients per 100 grams						
	Energy (kJ)	Protein (g)	Fat (g)	Total carbohydrate (g)	Sugar (g)	Dietary fibre (g)	Sodium (mg)
'Light'n'tasty' cereal	1540	8.7	3.1	71.3	23.6	7.7	225
Potato chips	2130	8.5	31.9	46.1	1.8	3.0	518
Apricot jam	1140	6.4	0.1	66.6	59.4	–	17
Barbecue-flavoured 'Shapes' biscuits	2184	10.2	25.2	63.3	1.4	–	752
Multigrain corn thins	380	9.5	3.0	77.6	0.7	8.5	201

HOW ABOUT THAT!

Nutrient careers

Nutritionists and dietitians are examples of two careers with a focus on nutrition. These careers may involve communication of nutrition messages to individuals or to various groups within the community. These careers may be in private, public or community health, in the food industry or in various types of research.

Clinical nutritionists may have face-to-face consultations and discussions with their clients about dietary changes that may be required. While clinical nutritionists approach issues from a 'nutrient' perspective, dietitians may be working in a hospital or private practice to advise their clients about food and lifestyle changes.

Dietitians provide advice to people diagnosed with diet-related diseases such as diabetes, coeliac disease, heart disease and certain types of cancers.

Dietitians may also be involved in determining the appropriate food solution for patients who require a drip or nasogastric tube (a tube that goes through the nose and down into the stomach).

UNDERSTANDING AND INQUIRING

REMEMBER

1 Give two reasons why you need to eat.

2 (a) List the five main groups of nutrients.
(b) Which of these are organic nutrients?

3 Identify shared features for the following pairs.
(a) Carbohydrates and lipids
(b) Cellulose and starch
(c) Fats and oils
(d) Iron and potassium
(e) Hormones and enzymes

4 How do cells get the energy that they need?

5 (a) What are proteins made of?
(b) Why are they important?

6 List some ways you can lose water.

7 Explain why it is important to drink water.

8 Describe the symptoms of dehydration.

9 What is fibre?

10 Why is it important to eat fibre even though the chemicals in it are not used by your body?

11 List the types of food you would recommend to a person lacking:
(a) vitamin C
(b) calcium
(c) iron.

12 Explain why the following vitamins are important to your health.
(a) A
(b) C
(c) K

13 Describe the deficiency signs of:
(a) calcium, zinc and magnesium
(b) vitamins A, B2 and D.

THINK AND INVESTIGATE

14 Suggest why pregnant women, children and adolescents need more protein than other adults.

15 Milk and other dairy products are well known as good sources of calcium. Which nutrients would be missing from the diet of someone whose food intake consisted mainly of dairy products?

16 Too much salt (sodium chloride) in your diet is not healthy. Why do we need salt at all?

17 Find out more about pregnancy and folate deficiencies.

18 Select a vitamin or mineral, find out details about it that interest you and then create a brochure to advertise it to others.

19 Suggest ways to encourage people to drink more water.

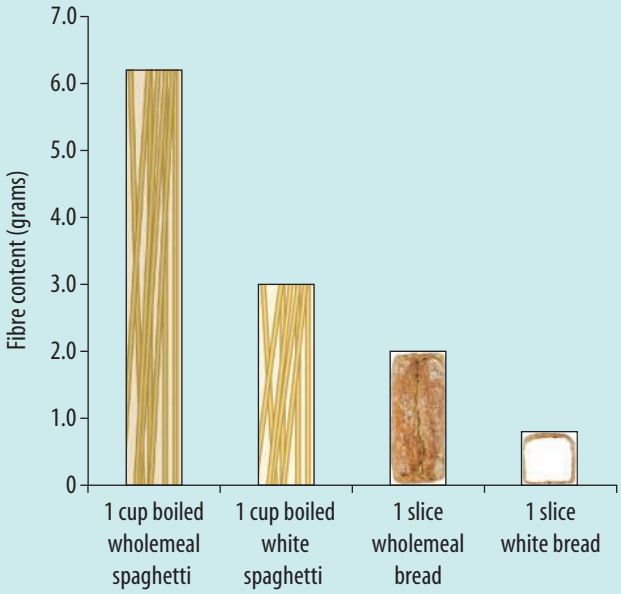
20 (a) An increased number of Australian women are being diagnosed as deficient in vitamin D. Suggest possible reasons for this situation.
(b) List the symptoms associated with vitamin D deficiency.
(c) Other than vitamin supplements, suggest ways in which this deficiency can be treated.
(d) Design an investigation to test the effectiveness of your suggested treatments.

21 The addition of fluoride to our water supplies has caused much controversy. Find out and report on the key arguments for and against fluoridation.

22 Suggest how science can help individuals and communities make choices about their diet in terms of vitamins and minerals that they require.

23 Predict the relationship between darker skin and the amount of sunlight required for vitamin D production. Research and record information about the link, citing your references. Pose three questions that could be used to guide further research.

24 What do the results in the graph below suggest?



25 Wholegrain products are high in fibre. Why do you think the word 'wholegrain' is used?

26 Some high-fibre breakfast cereals have more sugar added to them than some of the more highly processed breakfast cereals. Why do you think this is so?

INVESTIGATE, REPORT OR CREATE

27 Create your own vitamin and mineral learning tool to teach younger children the benefits of these nutrients to their health. This may be in the form of a song, play or poem, colourful flash cards with text and pictures, poster, brochure or booklet.

28 Construct your own vitamin or mineral wheel that is made up of two layers with a cut-out section in one area that allows the second layer to appear at the right time. One of the following formats should be used.
- One layer with questions and the other with answers to the questions
- One layer with types of foods and the other with vitamins or minerals found in those foods
- One layer with types of vitamins or minerals and the other with diseases that can be caused by a deficiency in that vitamin or mineral and the types of foods in which it can be found

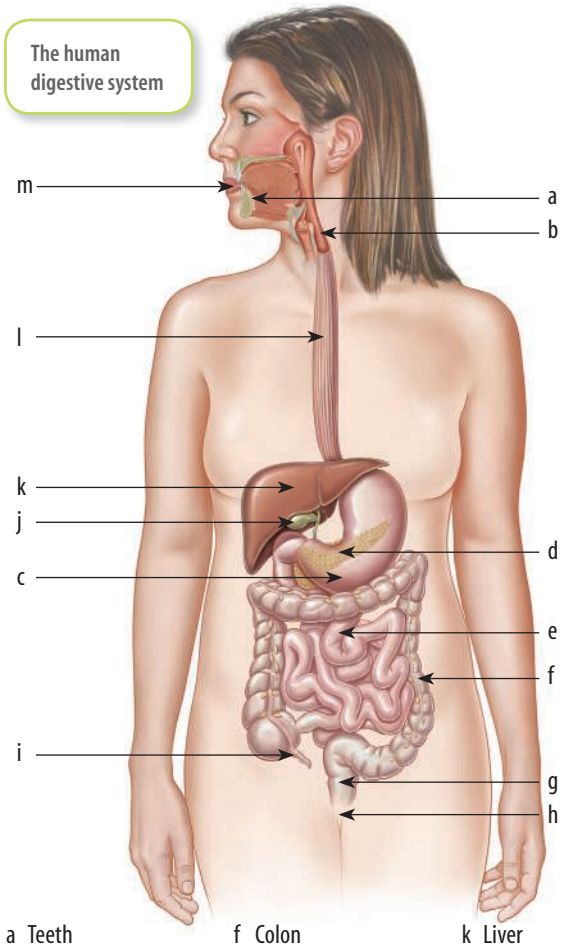
29 Prepare an advertisement to promote increasing fibre in people's diets. Your aim is to make high-fibre foods attractive to consumers. Your advertisement could be in the form of a poster, a dramatic performance, or a TV or radio commercial.

30 (a) In your team, brainstorm questions about proteins, lipids, vitamins and minerals.
(b) Select one of these questions and suggest five further questions that you could use to find out more about it.
(c) Use your questions to structure your research.
(d) Organise your findings into a format that you will be able to share with others.
(e) Report your findings back to your team or class.

work sheet 3.2 The digestive system

Digestion and excretory systems

The key role of your **digestive system** is to supply your body with the nutrients it requires to function effectively. It is then up to your **excretory system** to remove wastes, such as those not digested or the waste products of a variety of necessary chemical reactions.

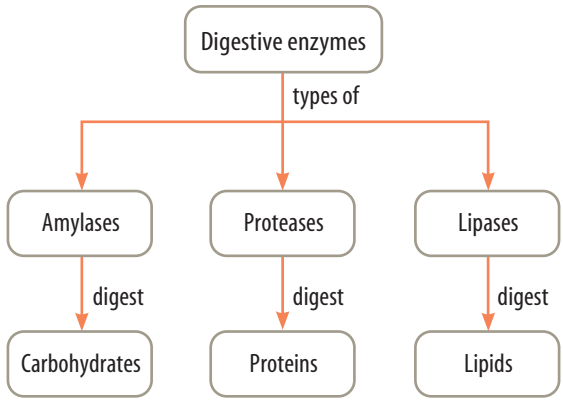


a Teeth
b Epiglottis
c Stomach
d Pancreas
e Small intestine
f Colon
g Rectum
h Anus
i Appendix
j Gall bladder
k Liver
l Oesophagus
m Mouth

Digestive system — down we go

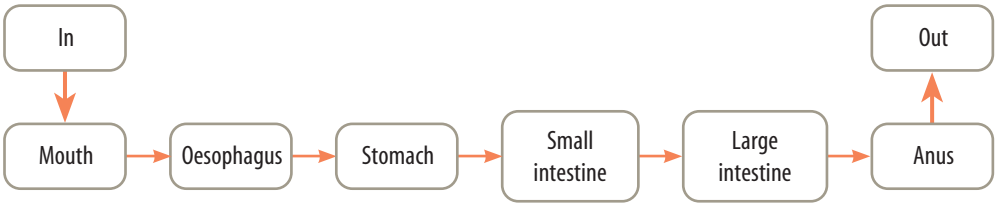
MOUTH

You ingest food, digest it, then egest it. The whole process of **digestion** starts with you taking food into your mouth. **Enzymes** (such as amylases) in your **saliva** are secreted by your **salivary glands** begin the process of **chemical digestion** of some of the carbohydrates. Your teeth physically break down the food in a process called **mechanical digestion**, then your tongue rolls the food into a slimy, slippery ball-shape called a **bolus**.



OESOPHAGUS TO STOMACH

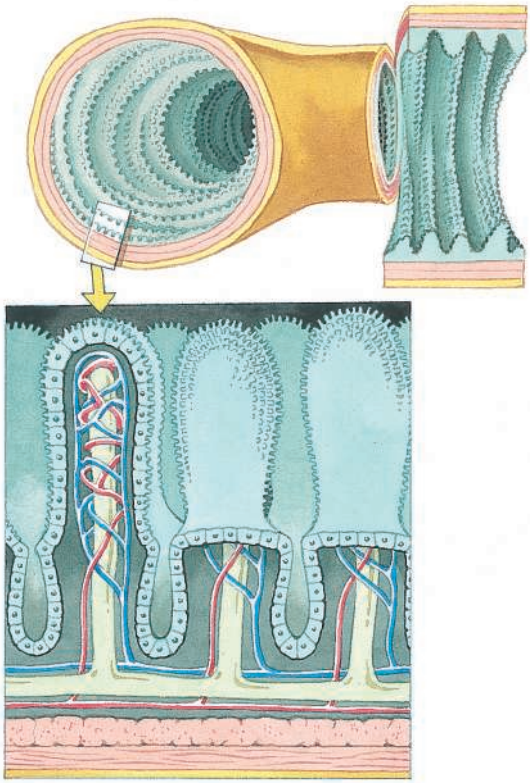
The bolus is then pushed through your **oesophagus** by muscular contractions known as **peristalsis**.



From here it is transported to your stomach for temporary storage and further digestion.

STOMACH TO SMALL INTESTINE

Once the food gets from your stomach to your **small intestine**, more enzymes (including amylases, proteases and lipases) turn it into molecules that can be absorbed into your body. The **absorption** of these nutrient molecules occurs through finger-shaped **villi** in the small intestine. Villi are shaped like fingers to maximise surface area to increase the efficiency of nutrients being absorbed into the surrounding capillaries. Once absorbed into the capillaries (of your circulatory system) these nutrients are transported to cells in the body need them.



The absorption of most nutrients into your body occurs in the ileum, the last section of the small intestine. The finger-like villi on its walls give it a large surface area that speeds up nutrient absorption. Many tiny blood vessels called capillaries transport the nutrients from the villi into your bloodstream. Undigested material continues on to the large intestine where water and vitamins may be removed, and then the remainder is pushed out through the anus as faeces.

Liver

Your liver is an extremely important organ with many key roles. One of these is the production of **bile** which is transported to your gall bladder via the bile ducts to be stored until it is needed. Bile is transported from the **gall bladder** to the small intestine where it is involved in the mechanical digestion of lipids such as fats and oils.

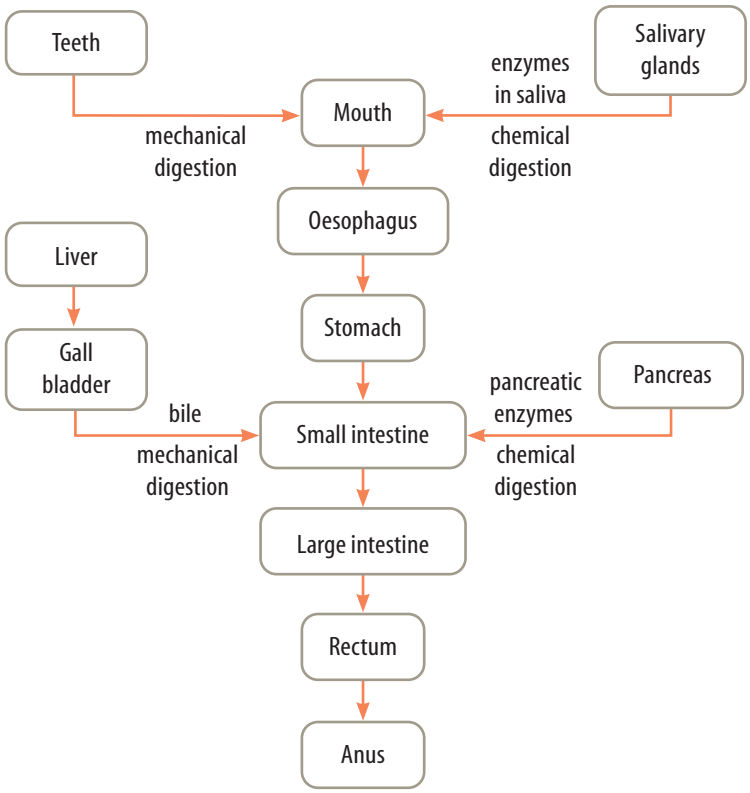
PANCREAS

Enzymes such as **lipases**, **amylases** and **proteases** (which break down lipids, carbohydrates and proteins respectively) are made by the **pancreas** and secreted into the small intestine to chemically digest these components of food materials.

LARGE INTESTINE

On its way through the digestive tract (alimentary canal), undigested food moves from the small intestine to the **colon** of the **large intestine**. It is here that water and any other required essential nutrients still remaining in the food mass may be absorbed into your body. **Vitamin D** manufactured by bacteria living within this part of the digestive system is also absorbed. Any undigested food, such as the **cellulose** cell walls of plants (which we refer to as fibre) also accumulate here and add bulk to the undigested food mass.

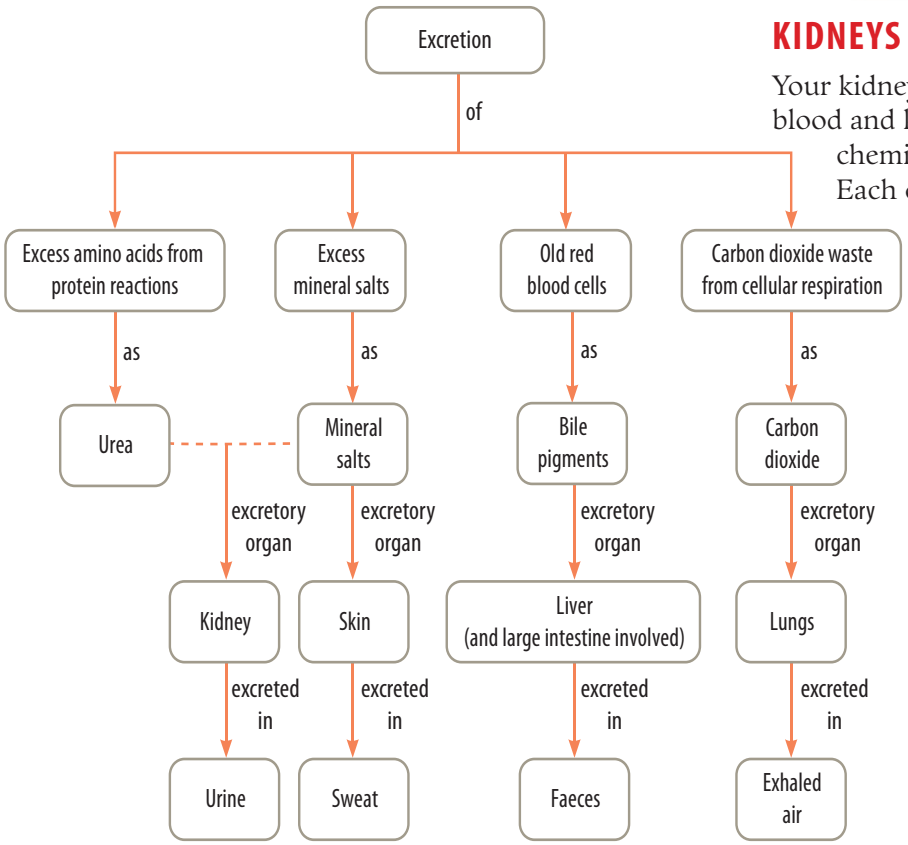
The **rectum** is the final part of the large intestine and it is where faeces is stored before being excreted through the **anus** as waste.



Digestion occurs within your digestive system in a systemic and organised manner.

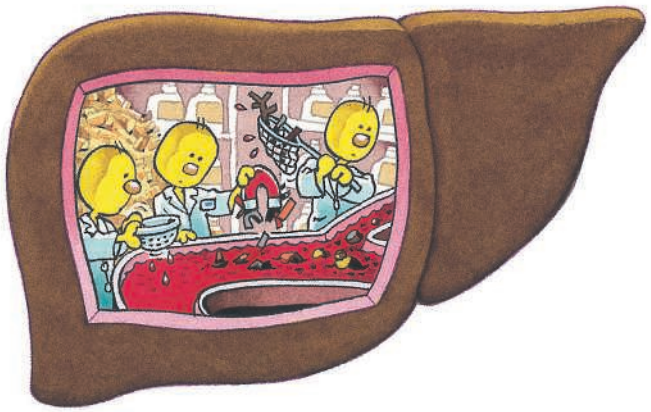
Excretory systems — out we go

Excretion is any process that gets rid of unwanted products or waste from the body. The main organs involved in human excretion are your **skin**, **lungs**, **liver** and **kidneys**. Your skin excretes salts and water as sweat and your lungs excrete carbon dioxide (produced by cellular respiration) when you breathe out. Your liver is involved in breaking down toxins for excretion and your kidneys are involved in excreting the unused waste products of chemical reactions (e.g. urea) and any other chemicals that may be in excess (including water) so that a balance within our blood is maintained.



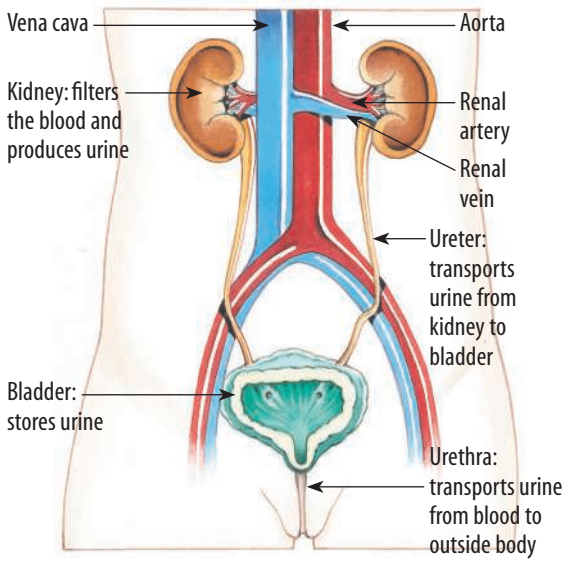
LIVER

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 help get rid of excess protein, which can form toxic compounds dangerous to the body. The liver converts these waste products of protein reactions 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 long harmful to the body. Your liver is an organ that you cannot live without.



KIDNEYS

Your kidneys play an important role in filtering your blood and keeping the concentration of various chemicals and water within appropriate levels. Each of your kidneys is made up of about one million **nephrons**. These tiny structures filter your blood, removing waste products and chemicals that may be in excess. Chemicals that are needed by your body are reabsorbed into capillaries surrounding them. The fluid remaining in your nephrons at the end of its journey then travels through to your **bladder** via your **ureters** for temporary storage until it is released as **urine**.



Your kidneys have an important role in the excretion of wastes from your body.

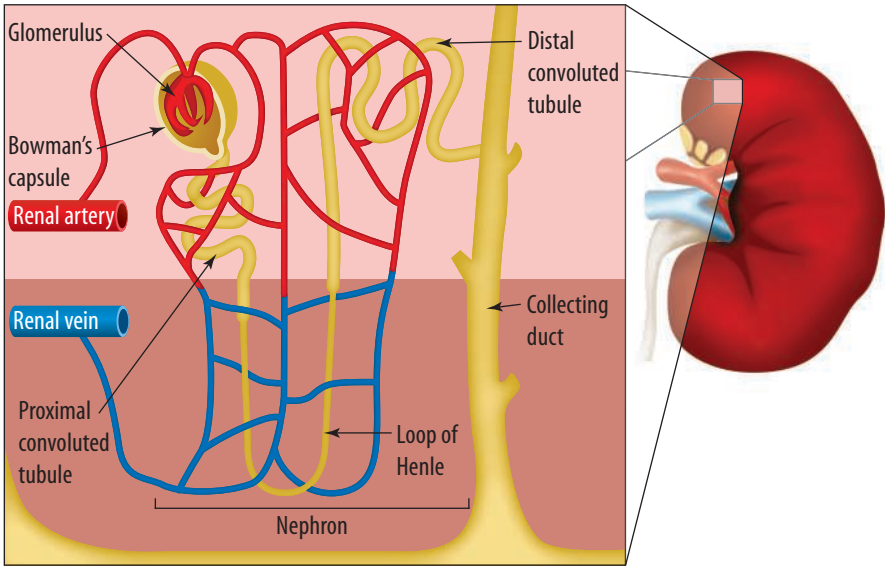
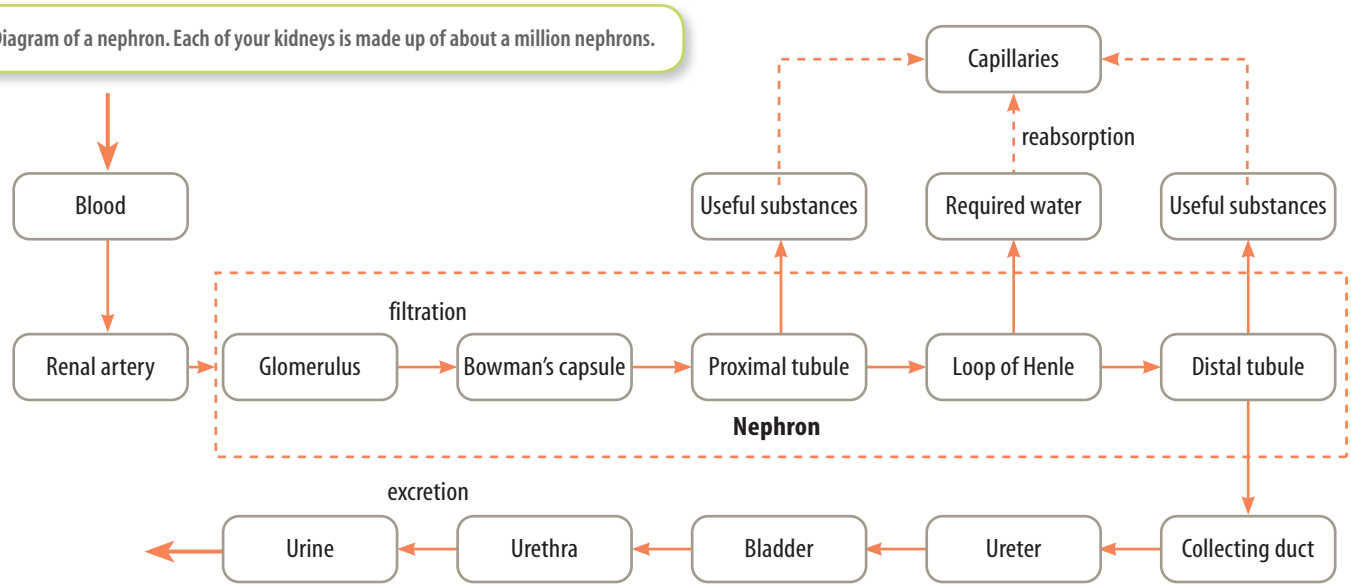


Diagram of a nephron. Each of your kidneys is made up of about a million nephrons.

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.



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 they may be transported out of the body.

HOW ABOUT THAT!

Fish maintain their salt and water balance in different ways. Saltwater fish, such as snapper, drink sea water constantly and produce a small volume of urine. Freshwater fish, such as Murray cod, however, rarely drink, but make lots of urine.

LUNGS

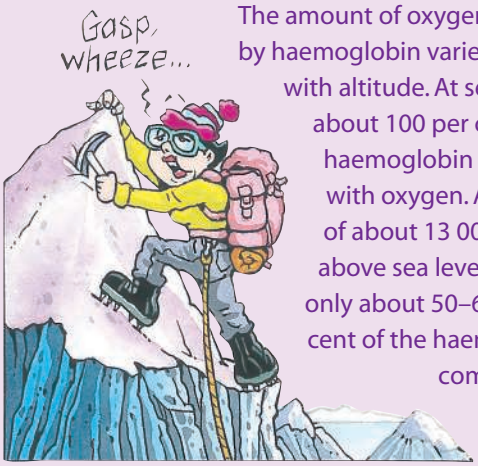
Did you know that your body is more sensitive to changes in levels of carbon dioxide than oxygen? If there is too much carbon dioxide in your body, it dissolves in the liquid part of blood and forms an acid. The resulting acidic blood can affect the functioning of your body.

Blood and carbon dioxide

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 levels of carbon dioxide in your blood increase, 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.

Cellular respiration

Glucose is an example of a nutrient that may be released from digested food. It is absorbed in your small intestine and then taken by the capillaries to cells for use in **cellular respiration**. In this process the glucose is combined with oxygen, and is then broken down into carbon dioxide (a waste product that needs to be removed from the cell) and water. During this reaction energy, in the form of **ATP** (adenosine triphosphate), is also released. ATP provides the cells with the energy needed to perform many of its activities, and is essential to life.

$$\text{Glucose} + \text{oxygen} \longrightarrow \text{carbon dioxide} + \text{water} + \text{energy (ATP)}$$

This is an example of systems working together. Glucose is supplied via the digestive system and oxygen is supplied via the **respiratory system**. The **circulatory system** transports nutrients (such as glucose) and oxygen to your cells and removes wastes (such as carbon dioxide) from your cells. These wastes are then removed from your body by your excretory systems. Without a supply of glucose and oxygen, cellular respiration could not occur. Without removal of wastes, your cells may die. If you systems did not work together like they do, you would not be able to stay alive.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Outline why the digestive system and the excretory system are important to the survival of your cells.

2 Identify examples of types of enzymes involved in the digestion of:
   (a) carbohydrates
   (b) proteins
   (c) lipids.

3 Explain why the villi in the small intestine are the shape that they are.

4 Describe how and where the nutrients are absorbed into your body from your digestive system.

5 Outline a way in which the liver is involved in digestion.

6 Identify the part of the digestive system in which water is absorbed into your body.

7 Construct a flowchart to show the route that undigested food material travels from your mouth to your anus.

8 Is cellulose digested? What happens to it?

9 Define the term *excretion*.

10 List examples of organs that are involved in human excretion.

11 Describe what happens when you drink a lot of water.

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

13 Suggest reasons why you can't live without your liver.

14 Identify the name given to the:
   (a) tiny structures that make up the kidney
   (b) fluid that travels from your kidneys to your bladder for excretion.

15 Construct flowcharts to show the route travelled from the:
   (a) renal artery, through the nephron to the collecting duct
   (b) collecting duct to the urethra.

16 Suggest why a supply of water is important to your cells.

17 Is your body more sensitive to changes in carbon dioxide or oxygen levels? Explain.

18 Explain why mountain climbers sometimes find it difficult to breathe during a climb.

19 Explain how your cells obtain glucose and why it is important to survival.

THINK AND DISCUSS

20 Use Venn diagrams to compare:
- (a) the digestive system and excretory system
- (b) the small intestine and large intestine
- (c) ingestion and egestion
- (d) proteases and lipases
- (e) cellulose and glucose
- (f) bile and enzymes
- (g) ureter and urethra
- (h) nephron and villi
- (i) the digestive system and respiratory system
- (j) the excretory system and circulatory system.

ANALYSE AND EVALUATE

21 Use the table and the other information on these pages 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?

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

INVESTIGATE, THINK AND CREATE

22 (a) Search the internet for animations or simulations that show how the excretory or digestive systems function.
- (b) Select your favourite animation or simulation.
- (c) Construct a PMI chart that outlines what you liked about the animation, what you didn't like and how it could be improved.
- (d) Create your own multimedia version on the circulatory system and/or respiratory system.
- (e) Share your creation with the class.

23 Find out more about the structure and function of either the digestive or excretory system and create a model that helps you to explain why the system is so important to our survival.

24 (a) Find examples of scientific research on either the digestive or excretory system.
- (b) Create a poster, PowerPoint presentation or podcast on the research that interests you most and present your findings to the class.

25 Imagine that you are a scientist working in a field related to the study of the circulatory or excretory system. Propose a relevant question or suggest a hypothesis for a scientific investigation and outline how you would design your investigation. Search the internet for relevant research or information.

26 Find examples of how developments in imaging technologies have improved our understanding of the functions and interactions of the digestive and excretory systems. Share your findings with your class.

27 Investigate how technologies using electromagnetic radiation are used in medicine; for example, in the detection and treatment of cancer of the digestive or excretory system.

28 There are often claims made in the media about particular products relating to the digestive and excretory systems. Examples include indigestion tablets, laxatives and weight loss tablets. Select one of these examples or one of your own to evaluate and/or test the claims being made in advertising or in the media.

29 Research and report on one of these conditions: urinary incontinence, kidney stones, dialysis, kidney transplants, cystitis.

30 Find out:
- (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.

3.3 Removing waste from the blood

Getting the message

Watch out! Your survival can depend on detecting changes in your environment.

Five senses

Imagine not being about to see, hear, feel or sense the world outside your body. No sound, no colour, no taste or smell — just darkness and silence. Without senses, you might not even be able to sense that!

Sense organs are used to detect **stimuli** (such as light, sound, touch, taste and smell) in your environment. Examples of human sense organs are your eyes, ears, skin, tongue and nose. These sense organs contain special cells called receptors. These receptors are named according to the type of stimuli that they respond to (as shown in the table below). You have photoreceptors for vision, chemoreceptors for taste and smell and mechanoreceptors for pressure, touch, balance and hearing.

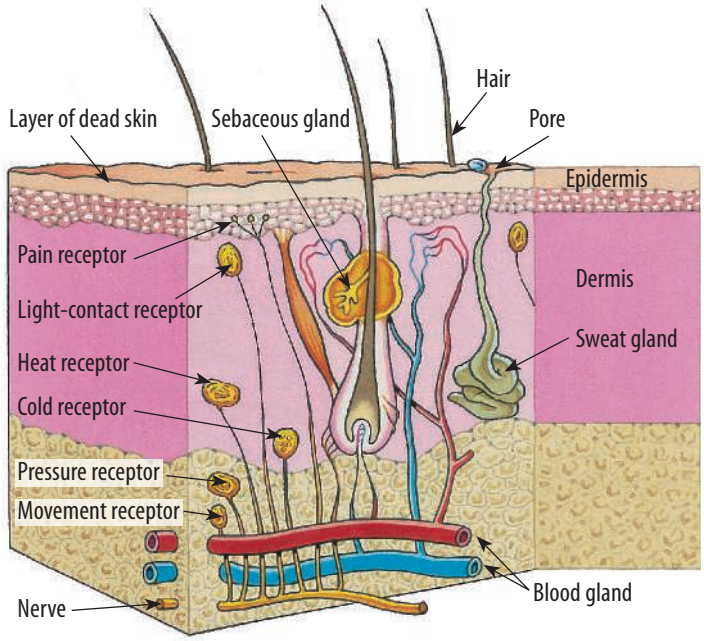
Five receptors

Thermoreceptors enable you to detect variations in temperature and are located in your skin, body core and part of your brain, called the hypothalamus. **Mechanoreceptors** are sensitive to touch, pressure, sound, motion and muscle movement and are located in your skin, skeletal muscles and inner ear. **Chemoreceptors** are sensitive to particular chemicals and are located in your nose and tastebuds and **photoreceptors** are sensitive to light and are only located in your eyes.

Pain receptors enable you respond to chemicals released by damaged cells. Detection of pain is important because it generally indicates danger, injury or disease. Although these receptors are located throughout your body, they are not found in your brain.

Touch — sharp or hot?

Your skin contains a variety of types of receptors. Pain receptors and mechanoreceptors enable you to detect whether objects are sharp and potentially dangerous. There also **hot thermoreceptors** that detect an increase in skin temperature above the normal body temperature (37.5 °C) and **cold thermoreceptors** that detect a decrease below 35.8 °C. These thermoreceptors can also protect you from burning or damaging your skin. The sensitivity of these receptors can depend on how close together they are and their location in your skin.



Your skin contains a variety of receptors that provide you with a sense of touch.

Examples of different types of receptors

Sense	Sense organ	Stimulus	Receptor	Type of receptor
Sight	Eye	Light	Rods and cones in the retina	Photoreceptor
Hearing	Ear	Sound	Hairs in the cochlea	Mechanoreceptor
Touch	Skin	Heat, cold Pressure, movement	Separate receptors for each type of stimulus	Thermoreceptor Mechanoreceptor
Taste	Tongue	Chemical substances: sweet, salty, bitter and sour	Tastebuds	Chemoreceptors
Smell	Nose	Chemicals: odours	Olfactory nerves inside nose	Chemoreceptors

INQUIRY: INVESTIGATION 3.3

Where is the skin most sensitive to contact?

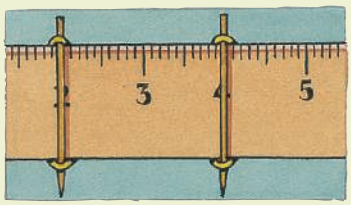
KEY INQUIRY SKILLS:

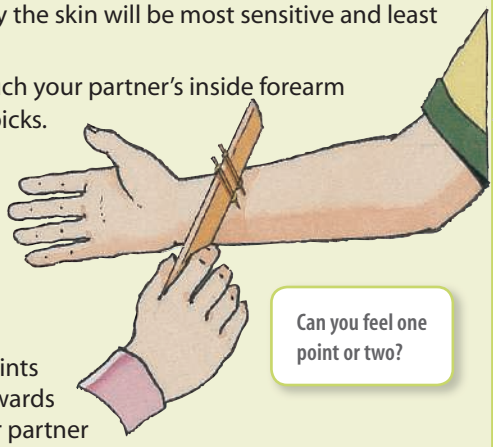
- questioning and predicting
- planning and conducting
- processing and analysing data and information
- evaluating

Equipment:

2 toothpicks ruler 2 rubber bands blindfold

- Draw a table like the one below in your workbook.
- Use rubber bands to attach two toothpicks to a ruler so that they are 2 cm apart.
- Predict in which areas of the body the skin will be most sensitive and least sensitive.
- Blindfold your partner. Gently touch your partner's inside forearm with the points of the two toothpicks.





- Ask your partner whether two points were felt. Move one toothpick towards the other in small steps until your partner is unable to feel both points. To make sure that there is no guesswork, use just one point from time to time.
- Record the distance between the toothpicks when your partner can feel only one point when there are really two points in contact.
- Repeat this procedure on the palm of one hand, a calf (back of lower leg), a finger and the back of the neck.
- Swap roles with your partner and repeat the experiment.

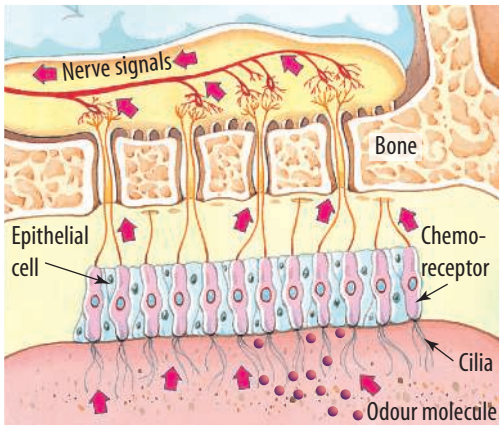
DISCUSS AND EXPLAIN

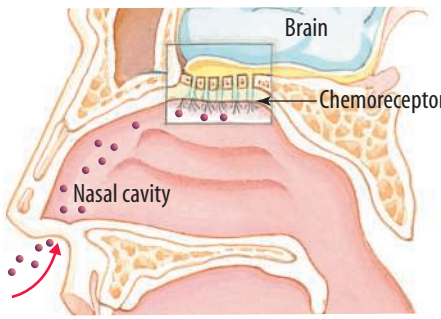
1. Which touch receptors were being used in this experiment?
2. Construct a graph to represent your data and comment on observed patterns.
3. Which area of the skin was (a) most sensitive and (b) least sensitive?
4. Suggest why the skin is not equally sensitive all over the body.
5. Which parts of the skin are likely to have the most contact receptors?
6. Discuss how your predictions compared to your experimental results.
7. Suggest improvements to this investigation and further experiments to investigate contact receptors.

	Distance (cm) between two points when only one point is felt	
Part of the skin	Your partner	You
Inside forearm		
Palm of hand		
Calf		
Finger		
Back of neck		

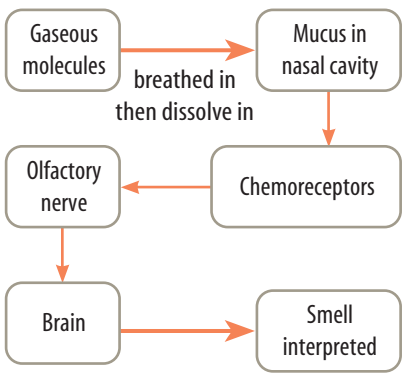
Smell — sweet or stinky?

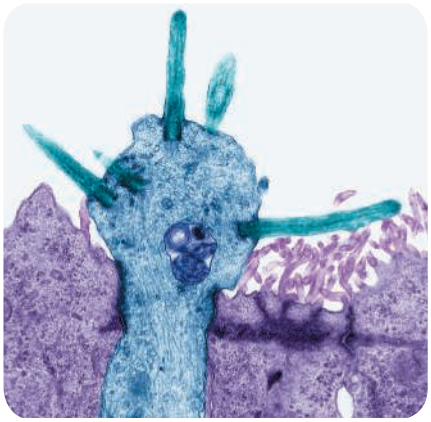
The sweet scent of a rose or the stink of garbage? Gaseous molecules from the air are breathed in through your nose. When dissolved in the mucus of your nasal cavity, the hair-like cilia of your nasal chemoreceptors are stimulated to send a message via your **olfactory nerve** to your brain to interpret it, giving you the sensation of smell.





Chemoreceptors in your nose enable you to have a sense of smell.

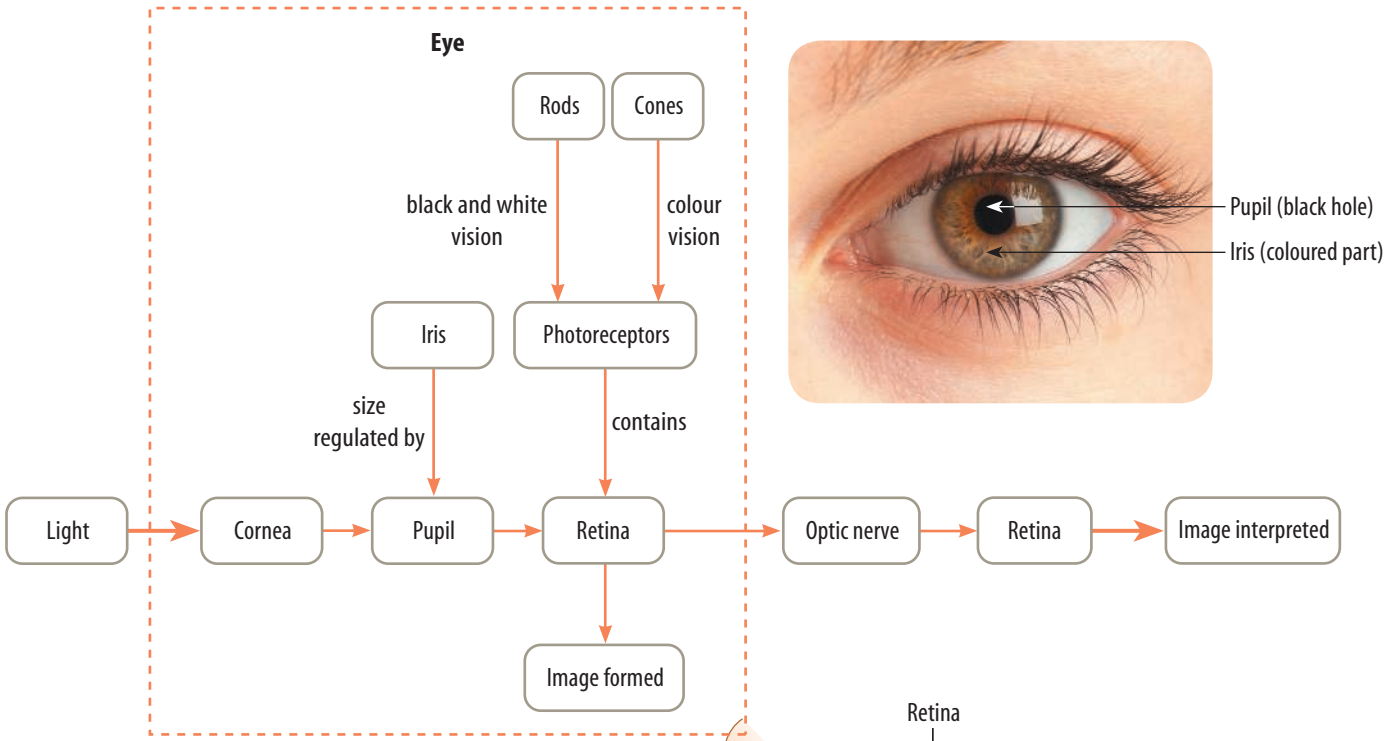


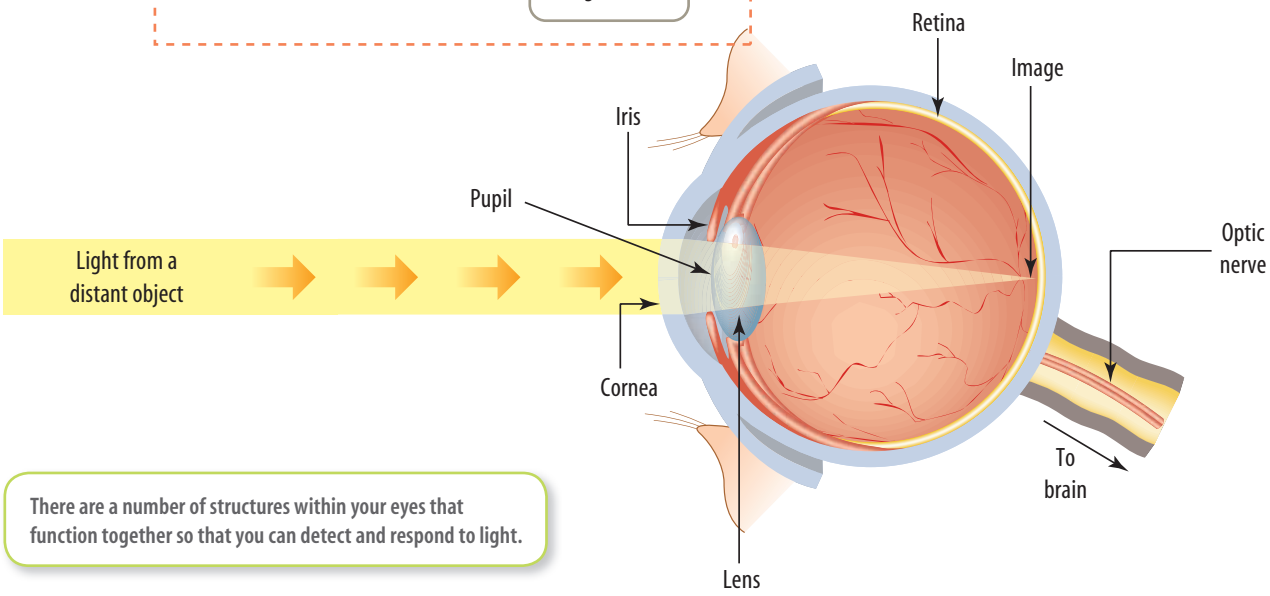


Transmission electron microscope (TEM) image of a chemoreceptor

Sight — in the wink of an eye

Your eyes, like your other sense organs, are made up of many different parts, each with its own special job to do. Look into a mirror (or into the eyes of the person next to you). The dark spot in the centre of your eye is called the **pupil**. Your pupil is simply a hole in the **iris**. Your iris is the coloured part of your eye. The amount of light entering into your eye is determined by the size of your pupil, which is controlled by your iris. Your iris is a ring of muscle, so when it relaxes the pupil appears bigger, letting more light into the eye; and when it contracts, the pupil looks smaller, letting less light into the eye. In a dark room, your pupil is large so that as much light as possible can enter your eye. If you were to move outside into bright light, your pupil would become smaller. This **reflex action** helps to protect your eyes from being damaged from too much light.





There are a number of structures within your eyes that function together so that you can detect and respond to light.

GETTING THE PICTURE

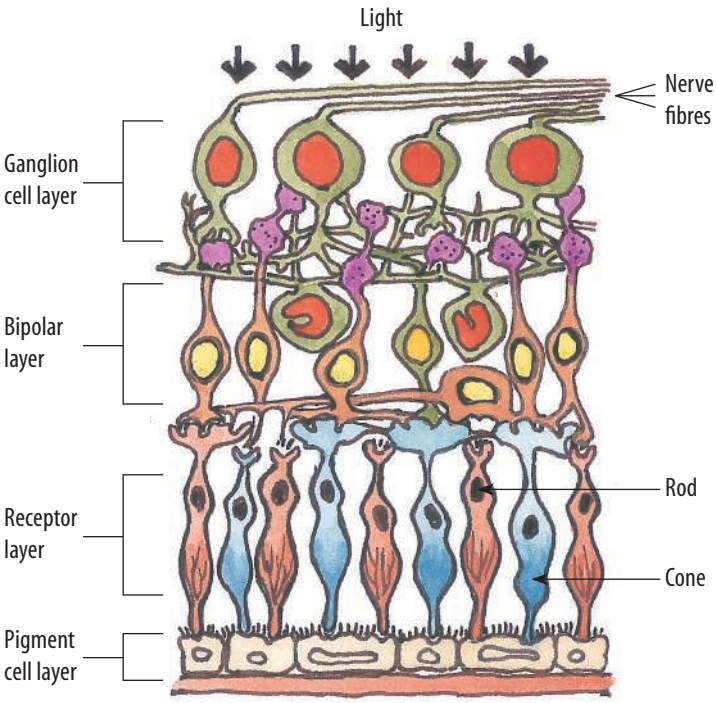
The **cornea** is the clear outer 'skin' of your eye. It is curved so that the light approaching your eye is bent towards the pupil. The clear, jelly-like **lens** bends or focuses light onto a thin sheet of tissue that lines the inside of the back of your eye called the **retina**. The lens is connected to muscles which can make it thick or thin. This allows your retina to receive a sharp image of distant or nearby objects. **Short-sightedness** and **long-sightedness** are conditions in which a sharp image is not received on the retina. In these cases, the image can be sharpened by using artificial lenses such as those in spectacles.

Although your eye receives light and produces an image of what you see, it is your brain that interprets and makes sense of the image. The photoreceptors in the retina respond to the light stimuli by sending signals to your **optic nerve** which then forwards them to your brain for interpretation.

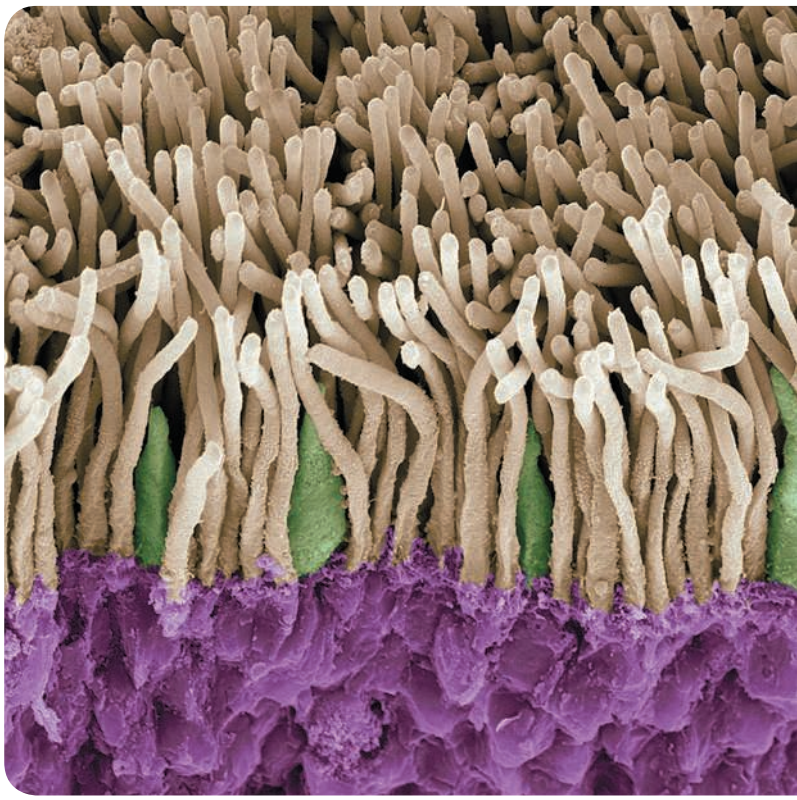
BLACK AND WHITE OR COLOUR?

Why do you see in black and white at night and in colour during the day? It is because of **rods** and **cones**. These are two different types of photoreceptors located in your retina. Rods are more sensitive to light and allow you to see in black and white in dim light. Cones are responsible for colour vision, are less sensitive to light and operate best in daylight. At night, there is not enough light for your cones to sense colour.

Are you colour blind? **Colour blindness** is an inherited condition that is generally more common in males; however, females can also be colour blind, due to the way in which the condition is inherited. There are also different types of cones. If you have a deficiency of one or more of these it may mean that you find it difficult to see a particular colour or combinations of colours.



The receptor cells in the retina respond to brightness and colour.



A scanning electron microscope (SEM) image of photoreceptors in your eye (rods shown as white and cones shown as green)

INQUIRY: INVESTIGATION 3.4

In the dark

- Cup your hands loosely over both eyes so that you cannot see anything but your hands. Keep your eyes open. Look at the insides of your hands.
- After about one minute, have your partner look carefully at your pupils.

DISCUSS AND EXPLAIN

1 What happens to the iris as your hands are removed?

2 Explain your observations.

INQUIRY: INVESTIGATION 3.5

Getting an eyeball full!

Equipment:

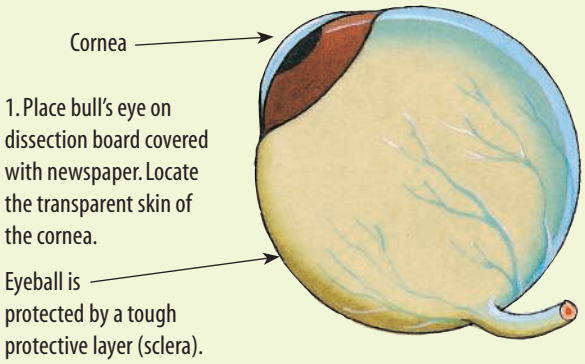
bull's eye or similar
dissection board
newspaper
paper towelling
scalpel or razor blade
safety glasses
forceps
stereo microscope
water

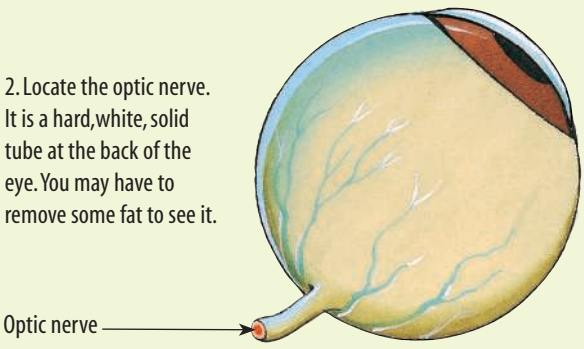
CAUTION: In this activity you will be using sharp instruments. discuss with your teacher and other members of the class a list of safety rules that should be followed carefully before beginning this activity.

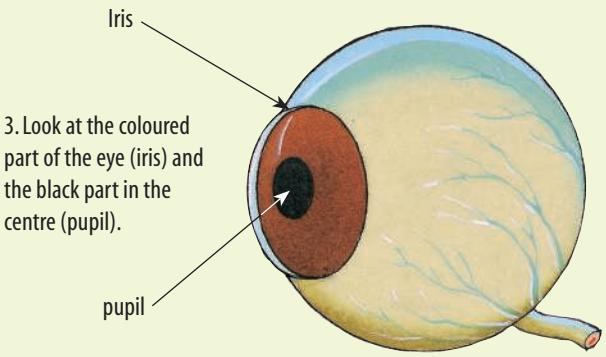
- Carefully place the bull's eye on a dissection board which has been covered with newspaper and paper towelling.
- Draw and label the structures of the bull's eye before and after your dissection. (Use the diagrams below to help you to label your drawing.)
- Add descriptive comments to your labels as you make your observations throughout this activity.
- Put on safety glasses just in case any of the aqueous or vitreous humour squirts out at you. Aqueous and vitreous humour are jelly-like liquids which give eyes their shape.
- Carefully cut a small window just behind the iris using a razor blade or scalpel. Record your observations regarding the toughness of the sclerotic coating.
- From this window, cut towards and then all the way around the iris so that you have cut the eye into two parts.
- Lift off the top part of the eye and examine the iris.
- Remove the lens with forceps and see if you can read the print on the newspaper through it.
- Use water to rinse out the jelly-like material (humour) from inside the eye and examine the retina.
- Follow your teacher's instructions regarding the cleaning of your equipment and disposal of the dissected eye.

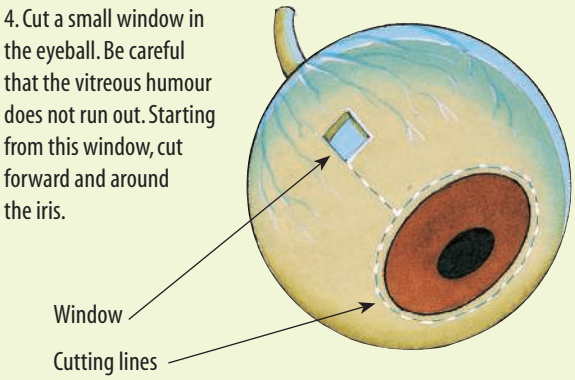
DISCUSS AND EXPLAIN

1. What is the black part in the middle of the iris?
2. What did you observe when you looked at the newspaper through the lens?
3. What did the retina look like? Could you find the optic nerve?
4. Summarise your findings in a table underneath your labelled bull's eye drawings.
5. What does the diaphragm in a microscope do? Which part of the eye does the diaphragm in a monocular microscope most resemble?
6. Find out more about one of the parts of the eye that you have observed, such as its function, related diseases or surgery.





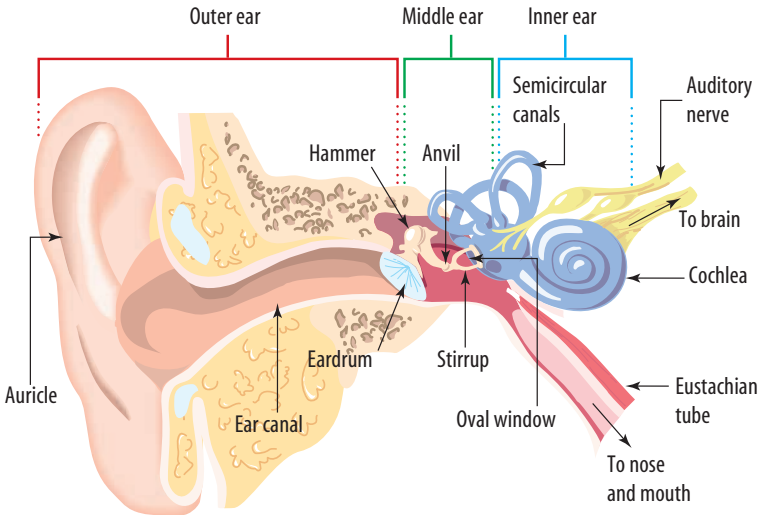




Hearing — catching vibrations

The ear is your sense organ that detects sound. When the air inside your **ear canal** vibrates, it causes your **eardrum** to vibrate at the same rate. Three tiny bones known as **ossicles** in your **middle ear** receive this vibration from your eardrum and then pass it to your inner ear. Inside your inner ear, thousands of tiny hairs attached to nerve cells of the snail-shaped **cochlea** detect the vibration and send a message to your brain via your **auditory nerve**. Your brain interprets the message as hearing sounds.

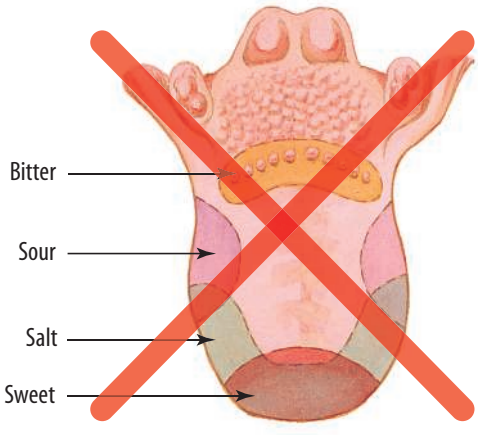
An electron micrograph of hair cells in the cochlea



Tasting — sweet or sour?

CHANGE OF TASTE

The **tongue** is your sense organ for taste. It was once thought tastebuds in different regions of your tongue could detect particular flavours such as salty, sweet, sour, bitter and savoury. New scientific discoveries have, however, disproved this model and it has now been replaced with a new model to explain how we gain our sense of taste.

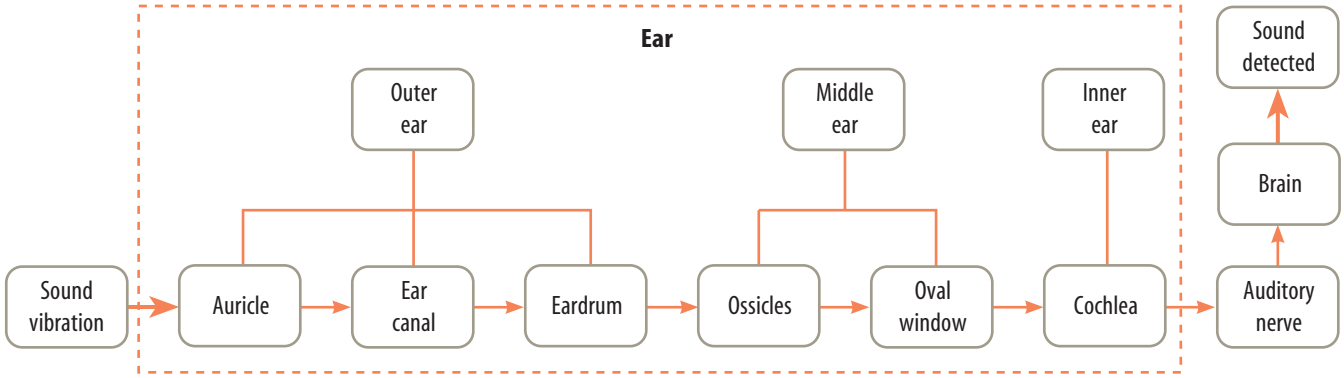


This model of taste is now obsolete. Current research suggests that we do not have different areas on our tongue for different taste sensations.

In the new model, **tastebuds** located within bumps called **papilla** across your tongue have the ability to sense all flavours. This is because each of these tastebuds contains taste cells with receptors for each of type of flavour.

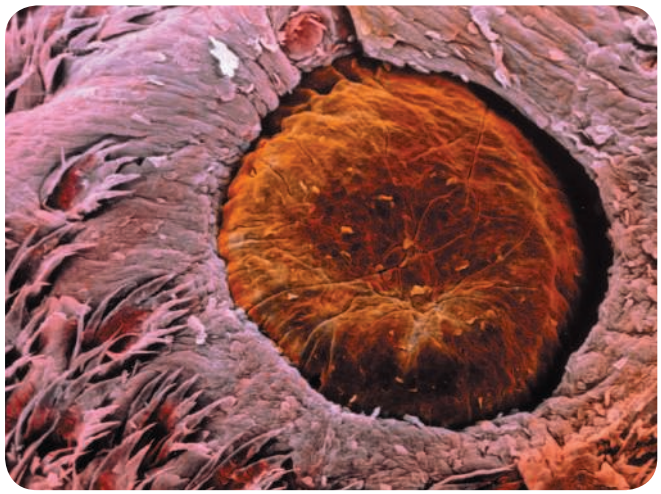
HARDWIRED FOR FLAVOUR

Our brains are wired so that we enjoy sweet, savoury and salty foods so that we can obtain the energy, protein and nutrients that we need to survive. Mass-produced foods, however, are often packed



with high amounts of sugar and salt. This has resulted in our sense of taste increasing our chance of suffering from conditions such as diabetes, heart disease and obesity.

Researchers have discovered tiny compounds that can magnify the taste of foods, so that they can taste saltier and sweeter than they really are. The use of these taste enhancers could lead to reduced sugar, salt and monosodium glutamate (MSG) being added to foods and fewer taste-related diseases.



Your tongue contains taste buds containing chemoreceptors (as shown here) sensitive to particular chemicals.

UNDERSTANDING AND INQUIRING

REMEMBER

1 State the purpose of the sense organs.

2 List examples of:
(a) five stimuli detected by human sense organs
(b) five human sense organs
(c) five types of receptors.

3 Provide an example of a type of receptor. State where you would find it and the stimulus that it detects.

4 Identify the location of the:
(a) optic nerve
(b) olfactory nerve.

5 Describe the difference and relationship between the pupil and iris in the eye.

6 Construct a mind map to show the structures that are important to vision.

7 In which part of the human body is an observed image:
(a) formed
(b) interpreted?

8 Outline the differences between the functions of rods and cones in the eye.

9 Construct a flowchart that shows structures involved in:
(a) smell
(b) vision
(c) sound.

10 Describe the new model that is used to explain the involvement of our tongues in the sensation of taste. How is this different to the previous model?

11 Suggest a reason why we are 'hardwired for flavour'.

12 Suggest how the discovery of taste enhancers may reduce the chances of getting 'lifestyle' diseases such as some types of diabetes, heart disease and obesity.

THINK AND DISCUSS

13 If cats have rods, but no cones, what does that mean in terms of how they see the world?

14 Why is the thickest part of your skin on the soles of your feet?

15 Why are some parts of your skin, such as the back of your hand, more sensitive to heat than others?

16 How do movement receptors receive a sensation of movement when they are well below the surface of the skin?

17 When you walk into a dark room at night, you cannot see anything. A minute later, without any additional light, you can see. What behaviour of the eye allows this to happen?

18 Olfactory receptor cells are important to enable us to smell things. A human has about 40 million, whereas a rabbit has 100 million and a dog has 1 billion! What effect might this difference have on the chances of survival for these animals?

19 Make some spectacles out of cardboard and use red-coloured cellophane for the lenses. If you wear the spectacles when a light or torch is turned on, your eyes will be using only their cones. When you return to the dark and remove the spectacles, your rods will be unaffected by the red light. Therefore you won't need to adapt to the dark, and can use your eyes immediately.

INVESTIGATE

20 Investigate and report on the work of Australian scientists such as Fiona Wood and Marie Stoner on artificial skin.

21 Click on the **Virtual medical centre** weblink in your eBookPLUS to find a flowchart on how hearing occurs.

eBookplus

work sheet 3.4 Skin

3.5 SCIENCE UNDERSTANDING

Coordination and control

You are a **multicellular organism** made up of many cells that need to be able to communicate with each other. They need to be able to let other cells know when they need help and support, when they need more of something or when they need to get rid of something.

While one of your cells may be a part of one of the systems in your body, it may also need to communicate and interact with other systems to stay alive. It may depend on your digestive system to break down nutrients so that its chemical requirements are in a form that can be used, and your circulatory system to deliver these. Your respiratory system will also be involved in ensuring a supply of oxygen and removal of carbon dioxide. Other organs in the excretory system will also be involved in removing wastes that may otherwise be toxic. You systems need to work together so that a comfortable stable environment for the cells is maintained.

Homeostasis

The internal environment in which your cell lives needs to be kept constant. Temperature, pH and concentrations of ions, glucose, water and carbon dioxide need to be within a particular range. Maintenance of this constant internal environment is called **homeostasis**.

STIMULUS–RESPONSE MODEL

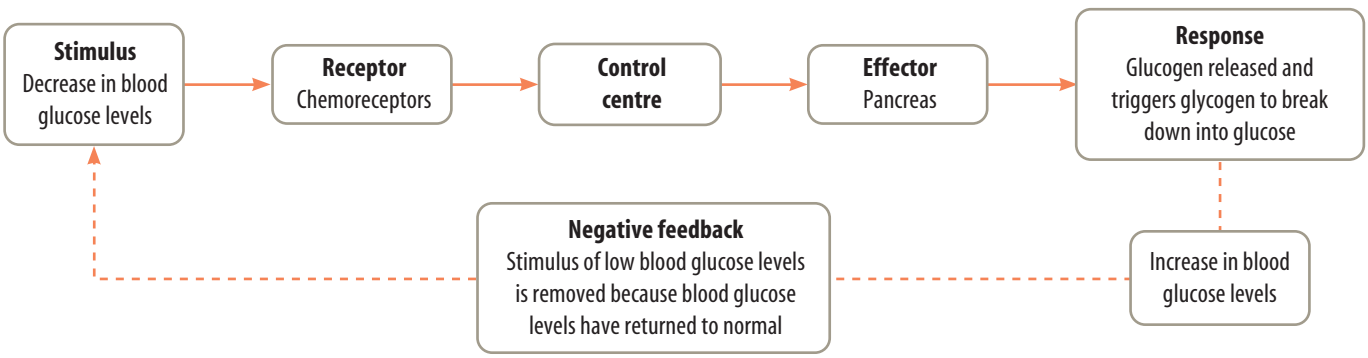
To be able to achieve homeostasis, any changes or variations (stimuli) in the internal environment need to be detected (by receptors). If a response is required, this needs to be communicated to effectors to bring about some type of change or correction so the conditions can be brought back to normal. This is described as a **stimulus–response model**.

FEEDBACK

Stimulus–response models can also involve negative or positive feedback. Most biological feedback systems involve negative feedback. **Negative feedback reactions** are those in which the response is in an opposite direction to the stimulus. For example, if levels of a particular chemical in the blood were too high, then the response would be to lower them and if the levels were too low, then they would be increased.

The regulation of glucose levels in your blood involves negative feedback. If a decrease in blood glucose levels has been detected, a response may involve the secretion of the hormone **glucagon** which triggers the breaking down of **glycogen** to break down into **glucose**, which can then be released into the blood, resulting in an increase in blood glucose levels.

Positive feedback reactions, however, keep the response going in the same direction. It has a positive effect on the stimulus. An example of a positive feedback reaction occurs when a mother is breastfeeding her baby. Another example involves the stimulation of uterine contractions during childbirth.



Staying in control

To work together effectively, these systems require coordination. The two systems with this responsibility are the **nervous system** and the **endocrine system**. While both of these systems require **signalling molecules** to communicate messages throughout the body, they have different ways of going about it.

NERVOUS OR HORMONAL?

The nervous system involves the message being sent as a nervous or electrical impulse along a neuron and then as a chemical message (**neurotransmitter**) across the gaps (synapses) between them. The endocrine system uses only chemical messages (**hormones**) transported throughout the circulatory system to its target cell. Other key differences are outlined in the table above right.

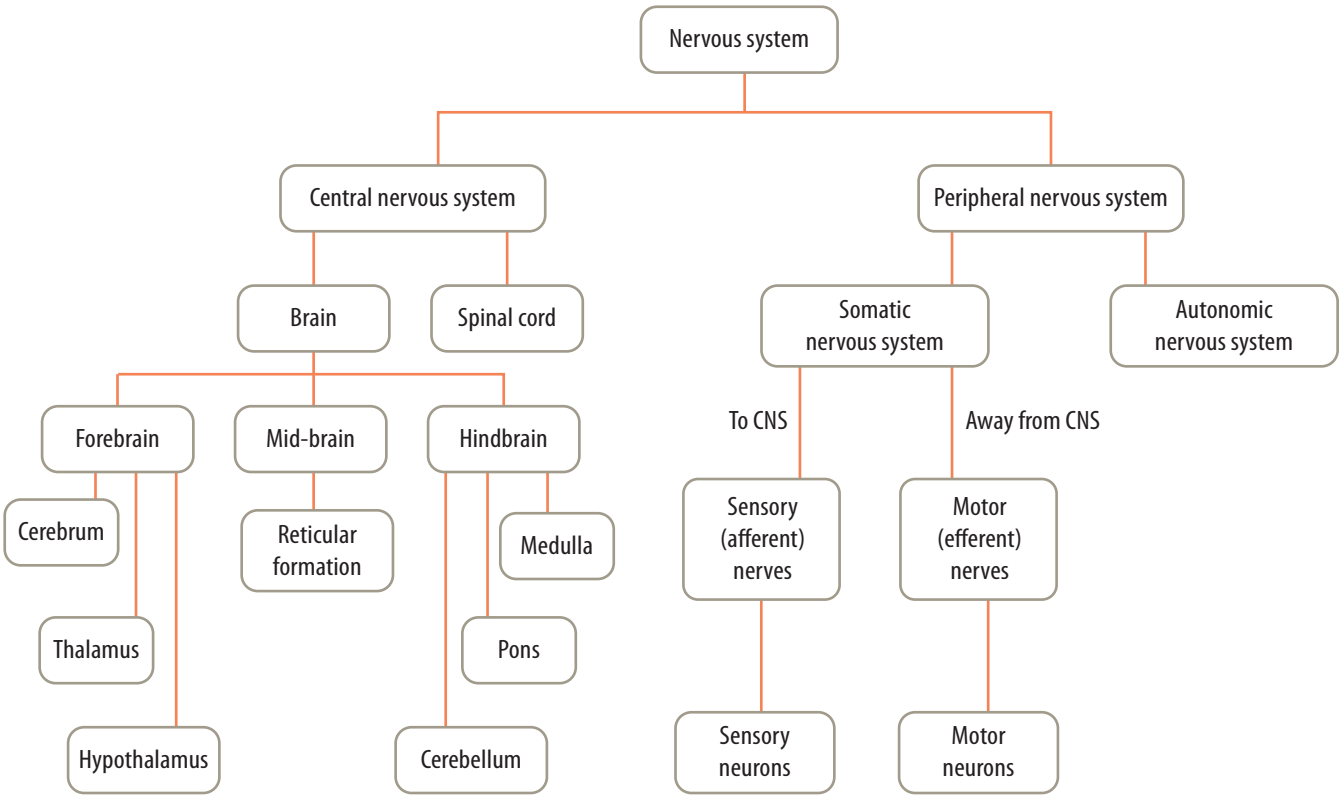
Feature	Endocrine system	Nervous system
Speed of message	Slow	Fast
Speed of response	Usually slow	Immediate
Duration of response	Long lasting	Short
Spread of response	Usually slow	Very localised
How message travels through body	In circulatory system — in bloodstream	In nervous system — along nerves and across synapses
Type of message	Hormones (chemicals)	Electrical impulse and neurotransmitters (chemicals)

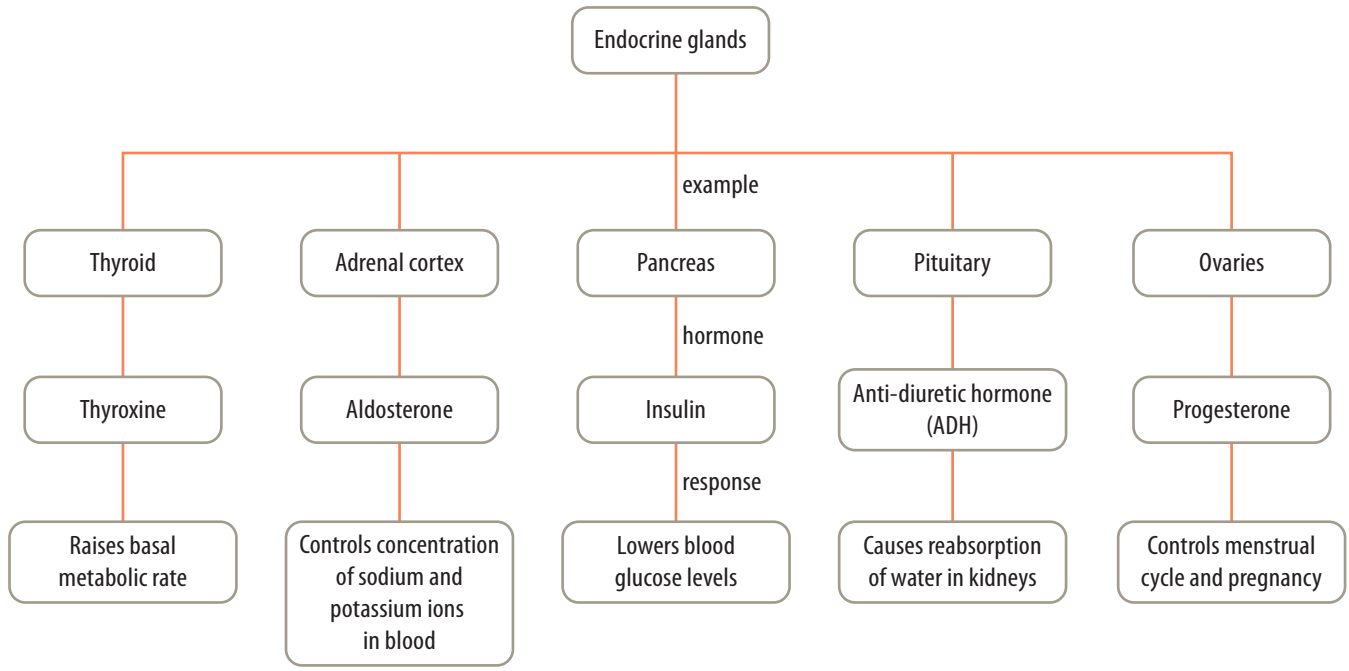
Nervous system

Your nervous system is composed of the **central nervous system** (brain and spinal cord) and the **peripheral nervous system** (the neurons that connect the central nervous system to the rest of the body).

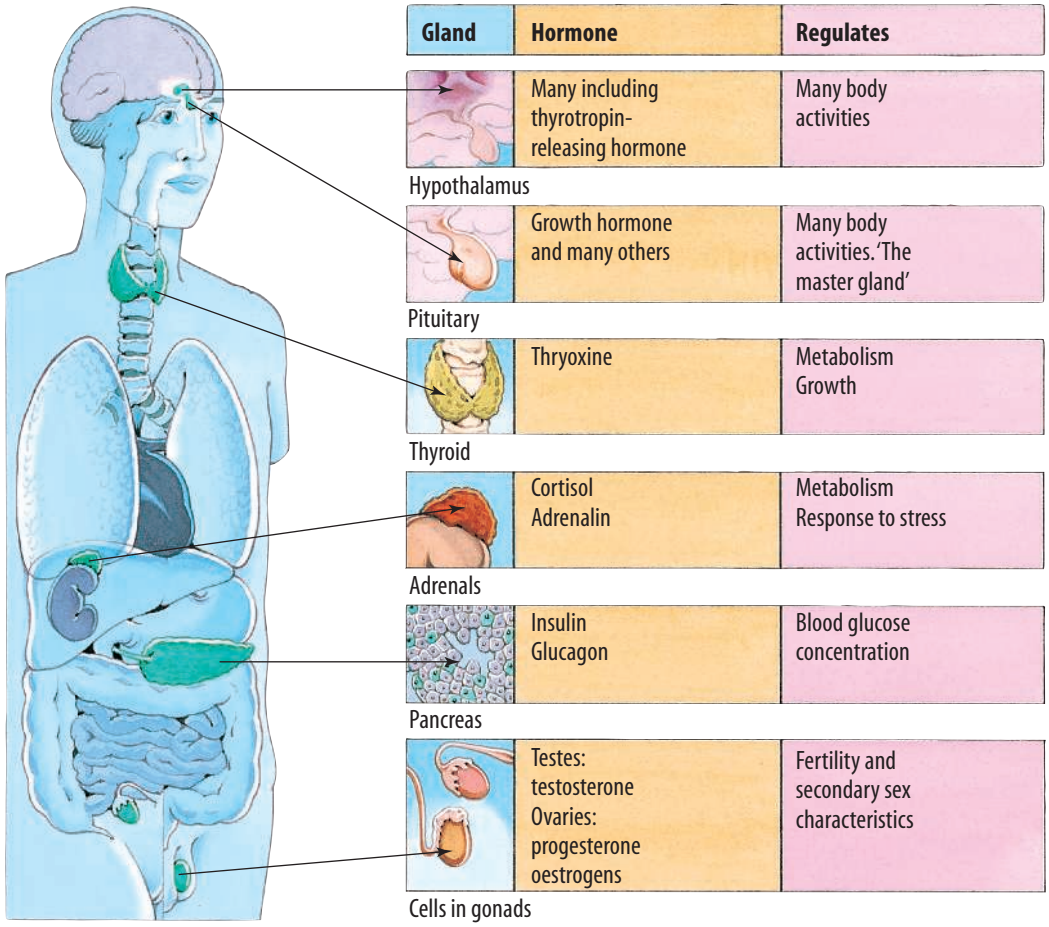
Endocrine system

Your endocrine system is composed of **endocrine glands** that secrete chemical substances called hormones into the bloodstream. Once in the bloodstream, the hormones circulate around the body and bring about a response in specific target organs.





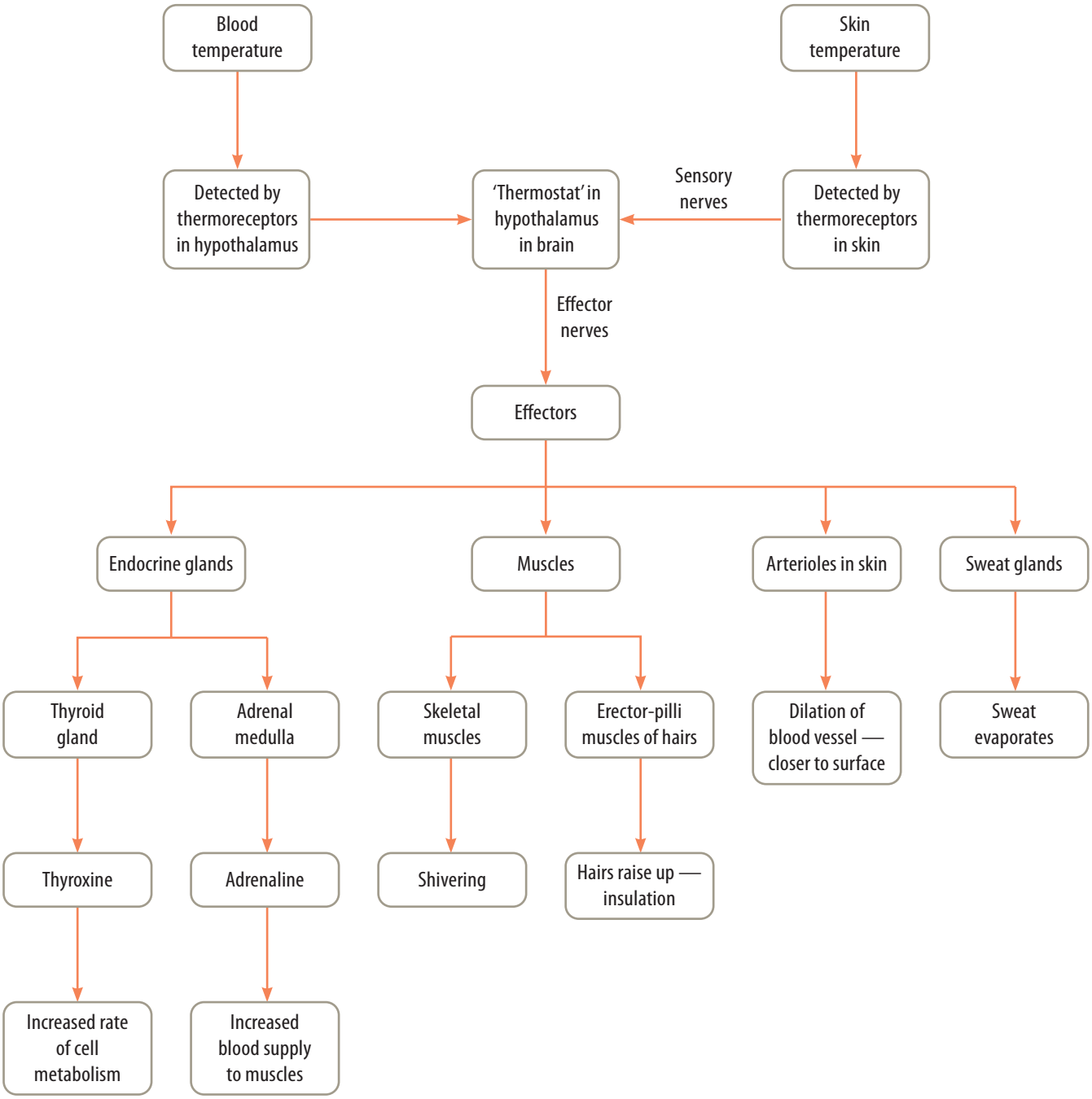
Examples of endocrine glands and their hormones



Working together

The control of body temperature, referred to as **thermoregulation**, provides an example of the nervous and endocrine systems working together. Evidence suggests that a part of your brain called the hypothalamus contains a region that acts as your body's **thermostat**. It contains thermoreceptors that detect the temperature of blood that flows through it.

If your body temperature increases or decreases from within a particular range, messages from thermoreceptors in your skin or hypothalamus trigger your hypothalamus to send messages to appropriate effectors to bring about a response that will correct it. The figure below provides examples of some of these responses.



Temperature regulation is an example in which the nervous system and the endocrine system work together to maintain your body temperature within a range that is healthy for your cells. Can you suggest terms to describe the links in the figure above?

UNDERSTANDING AND INQUIRING

REMEMBER AND THINK

1 Match the terms listed in the box with the correct description below.

Central nervous system	Chemoreceptors
Control centre	Effector
Electrical impulse	Endocrine gland
Endocrine system	Glucagon
Glucose	Glycogen
Homeostasis	Hormone
Insulin	Motor neuron
Negative feedback	Nervous system
Neurotransmitter	Pancreas
Peripheral nervous system	Receptor
Response	Sensory neuron
Stimulus	Stimulus–response model

(a) I describe a model that helps you to achieve homeostasis.
(b) I am a response that is in the opposite direction to the stimulus.
(c) I consist of the brain and the spinal cord.
(d) I take messages to the central nervous system.
(e) Insulin is an example of what I am.
(f) I detect chemicals and can detect a decrease in blood glucose levels.
(g) I carry chemical messages within the nervous system.
(h) I take messages away from the central nervous system.
(i) I secrete hormones into your bloodstream.
(j) I help you to respond to stimuli.
(k) I use hormones to transport messages throughout your circulatory system to a target cell.
(l) I am a 'central' part of the stimulus–response model.
(m) I am the result of the action of an effector.
(n) I carry the message through your neurons.
(o) I am known as a storage polysaccharide and am made up of many glucose subunits.
(p) Your pancreas releases hormones to keep my blood levels within a narrow range.
(q) I am released by your pancreas when blood glucose levels are below normal.
(r) I am involved in maintaining a constant internal environment within your body.
(s) My release from the pancreas results in a lowering of blood glucose levels.
(t) My cells release both insulin and glucagon.
(u) I use neurons, electrical impulses and neurotransmitters to pass on messages.
(v) I am detected by a receptor.
(w) I detect a stimulus.
(x) I contain neurons that connect the central nervous system to the rest of the body.

2 Organise the terms below into a Venn diagram so that they are grouped into their families.

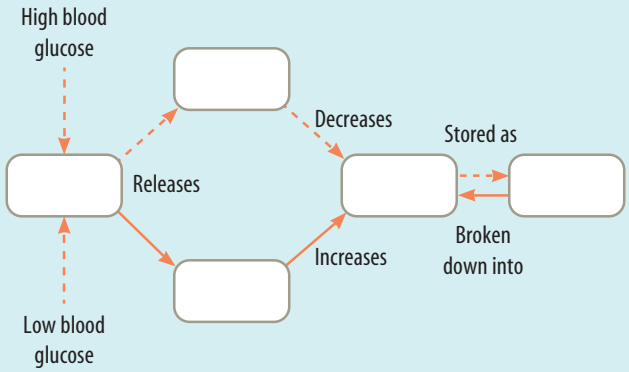
Central nervous system	Electrical impulse
Endocrine gland	Glucagon
Insulin	Homeostasis
Hormone	Motor neuron
Neurotransmitter	Pancreas
Peripheral nervous system	Sensory neuron
Stimulus–response model	

3 What is a stimulus–response model?

4 Give an example of a negative feedback mechanism in the human body.

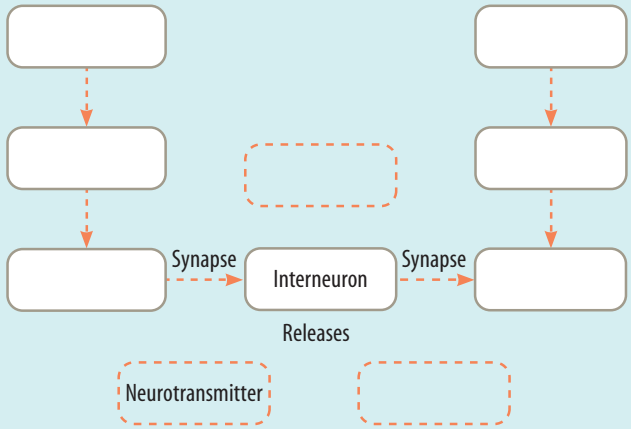
5 Suggest how you could link the endocrine system terms in the flowchart below.

Glucagon	Insulin	Pancreas
Glycogen	Glucose	



6 Suggest how you could link the nervous system terms in the flowchart below.

Electrical impulse	Receptor
Motor neuron	Neurotransmitter
Sensory neuron	Stimulus
Response	Effectors



Nervous system — fast control

Your nervous system is made up of nerve cells called **neurons**. Neurons are grouped together to form **nerves**.

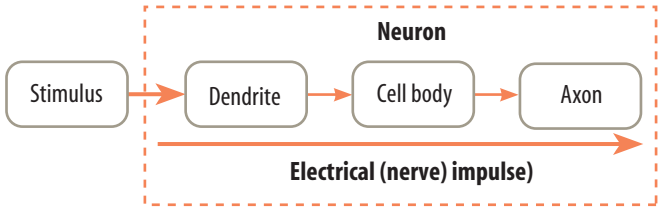
Neurons

There are three different types of neurons: **sensory neurons**, which carry the impulse generated by the stimulus to the central nervous system; **interneurons**, which carry the impulse through the central nervous system; and **motor neurons**, which take the impulse to effectors such as muscles or glands.

STRUCTURE OF A NEURON

Neurons, like most other eukaryotic cells, contain a **nucleus** and other cell **organelles**, **cytosol** and a **cell membrane**. However, the various types of neurons are all quite different. These differences mean that each particular neuron type is suited to its specific communication role in the nervous system.

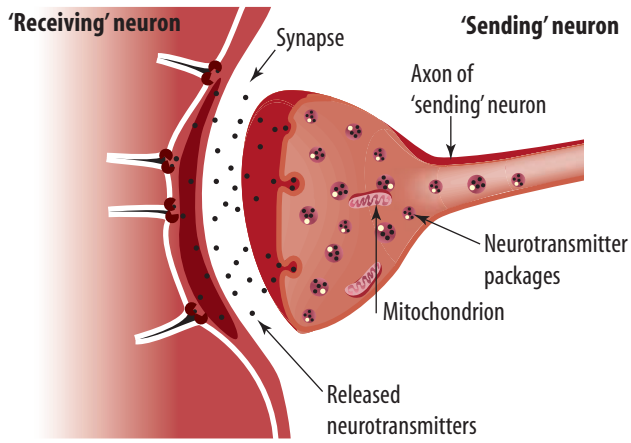
On the cell membrane of the **cell body** of a neuron are highly sensitive branching extensions called **dendrites**. These dendrites possess numerous receptors that can receive messages from the other cells. Once this message has been received it moves as an electrical impulse in one direction from the dendrite, through the cell body and then through a long structure called an **axon**. This structure is often covered with a white insulating substance called **myelin**, which helps speed up the conduction of the message through the neuron.



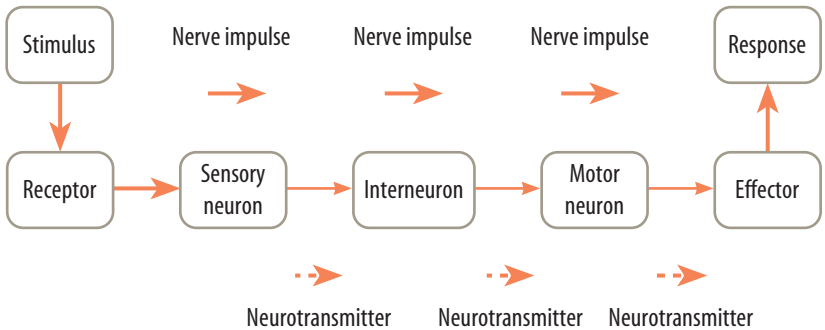
An electrical impulse moves in only one direction through a neuron.

SYNAPSES

The gap between neurons is called a **synapse**. When the nervous impulse has reached the axon terminal of a neuron, tiny **vesicles** containing chemicals called **neurotransmitters** are transported to the cell membrane of the neuron. These chemicals are then released into the synapse.



Neurotransmitters passing along the synapse to the next neuron



Your nervous system involves the use of both electrical signals (nerve impulses) and chemical signals (neurotransmitters).

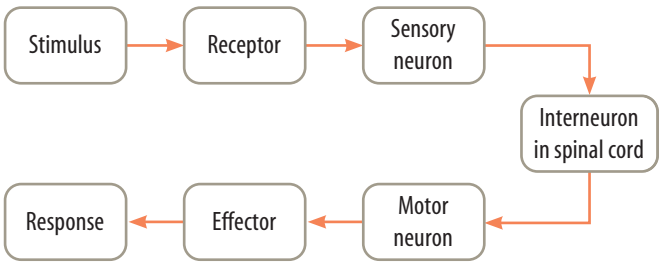
The neurotransmitters move across the synapse and bind to receptors on the membrane of the dendrites of the next neuron. This may result in triggering the receiving neuron to convert the message into a nervous impulse and conduct it along its length.

When it reaches the axon terminal, neurotransmitters are released into the synapse to be received by the dendrites of the next neuron. This continues until the message reaches a motor neuron which then communicates the message to an **effector**, such as a muscle or gland. The effector may then respond to the message; for example, a muscle cell may contract or a gland may secrete a chemical.

REFLEX ACTIONS

Have you ever had sand thrown in your eyes or touched something too hot? Sometimes you don't have time to think about how you will react to a situation. Some actions need to be carried out very quickly — it may be a matter of survival! These actions are examples of reflex actions.

Reflex actions may involve only a few neurons and require no conscious thought. Once the stimulus is detected by a receptor, the message is sent via the sensory neuron to the interneuron in the spinal cord and then from the motor neuron to the effector to bring about a response. The message does not have to go the brain. This type of pathway, which involves only a few neurons and travels only to and from the spinal cord, is called a **reflex arc**.



Watch out! Sometimes you need to react very quickly and there is no time to think.

ACT! NO TIME TO THINK!

Your fast response when you move away from a hot flame is an example of a reflex action. This is a reaction to an external stimulus. You also react to many internal stimuli using reflex actions. Breathing, for example, is a response regulated by chemoreceptors detecting changes in carbon dioxide levels in your blood. It's very helpful that you don't have to remember to breathe — imagine what would happen if you forgot to!

THINK ABOUT IT

More complex actions require more neurons and more thinking about. This involves your brain and can involve making decisions about which responses are needed. Some of these may result from external stimuli, such as making decisions involving catching a ball, and others internal stimuli, such as those required to stand up.

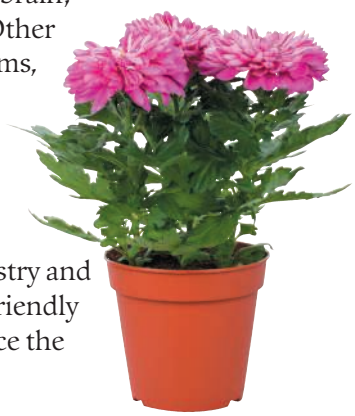
Chemical warfare

Beware of toxic ticks, stinging trees, nasty nettles or jellyfish! Many plants and animals have ways of repelling boarders or paralysing their prey.

PESTS AND POISONS

How do they do it? Blue-ringed octopuses, paralysis ticks, tiger snakes and other animals and plants produce cocktails of poisons that block the production and action of neurotransmitters at synapses. The poison from a red-back spider, for example, empties the impulses out of the neurotransmitters. Interfering with the neurotransmitters' job of carrying the message to the next neuron interferes with the transference of the message and can cause spasms and paralysis.

Many plants produce chemicals that sting by strongly stimulating the pain receptors in the skin. Messages are sent rapidly to the brain, which interprets them as pain. Other plants, including chrysanthemums, produce insecticides such as pyrethrums. These target the nervous system of insects, resulting in their death. The commercial production of such natural pesticides is a large industry and is regarded as environmentally friendly because natural pesticides replace the use of more harmful chemicals.



INQUIRY: INVESTIGATION 3.6

How good are your reflexes?

KEY INQUIRY SKILL:

- questioning and predicting

Equipment:

well-lit room *chair*

stopwatch or clock with a second hand

Work in pairs for both parts of this activity. Decide who will be the experimenter and who will be the subject. Then swap roles and repeat both parts.

Part A: Kept in the dark

- If you are the experimenter, look closely at the eyes of your partner, noting the size of the pupils.
- Ask your partner to close his or her eyes for 60 seconds.
- At the end of this time, monitor your partner's eyes for any changes.

DISCUSS AND EXPLAIN

1. What changes did you notice?
2. Identify the (a) stimulus and (b) response.
3. Why do you think this reflex action is important to our survival?
4. Can you control the size of your pupil?
5. Suggest possible improvements to this experiment and suggest further relevant investigations that could be carried out.

Part B: Knee jerk

- Have your partner sit on a chair with one leg crossing over the other knee.
- Use the edge of your hand to gently strike the crossed leg of your partner just below the knee in the joint.
- You may need to repeat this a few times to get a response from your partner.

DISCUSS AND EXPLAIN

6. Describe your observations.
7. Identify the (a) stimulus, (b) response and (c) effector.
8. Did you get the response the first time? Why or why not?
9. Can you control a knee-jerk response?
10. Suggest possible improvements to this experiment and suggest further relevant investigations that could be carried out.

NERVE NASTIES

Similar chemicals have been used as agents of human warfare. These chemicals specifically target the nervous system. Nerve gas, for example, contains a substance which prevents neurotransmitters functioning properly at the synapses. The neurotransmitters accumulate, causing the nervous system to go haywire. Such chaos can result in death.

The first nerve gas, tabun, was initially developed when German scientists were developing a better insecticide. This has led to more deadly agents such as sarin and VX. All nerve gases block the body's production of an enzyme called acetylcholinesterase. This enzyme regulates the nerves controlling the action of particular muscles. A deficiency of acetylcholinesterase leads to tightening of your diaphragm, convulsions and death.

Some chemicals can specifically target your nervous system and disrupt its functioning. Scientists and experts working with dangerous materials use suits such as those shown here for protection.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Describe one way in which animals can cause paralysis.

2 Describe how some plants defend themselves against:
   (a) humans
   (b) insects.

3 What is the difference between:
   (a) a receptor and an effector
   (b) a sensory neuron, an interneuron and a motor neuron
   (c) a neuron and a nerve?

4 Use a diagram to describe how impulses are transmitted between sensory and motor neurons.

THINK AND DISCUSS

5 How does blocking the production and action of neurotransmitters cause paralysis?

6 What could be the effect of toxins on aquatic food chains?

7 Suggest ways in which chemicals that affect the nervous system may be mopped up.

8 What do insecticides do?

9 Suggest why nerve gas is used in warfare.

INVESTIGATE AND DISCUSS

10 Conduct a survey of insecticides at your local nursery, garden supplies shop or supermarket. Construct a table in which to record:
   (a) the names of commercial brands of insecticides
   (b) the target organisms
   (c) the active chemical ingredients
   (d) information given about safety precautions.

   Find out how the main ingredients act in each of the insecticides and include them in a report in your survey.

11 Researchers studying Gulf War syndrome carried out experiments on chickens to discover the cause of the illness.
   (a) Find out about their experiments and conclusions.
   (b) Do you think the researchers were justified in carrying out these experiments? List arguments for and against.

12 Test your knowledge of the nervous system by completing the **A nervous response** interactivity in your eBookPLUS. **int-0670**

13 Learn more about your nervous system by completing the **A bundle of nerves** interactivity in your eBookPLUS. **int-0015**

14 There is a danger that chemical and biological weapons may one day be used in acts of terrorism.
   (a) Search the media for relevant examples of chemicals and their effects.
   (b) Report on your findings and discuss them with your team.
   (c) Is the use of chemical warfare ever justifiable? Discuss this with your team, recording all the various opinions and views.
   (d) What sorts of strategies do we have in Australia to cope with threats of chemical warfare? How effective do you consider these to be? In your teams, brainstorm other strategies that could be used.
   (e) On your own or in a team, write a story, newspaper article or diary entry that describes the effects of a chemical warfare attack in Australia.

15 Working in groups of four, make a list of about 10 different poisonous or venomous Australian plants and animals. Each person is to research and report on at least one. As a group, decide what aspects to include in the report. Present your findings as a PowerPoint presentation or poster with a taped commentary.

CREATE

16 Make models of the different neuron types using balloons, string or cotton, straws and tape.

17 In a group, act out a simple reflex arc and a conscious response.

INVESTIGATE, THINK AND DISCUSS

18 Imagine that you are a scientist involved in researching the nervous system. Propose a relevant question or suggest a hypothesis for a scientific investigation and outline how you would design your investigation. Search the internet for relevant research or information.

19 Find examples of how developments in imaging technologies have improved our understanding of the functions, interactions and diseases of the nervous system. Share your findings with your class.

20 Investigate how technologies using electromagnetic radiation are used in medicine, for instance in the detection and treatment of cancer of the brain or other parts of the nervous system.

21 There are often claims made about particular products in the media relating to the nervous system. Examples include drugs that regulate moods or enhance memory. Select one of these examples (or one of your own), find out more about it and then evaluate the claims being made in advertisements or in the media.

work sheet 3.5 The nervous system

3.7 SCIENCE UNDERSTANDING

Endocrine system — slow control

Feeling excited? Feeling stressed? Butterflies in your stomach? Have you ever wondered what causes you to react in a particular way to stressful situations?

Helpful hormones

Your nervous system is not the only means of controlling and coordinating activities in your body. Your endocrine system uses chemical messengers called **hormones**. They are produced in your **endocrine glands** and are released directly into your bloodstream. Although hormones are carried to all parts of your body, only particular cells have receptors for particular hormones. It is a little like radio signals, which are sent out in all directions but picked up only by radios attuned to a particular signal. These **target cells** are attuned to the hormones carried through your body and respond in a particular way.

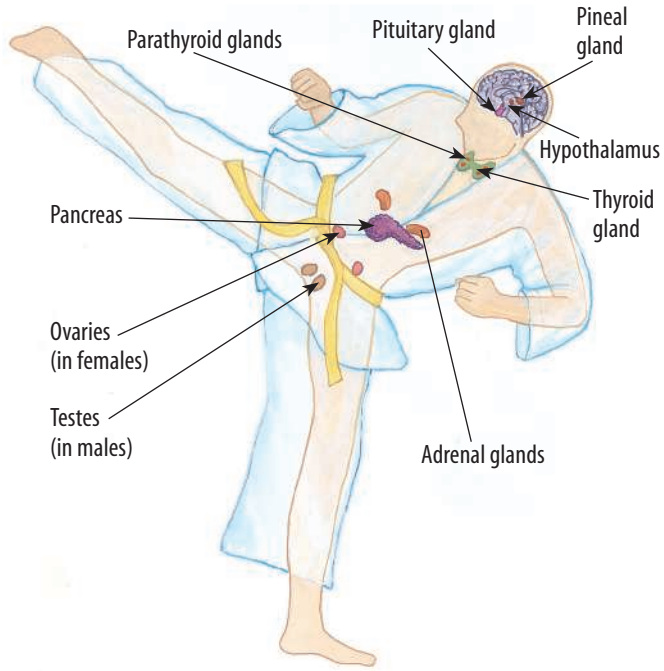
Hormones control and regulate functions such as metabolism, growth, development and sexual reproduction. Like the nervous system, the endocrine system detects a change in a variable, and often acts using a negative feedback mechanism to counteract the initial change. The endocrine system also works with the nervous system to regulate your body's responses to stress. The effects of the endocrine system are usually slower and generally longer lasting than those of the nervous system.

Gland	Type of hormone(s) produced	Hormone's function/effect
Pituitary gland (called the 'master gland' because it controls many other endocrine glands)	Many hormones including: follicle stimulating hormone (FSH) and luteinising hormone (LH) Growth hormone Prolactin	Stimulates ovaries to produce ova and Stimulates testes to produce sperm Affects cell growth Stimulates production of milk in breasts
Hypothalamus	Many hormones	Connects the nervous system with the endocrine system; controls body temperature, growth, sex drive, thirst, hunger and pleasure and pain sensations
Pineal gland	Melatonin	Controls body rhythms such as sleeping and waking
Thyroid gland	Thyroxine	Controls rate of chemical activity in cells and regulates growth
Adrenal glands	Adrenaline and others	Raises blood pressure, heart rate, breathing rate and supply of blood to muscles
Pancreas	Insulin Glucagon	Decreases blood glucose level Increases blood glucose level
Parathyroid glands	Parathormone	Maintains level of calcium in the blood
Ovaries (females)	Oestrogen and progesterone	Controls development of breasts; prepares uterus for zygote and controls menstrual cycle
Testes (males)	Testosterone	Controls body hair, deepening of voice and sexual urges

Keeping balance

KEEPING WARM

Negative feedback helps our body to keep its internal conditions stable so that you can function effectively. An example of this is if your body temperature is too low. The decrease in body temperature acts as the stimulus, which is detected by thermoreceptors in your body. This message is taken to the hypothalamus, which activates warming mechanisms. One of these mechanisms involves the thyroid gland. It responds by secreting the hormone thyroxine, which increases the metabolic rate of cells, releasing heat to warm you. Raising body temperature reduces the need for the hypothalamus to direct the thyroid gland to secrete thyroxine.



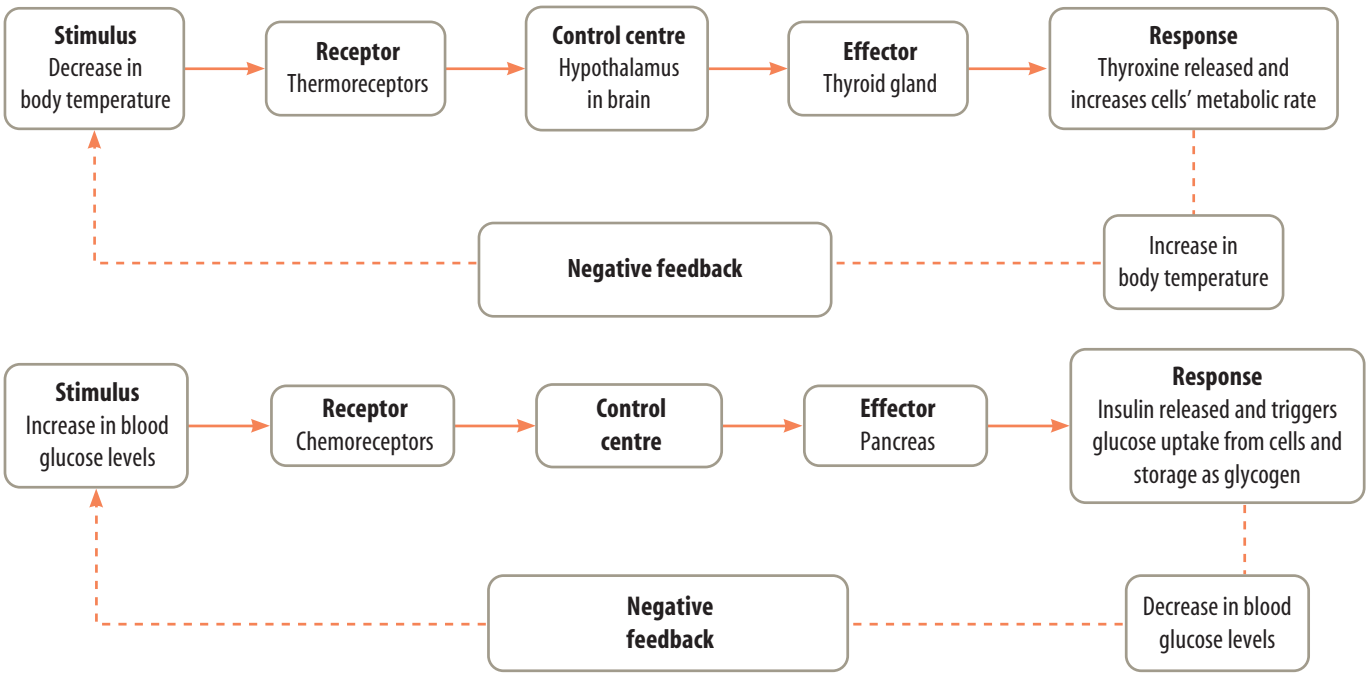
Some of the main glands of the endocrine system

SWEET CONTROL

Insulin, a hormone produced by your pancreas, acts on target cells in the liver. After you have eaten a lot of sugary food, your blood glucose (or blood sugar) level rises. The rise is detected by cells in the pancreas. The pancreas then secretes insulin, which travels through the bloodstream to the liver. Specific target cells respond by converting glucose from your blood into glycogen, which is then stored. This has the effect of lowering the amount of glucose in your blood. Another hormone, glucagon, also produced by your pancreas, has the opposite effect and raises your blood glucose levels.

Superhuman feats?

'Butterflies' in your stomach are the effects of a hormone called adrenaline. When you experience some kind of fright or stress, the adrenal gland releases adrenaline into your bloodstream. Not all parts of your body will be affected by its presence in the bloodstream. Adrenaline may cause your face to turn pale, your heart to beat faster and your



muscular actions and energy levels to increase. This prepares your body to escape from, or fight your way out of, a dangerous situation. Adrenaline is often referred to as the 'fight or flight' hormone.

Harvesting hormones

Observations made in the days of gas street lamps caused scientists to think about the trees downwind of the lamps that shed their leaves. Experiments led to the discovery that the ethylene gas used in the lamps was responsible. Further research showed that ethylene was a plant hormone that promotes a plant's ability to shed leaves.

Such investigations have increased our level of understanding and allowed us to put some hormones to work. The mind map below shows some of the many uses of hormones.

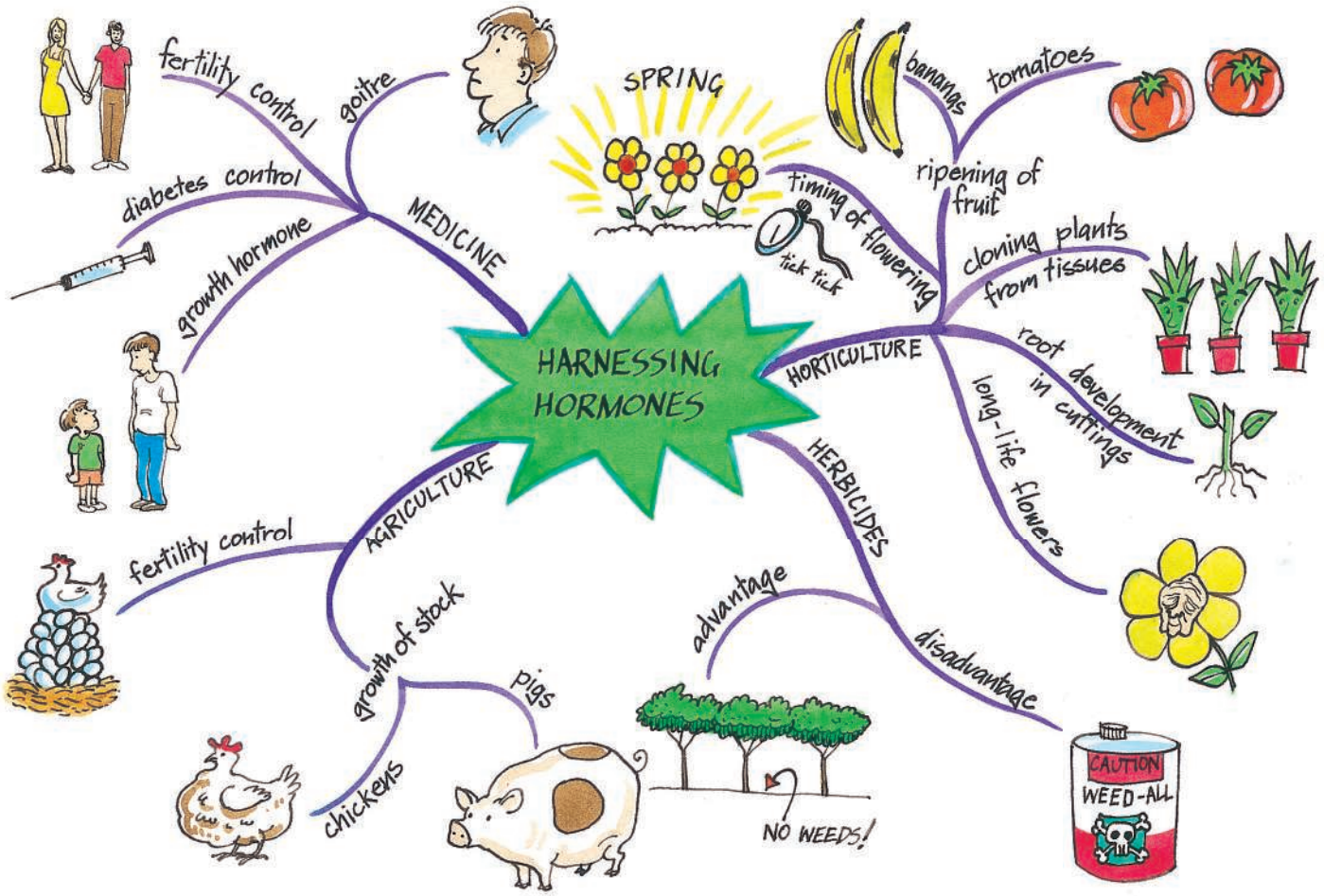
His and her hormones

Hormones can also be harnessed to either increase or decrease fertility. In some situations, hormones can even be involved in aborting embryos. There are a number of issues that have been expressed about the production, availability, uses and consequences of these hormones.

HORMONES FOR HER

A commercially produced hormone RU486 (Mifeprex), also known as the abortion pill, is one such example. RU486 not only offers possibilities of contraception, but it also can terminate a pregnancy by blocking the action of progesterone. This causes the lining of the uterus to break down so that the embryo is unable to implant into it. This pill is less invasive and has fewer side effects than a surgical abortion and it enables termination at a much earlier stage. The possibility of using this pill as an abortion option, however, has resulted in a division of opinions as to whether it should be made widely available in Australia. There have been some reports suggesting that it is being over-used in other countries.

While other hormone-based contraceptives are increasingly available, they are no longer seen only in



a pill form. They are now appearing in patches, gels, implants and insertable vaginal rings. There is also research on the development of a 'morning-before' pill. This pill works by altering the ion content of the woman's reproductive tract for about 36 hours. The changes that it produces make it more difficult for the sperm to swim and hence less likely for them to reach the ovum to fertilise it.

There are also plans to develop contraceptive drugs that target hormone receptors rather than altering hormone levels. These new contraceptives may work by tricking the egg into thinking that it is already fertilised so that it blocks sperm from penetrating it. Other new contraceptives may involve the development of hormones that prevent the fertilised egg from implanting in the uterus.

HORMONES FOR HIM

Scientists are working on developing male contraceptive pills. These are based on combinations of androgen and progesterone. Androgen blocks sperm development and progesterone blocks testosterone production. While combinations of these hormones may be used to prevent fertility, there are possible side effects that need to be considered.

UNDERSTANDING AND INQUIRING

REMEMBER

1 What do street gas lamps have to do with the discovery of ethylene?

2 State examples of ways in which hormones could be used for:
(a) horticulture
(b) agriculture
(c) medicine.

3 What are other names for RU486?

4 Why do people use RU486 and how does it work?

5 Other than pills, in which forms can hormone-based contraceptives be used?

6 (a) Name the two hormones that may be used in a male contraceptive pill.
(b) Outline how these hormones can be used to prevent fertility.

7 What are hormones and where are they produced?

8 Are all parts of the body affected by a particular hormone? Explain.

9 List some functions that hormones control and regulate.

10 Why is adrenaline referred to as the 'fight or flight' hormone?

11 Insulin and glucagon both help regulate your blood glucose level. How are they different?

12 Which hormones cause many of the changes that take place during puberty?

13 Construct a table to summarise how the endocrine system is different from the nervous system.

INVESTIGATE, DISCUSS AND PRESENT

14 Find out what other effects ethylene may have on plants.

15 Discover more about the hormones used to increase milk or food production (for example, lactation in cows and goats or growth in cows, sheep or chickens). Gather information on the advantages and disadvantages of these hormones. Use the information in a class debate entitled: *Hormones should be used to increase food production for humans*.

16 Find out and report on hormones that could be used to the advantage of humans. Present your information in an advertising brochure.

17 A synthetic chemical called pyrethrin is increasingly being used in sheep dip. It breaks down within a few days, but during that time it can kill many types of invertebrates in the waterways.
   (a) Why are sheep dipped?
   (b) How could sheep dip reach waterways?
   (c) Suggest implications for the deaths of invertebrates on other organisms.

18 (a) Find out about the history, development and side effects of RU486.
   (b) Search media resources and the internet for arguments for and against the availability and use of RU486.
   (c) Share and discuss your information with others in your team.
   (d) Reflect on your findings and discussions and then state your opinion on the availability and use of RU486. Give reasons for your opinion.
   (e) As a class, be involved in a debate on RU486.

19 Find out more about research on male contraceptives. Prepare a newspaper article or brochure outlining your findings.

20 Male and female fertility patterns are different. Find out the key differences and comment on how they may affect the development and use of effective hormone-based contraceptives.

21 The presence of chemical wastes in water supplies and our environment has caused some concern. Some of these chemical wastes contain hormones or chemicals that interfere with hormones. Find out and report on two examples of these.

THINK AND DISCUSS

22 Use the information provided in this section to make up your own summary mind map on the endocrine system.

23 Suggest some advantages and disadvantages of the effects of adrenaline in modern-day living.

24 How might hormone replacement therapy help reduce the effects of menopause in women?

25 What three things do the endocrine system and the nervous system have in common?

INVESTIGATE

26 Find out about other ways in which your body temperature is regulated.

27 How are hormones involved in the balance of water in your body?

28 Find out about the effects of having deficiencies in any of the hormones listed in the table at the beginning of this section.

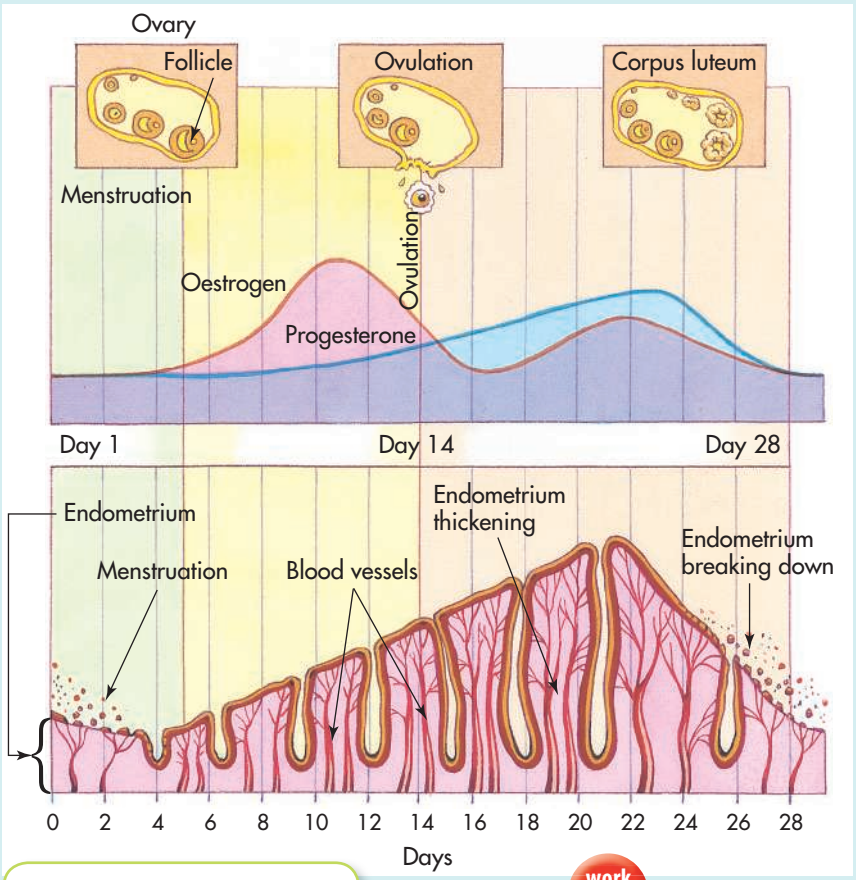
29 Investigate the statement: *Too much adrenaline can cause stress-related diseases*.

ANALYSING DATA

30 (a) Which hormone in the graph below is at the highest level just prior to ovulation?
   (b) When is ovulation likely to occur?
   (c) When is progesterone at its highest levels?
   (d) At what stage in the cycle is the endometrium the thickest?
   (e) Describe the changes in the concentrations of each of the hormones throughout the menstrual cycle.
   (f) Research the changes in the levels of FSH (follicle stimulating hormone) and LH (luteinising hormone) throughout the menstrual cycle.

CREATE

31 Use the diagram in this section illustrating the control of blood glucose as a guide to write and act out a play about how blood glucose is controlled in your body.



Hormones 'direct' the menstrual cycle.

work sheet 3.6 The endocrine system

Living warehouses

It can be confusing trying to figure out what a healthy diet is when you are bombarded by so many different fad diets!

Many of these diets eliminate whole food groups and may put you at risk of developing a nutritional deficiency. Knowing how your body stores and uses energy — like a living warehouse — may help you to weigh up the risks and benefits of these 'wonder diets'.

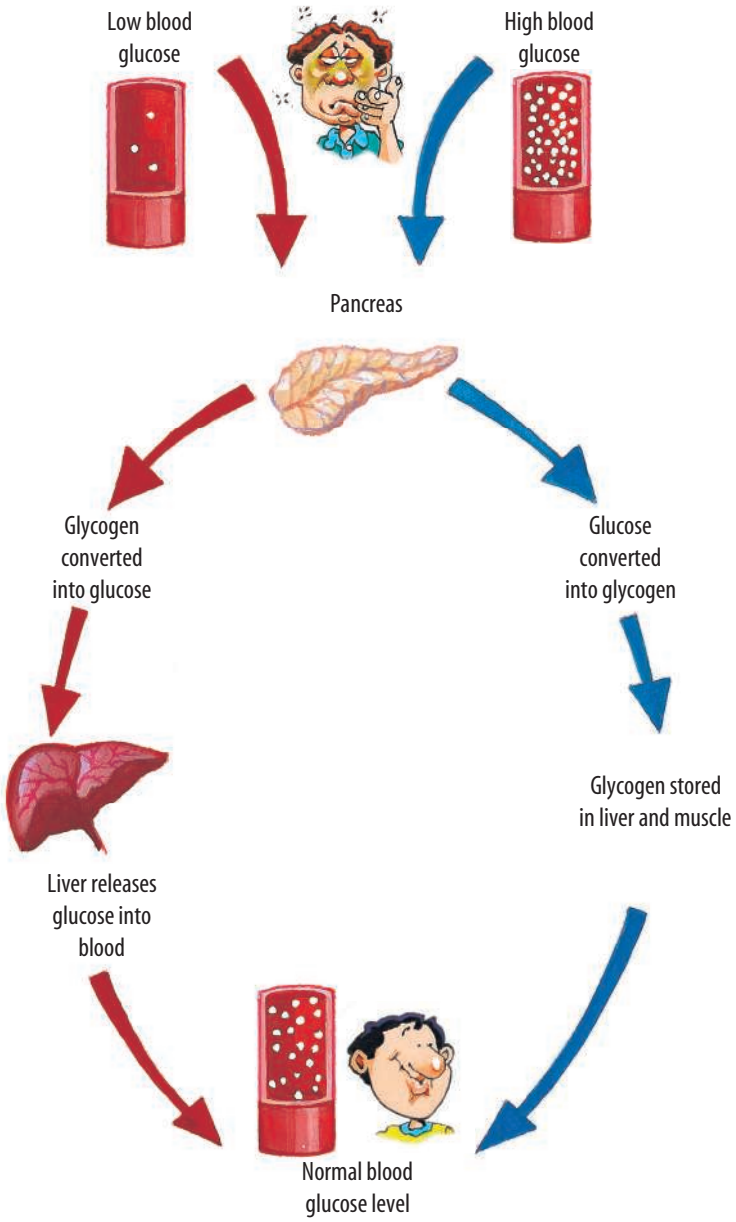
Your own food storage system

Only a small amount of glucose is required in your blood to provide your cells with energy. Your pancreas contains special cells that sense when there is too much glucose in the blood and then it releases insulin into the bloodstream. Your bloodstream carries this substance to the liver, which converts glucose into the main animal storage carbohydrate, glycogen. Glycogen is stored in your liver and muscle tissue.

Your pancreas stops making insulin when the amount of glucose in your blood gets too low. Glucagon is another hormone secreted by your pancreas. It tells your liver to convert glycogen back into glucose. The glucose may then be released into your bloodstream to keep your blood sugar balanced. Humans are able to store enough glycogen to provide the energy needed for about half a day of moderate level activity.

People who have too much sugar in their blood and cannot effectively convert glucose to glycogen are suffering from a condition known as **diabetes**. In this case, the liver does not effectively convert glucose into glycogen.

One of the latest food fads is the low carbohydrate diet. Although you may initially lose weight, this is because you are depleting your glycogen stores rather than losing any fat. The weight loss is due only to loss of water and carbohydrates.



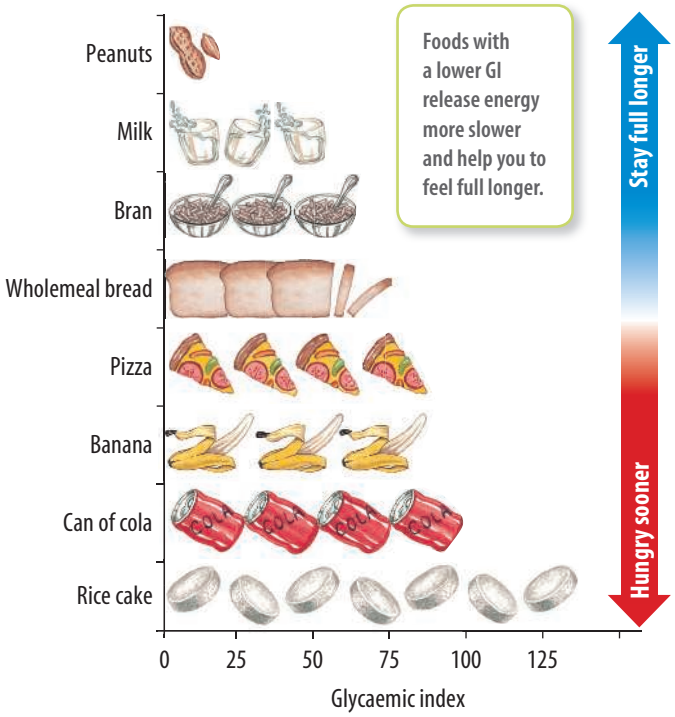
Keeping your blood sugar level balanced. The pancreas releases insulin to convert excess glucose into the storage carbohydrate glycogen. When the amount of glucose in your blood is low, the pancreas releases glucagon to convert glycogen back into glucose.

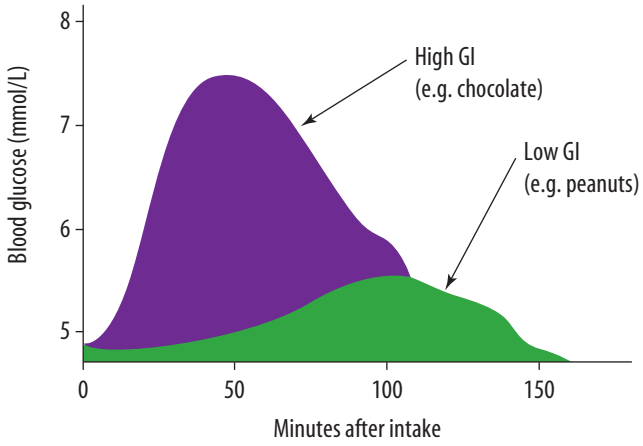
What is the glycaemic index?

Recently, there has been a trend towards selecting the foods in your diet on the basis of their **glycaemic index (GI)**. The glycaemic index measures how fast a particular food raises the blood sugar level over a two-hour period. The quicker the carbohydrates in the food are broken down by your digestive enzymes, the higher the GI value and the greater its effect on your blood sugar level.

FOODS WITH A HIGH GI

Foods such as white bread, rice and mashed potatoes contain starch and sugar, which are porous and have a high surface-to-volume ratio. This means that they can be digested easily by the enzyme amylase. Such foods have a high glycaemic index and can cause a sharp rise in blood sugar. These foods are very good if you have been active and need to replenish energy stores quickly. The chart and table below show some foods that will supply energy quickly and some that will help you to feel full longer.





Foods with a high GI, such as chocolate, cause a sharp rise in blood sugar. Foods with a low GI, such as nuts, result in a more moderate but longer lasting rise in blood sugar.

FOODS WITH A LOW GI

Foods rich in fibre, such as wholemeal bread and thick pasta like spaghetti, are digested more slowly. This is because the more compact physical form of these foods makes it harder for the enzyme amylase to reach its substrate. These foods cause only a moderate change in your blood sugar level, so can help provide you with lasting energy throughout your day.

The table below indicates the glycaemic index of a range of foods. The graph above shows the energy spike and drop that occurs after eating high GI foods, and the more moderate, longer lasting rise in blood sugar level after eating low GI foods.

Glycaemic index	Extremely high	High	Moderately high	Moderately low	Low
Grains	Puffed rice Cornflakes White bread	Wholemeal bread Muesli Brown rice Porridge oats	Bran Rye bread White pasta Brown pasta	Tomato soup Lima beans	Barley
Fruit and vegetables	Parsnip Baked potato Carrot	Sweetcorn Mashed potato Boiled potato Apricots Bananas	Sweet potato Peas Baked beans grapes Orange juice	Pears Apples Orange Apple juice	Red lentils Soybeans Peaches Plums
Sugar	Glucose Honey	Sucrose			
Snacks		Corn chips Chocolate Crackers Biscuits Low-fat ice-cream	Potato chips Sponge cake	Yoghurt High-fat ice-cream	Peanuts

Fats, feasts and famines

The ability of your ancestors to store high-energy molecules may be how you got to be here today. Fats are especially rich in energy, providing about twice as much energy as the equivalent amount of carbohydrate or protein.

When more kilojoules of energy are consumed than required, the body tends to store the excess energy in the liver and muscle cells as glycogen. If glycogen stores are full and the energy intake still exceeds that required, the excess may be stored as fat in the form of fat cells just beneath the skin.

When extra energy is required, the liver glycogen is used first, then the muscle glycogen and finally the fat. Most people have enough fat cells stored to provide energy for 3–7 weeks. The human body tends to hoard fat, immediately storing fat molecules obtained from food.

Most people should consume about 30–40 g of fat a day. The table below indicates some common takeaway foods and their fat content per serving.

The amount of fat in your diet can have a more direct effect on weight gain than carbohydrates. Although fat hoarding can be a liability today, it may have increased the chances of survival of your hunting and gathering ancestors. Recent discoveries suggest that the regulation of fat storage may be controlled by a hormone called leptin and several genes inherited from your parents.

Fat content of some takeaway foods

Food	Fat (g) /serve
Burger & fries	53
Chicken & chips	48
Bacon burger	48
Spaghetti carbonara	45
Burger	39
Chicken burger	23
Fried rice	14
Skin-free chicken	13
Spaghetti napoletana	13
Minestrone soup	6
Dim sim (1)	4
Japanese roll	2

How much energy do you need?

The amount of energy that you need depends on:

- how active you are
- how big you are
- how quickly you are growing
- how fast your body uses it.

The table below shows the recommended energy intake for children, adolescents and adults.

Group	Age	Recommended daily energy intake (kJ)	
		Male	Female
Children	1	5 000	4 800
	5	7 600	6 800
	9	9 000	7 900
Adolescents	12	9 800	8 600
	13	10 400	9 000
	14	11 200	9 200
	15	11 800	9 300
Adults (height 190 cm)	18–30	12 000	10 600
	30–60	11 400	9 500
	over 60	9 700	8 800

HOW ABOUT THAT!

When food supplies are scarce, or during hibernation, an animal's ability to store energy reserves greatly assists its chances of survival. Penguins, for example, use their fat reserves to provide them with energy when required. Male emperor penguins are able to keep eggs warm for nine weeks at a time without any food. Animals that live in cold regions also use their fat storage ability to insulate themselves against the very cold weather conditions. Whales and seals have a thick layer of fat cells called blubber, which serves as an insulation layer in their cold, watery habitats.

INQUIRY: INVESTIGATION 3.7

Measuring the energy in food

KEY INQUIRY SKILLS:

- questioning and predicting
- planning and conducting

Equipment:

small metal basket (used to fry food)

samples of small biscuits, potato chips, uncooked pasta, crouton or small piece of toast

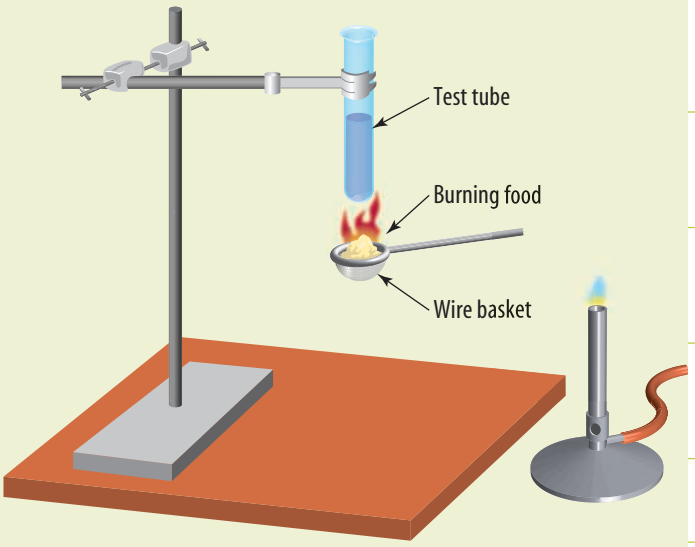
thermometer

retort stand, bosshead and clamp

large test tube

Bunsen burner

measuring cylinder



CAUTION: Before starting this experiment, read all the steps below and make a list of the risks associated with this activity and how you plan to minimise these risks.

- Use the clamp to attach the test tube to the retort stand.
- Measure 30 mL of water and pour it into the test tube.
- Measure the temperature of the water.
- Weigh the biscuit.
- Place the small biscuit in the wire basket and set fire to it using the Bunsen burner. When the biscuit is alight, put the basket containing the biscuit underneath the test tube. The heat released from the burning biscuit will heat the water. Hold the basket under the test tube until the biscuit is completely burned. You can tell that the biscuit is completely burned if it is all black and will not re-ignite in the Bunsen burner flame.
- Measure the temperature of the water again.
- Calculate the amount of energy that was stored in the biscuit, using the following equation.

  Energy (in joules) = 4.2 × volume of water (in mL) × increase in temperature (in °C)
- Calculate the amount of energy per gram of food by dividing the amount of energy by the mass of the food.
- Repeat the steps above using the other food samples.
- Copy and complete the table below.

Food	Biscuit	Chip	Pasta	Crouton/ toast
(a) Mass of food (g)				
(b) Volume of water (mL)				
(c) Initial temperature of water (°C)				
(d) Final temperature of water (°C)				
(e) Increase in temperature (= $d - c$)				
(f) Energy in food (J) (= $4.2 \times 30 \times e$)				
(g) Energy in food (kJ) (= $f \div 1000$)				
(h) Energy per gram of food (kJ/g) (= $g \div a$)				

DISCUSS AND EXPLAIN

1 Copy and complete the aim of this experiment: 'To compare the amount of _____ contained in a range of foods'.

2 Copy and complete the conclusion: 'The food that contained the most energy per gram was _____'.

3 Why was it necessary to calculate the amount of energy per gram of food?

4 Did all the heat from the burning food go into heating the water? Explain how this might have affected the validity of this experiment.

CHILDHOOD OBESITY ON THE RISE

Jacqueline Freegard

Obese primary school children are showing signs of diseases normally only seen in overweight adults, research has revealed.

High levels of hyperinsulinism, fatty liver and other complications have been found in children as young as six.

Obese and overweight children were also found to suffer from sleeping disorders, depression, bullying and muscle pain.

Dr Zoe McCallum from the Murdoch Childrens Research Institute said increasing numbers of overweight children were presenting with the early stages of serious diseases, including type 2 diabetes.

'We know there is increasing liver disease, increasing hyperinsulinism and increasing raised blood fats,' Dr McCallum said.

'And we know that there are children being diagnosed with type 2 diabetes at a younger age, which is traditionally seen in the adult population.'

Dr McCallum said the incidence of childhood obesity in Victoria has tripled in the past 15 years.

One-in-four Victorian children is overweight or obese, with 5 to 6 per cent classified as obese.

Australia now matched US rates of childhood obesity.

'We are following our American cousins and getting fatter faster than America,' she said.

'There are more obese children and they are carrying much more weight than they ever have.'

The study found overweight and obese children were unlikely to show symptoms of underlying diseases.

'These children on the whole, apart from the fact they are clearly carrying too much weight, will actually be quite healthy and may not suffer any ill effects from having these abnormal blood tests,' she said.

Dr McCallum said the study, from Perth's Princess Margaret Hospital, found parents were generally unaware of the problems associated with obesity.

'It won't be until 10 or 20 years later that there will be an impact,' she said.

'Children who have raised insulin, raised blood fats and elevated liver enzymes have hard evidence of future risks of diseases that do shorten life.'

Detecting the diseases early meant young children could be cured.

'The beauty of detecting it in kids is you can actually do something about it,' she said.

'If we slow the rate at which a child puts weight on then we can reverse some of those results.'

But she said even very young obese children suffer from the stigma associated with the disease.

Source: Herald Sun, 1 June 2005

UNDERSTANDING AND INQUIRING

REMEMBER

1 How does the pancreas know when to release insulin into the bloodstream?

2 Why is glycogen stored in your body? Which organ converts glucose to glycogen?

3 How is fat storage different from carbohydrate storage?

4 How does your body provide itself with energy once its fat reserves are used?

5 Outline two ways in which fat storage assists the survival of animals.

6 What happens when we eat more kilojoules that we use?

7 How can you eat a diet high in kilojoules and not put on weight?

8 Describe the effects of the hormones insulin and glucagon on blood sugar levels.

9 What has the glycaemic index of foods got to do with blood sugar levels?

10 When would it be a benefit to eat high GI foods?

11 List examples of:
   (a) high GI foods
   (b) low GI foods.

USING DATA

12 Use the table in this section that shows recommended energy intakes to answer the following questions.
   (a) Plot a graph to show how energy needs change with age. You will need to plot two lines: one for males and one for females. The age should be on the horizontal axis. (If a computer is available, you could use a spreadsheet.)
   (b) Why do you think females seem to need less energy?
   (c) Why do you need more energy as you approach your late teens?

THINK

13 Read the article *Childhood obesity on the rise* above and answer the following questions.
   (a) How much has the incidence of childhood obesity in Victoria increased in the last 15 years?
   (b) Create a mind map on the problems that have been found in obese primary school children.
   (c) Brainstorm ways to reduce the incidence of obesity in Australia.

THINK AND INVESTIGATE

14 Use the nutrition information in section 3.2 and other sources to put together a menu for a day that has the recommended daily kJ for your age.

eBookplus

15 Use the **Kilojoule Burn calculator** weblink in your eBookPLUS to learn how many calories you will burn from performing a number of common exercises.

Getting back in control

Imagine not being able to move. Your brain tells your legs or arms to do something but they ignore you. How would it feel? What can you and science do to help?

Damage to the spinal cord of the nervous system may be the result of a disease or an accident or be congenital (already present at birth). Whatever the cause, this type of damage can be devastating and debilitating.

Although there is currently no cure for spinal injury, teams of scientists around the world are involved in research that is aimed at improving the quality of life for those with this injury. Perhaps a technology not yet developed may one day lead to a cure.

Paralysis and spinal injury

All of the nerves in your peripheral nervous system throughout your body connect to your spinal cord. Damage to this cord can prevent communication of messages between your brain and your body. This loss of communication can lead to **paralysis** (loss of movement).

Damage to different parts of the spinal cord results in different types of paralysis. For example, if you were in an accident in which the lower back section of your spine was completely crushed, messages would not be able to travel between your legs and feet and your brain. This loss of communication would mean that you would not be able to sense pain, heat, cold or touch in these parts of your body. You would also be unable to stand or walk as you would not be able to control the muscles in your legs and feet.

Christopher Reeve, an actor who played Superman in a series of early movies, damaged his spinal cord in the neck region in a sporting accident. The consequence was that he was paralysed below the neck and required the use of a machine to breathe air into and out of his lungs as he was unable to breathe for himself. In the years following his accident he raised awareness of spinal injuries and increased public and political interest in related research.

Actor Christopher Reeve raised awareness of the consequences and need for research related to spinal injuries.

Paralysis and disease

A number of diseases can also result in paralysis. One such condition is motor neuron disease. Although the cause of this disease is still unknown, its effects are devastating. While the brain and the senses are usually unaffected, the person with the disease becomes increasingly paralysed.

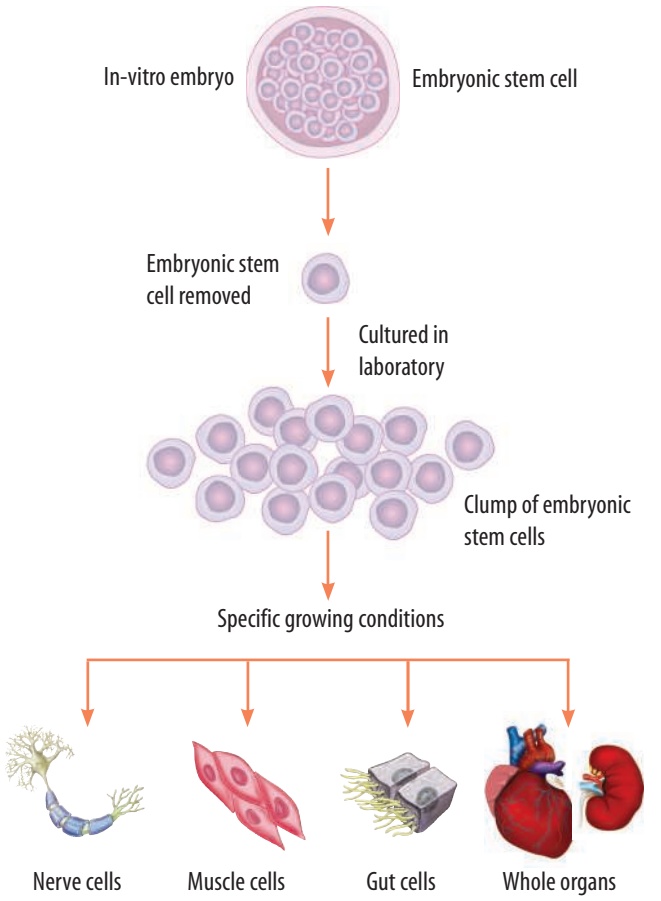
Motor neuron disease, as the name suggests, targets motor neurons and progressively destroys them. Sensory neurons, however, remain unaffected. This means that a person paralysed with motor neuron disease could hear and see a mosquito, feel it biting their arm, feel the itchiness, but be unable to move to scratch it or talk to tell someone to scratch it for them.

People with motor neuron disease sense their environment, but increasingly cannot respond to it. This paralysis eventually involves all muscles within the body. Sadly, motor neuron disease is fatal.

Stem cells — a possible treatment?

Embryonic stem cells (a topic introduced in *Science Quest 8*) have many properties that scientists find exciting. They can produce new cells for longer than other cells and under the right conditions they can be made to differentiate into particular cell types. Some current research is investigating the injection of nerve cells produced from embryonic stem cells into the site of spinal injury. Although it is early days for this research, it is hoped that it may lead to the recovery of muscle function in some cases.

Although the possible applications of this research are exciting, technologies involving the use of human embryonic stem cells are fraught with issues and controversy. Most of this debate centres on the source of the stem cells — human embryos that have been obtained from the surplus embryos of couples undergoing IVF treatment.



The use of stem cells to treat (and possibly even cure) a variety of diseases is being investigated. The research is, however, accompanied by much debate.

Brain-control interface technology

Currently making an entrance into the mass market are games and toys which utilise **brain-control interface technology**. In these applications, computer software in 'mindsets' are used to decode brain wave patterns and facial movements to bring about particular responses in the external environment (for example, moving an object by just thinking about it).

Broader applications of this technology, for example **implanted electrodes** and **neural prostheses**, are being researched and developed in order to provide assistance to people with a variety of disabilities. There have already been cases in which paralysed people have been able to move their wheelchairs by just thinking about the movement, or those who are unable to talk have been able to use their brain to result in their thoughts being spoken aloud.

Could such technology be used in other ways — could it be used to help blind people to see, and deaf people to hear? What other senses could be assisted using this technology? Could it be used to enable us to experience senses that humans do not currently possess?

Brain-control interface technology has many possible applications.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Define the terms *spinal cord*, *paraplegia*, *quadriplegia* and *paralysis*.

2 Outline the properties that make stem cells interesting to researchers.

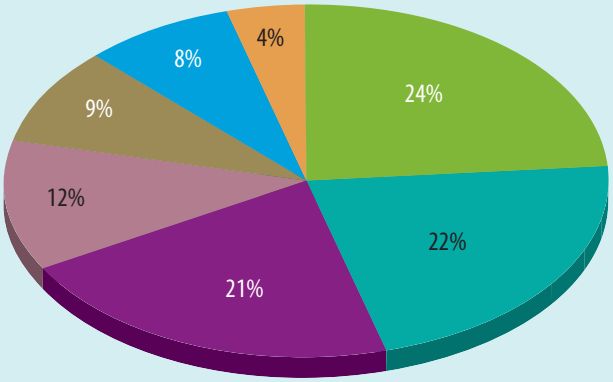
3 Describe evidence that suggests that stem cells may one day be used to restore some mobility after a spinal injury.

4 Outline how brain-control interface technology can bring about body responses.

5 Describe an application of implanted electrodes or neural prostheses.

THINK

6 Use the graph below showing the causes of spinal injury to answer the following questions.



(a) What are the two leading causes of spinal injury?
(b) What percentage of spinal injuries are sports related? Suggest which sports might have the highest risk of spinal injury.

7 Explain why an injury in the neck region of the spinal cord may result in quadriplegia, whereas an injury in the lower back region of the spinal cord may result in paraplegia.

8 Imagine that you are on an ethics committee for a university. An ethics committee is a group of people that decides whether experiments should be carried out on ethical grounds. Discuss whether you would allow scientists to do experiments that involve deliberately crushing the spinal cord of rats.

INVESTIGATE

9 Draw a map to show the location and type of wheelchair access available at your school. Do the same for your local shopping centre. Are there any places it would be impossible for a disabled person to get to? Find out from your local council what regulations there are relating to wheelchair access to parks and public and commercial buildings.

Standard disability parking and access signs

10 Investigate some improvements to wheelchair design that have been made in the last 20 years.

11 Find out about wheelchair designs for particular sports such as wheelchair basketball and racing.

THINK, INVESTIGATE, DISCUSS AND CREATE

12 Formulate questions about brain-control interface technology that could be investigated scientifically and then design an experiment that could be used to investigate one of your questions.

13 Intercranial electrodes may be very useful in brain-control interface applications and benefit those who are paralysed or have conditions such as motor neuron disease.
(a) As a group, formulate questions about intercranial electrodes, brain-control interface applications, paralysis and motor neuron disease.
(b) Research questions proposed by your group and then discuss your findings.
(c) Suggest further questions that could be explored and research these.
(d) Use your imagination and creativity to share your findings as a model, a science fiction story, an animation or a multimedia documentary.

14 (a) Find out more about modern brain implant technologies.
(b) Suggest ethical issues that may be raised about the research and application of these technologies.
(c) Organise a class debate that considers various perspectives on these technologies.

Relations diagrams and mind maps

1. Write the problem or situation that you are going to analyse in the centre of a sheet of paper.
2. Ask yourself possible reasons why the problem occurred.
3. Write your answers (causes) around the problem. These are your primary causes.
4. Ask yourself why each cause occurred: for example, 'What might the cause of the cause be?'.
5. Write these secondary causes around each primary cause and join them with arrows to show how they are linked.
6. Look for other links in your diagram and add arrows to show these.
7. Colour or highlight those you think are the main causes of the problem.

how to ...?

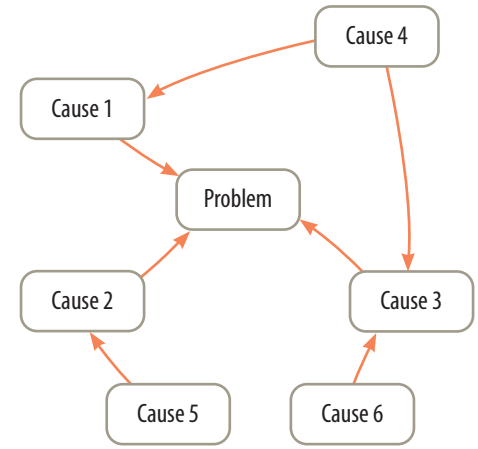
why use?

Helps you to see possible reasons for difficult situations or problems

question

What is causing this problem?

Relations diagram



also called

Multi-flow map; process map

comparison

Similarity

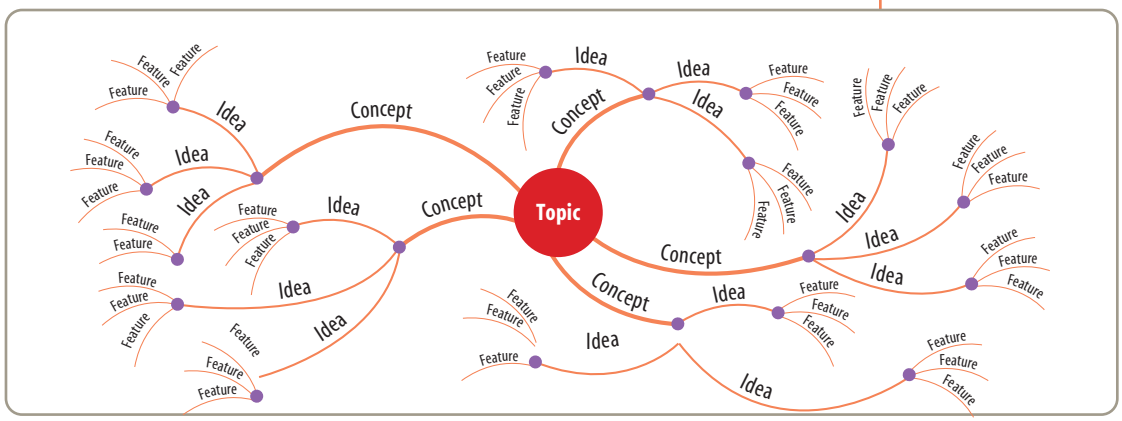
Both show graphically the structure of a topic in a hierarchical way.

Difference

Concept maps explain the relationship between the parts or elements with statements on the links.

Mind map

example



UNDERSTANDING AND INQUIRING

THINK AND CREATE

1 Overheating can lead to heat exhaustion. This is your body's response to an excessive loss of water and salt (in your perspiration). If you get too hot, heat exhaustion may lead to heatstroke. When this occurs you may be unable to control your body temperature and death may result.

(a) The relations diagram above shows some causes of overheating. In a team, suggest some other possible causes of overheating that could be added to the diagram.

(b) Construct a mind map of a team brainstorm on symptoms of overheating, heat exhaustion and heatstroke, strategies that could be used to avoid heatstroke, and treatments for heat exhaustion and heatstroke.

2 Having extremely low body temperature is also potentially life threatening. This condition is called hypothermia. Find out more about this condition and present your findings in a relations diagram.

3 Thermoregulation is the process whereby your body tries to keep your internal body temperature stable. Find out how your voluntary behaviour and your nervous and endocrine systems can help to cool or heat you. Present your findings in a mind map with diagrams or hyperlinks.

4 Use the following questions to find out more about the singing behaviour of a particular species of bird. Present your findings in the form of a mind map or web page with bird songs included, or a mind map with hyperlinks to relevant websites or resource information.

(a) Why do birds sing?

(b) When do birds sing? Are they more likely to sing at certain times of the day?

(c) Do male and female birds of your chosen species both sing? If so, what do their songs sound like?

(d) Do some birds in your species sing better than others? What is 'better' and how can it contribute to sexual selection and evolution?

(e) What does research suggest about how birds recognise a song?

(f) How may hormones be involved in bird songs?

(g) Attempt to imitate your bird's song.

5 (a) Use the information entitled *Hairy stuff!* below to construct a relations diagram on some causes of hairiness.

(b) Find out more about one of the disorders or diseases that has increased hairiness as a symptom. Present your findings in a mind map.

Hairy stuff!

Hormonal changes throughout life can cause changes in hair type and how it's produced. For example, prior to puberty, facial hair is a fine, thin type (vellus hair). Hormones released once puberty occurs can transform facial hair into a coarse, pigmented variety (terminal hair). While the growth of vellus hair is not affected by hormones, the growth of terminal hair is.

When females are experiencing menopause, there may be changes in the ratio of male and female hormones (androgens to oestrogen). This hormonal ratio change can produce an increase in facial hair. Heredity can also play a part in facial hair as it determines how thickly hair follicles are distributed throughout your skin.

Some medications and substances can cause hairiness (hirsutism). These include testosterone, steroids, Minoxidil, Rogaine and some blood pressure medication. Hairiness can also be a symptom of a number of disorders or diseases such as adrenal disorders (including Cushing's syndrome), anorexia nervosa, polycystic ovary syndrome and some pituitary disorders.

STUDY CHECKLIST

DIGESTIVE AND CIRCULATORY SYSTEMS

- identify nutrients that are essential for a healthy body
- provide examples of two vitamins and two minerals that are essential for your health and possible consequences of deficiencies
- outline the overall function and key components of the digestive system and circulatory system
- use flowcharts to describe how structures within the digestive system and circulatory system work together

EXCRETORY AND RESPIRATORY SYSTEMS

- outline the overall function and key components of the excretory system and respiratory system
- use flowcharts to describe how structures within the excretory system and respiratory system work together

NERVOUS SYSTEM

- state the function of receptors and provide examples of at least three types
- use a flowchart to show how receptors are involved in your ability to sense your environment
- use a flowchart to describe the stimulus–response model
- describe how negative feedback can assist you in maintaining homeostasis
- outline the overall function of the nervous system
- outline the key components of the nervous system
- draw a labelled diagram of the structure of a neuron
- use a flowchart to show how a message is conducted and transmitted in the nervous system
- compare and contrast nervous impulses and neurotransmitters
- use a flowchart to describe the process involved in a reflex action
- explain the need for some reactions to be reflex actions
- compare reflex actions with those under conscious control
- describe how damage to the nervous system can result in paralysis
- outline the effects of motor neuron disease on the ability to sense and respond to the environment

ENDOCRINE SYSTEM

- outline the overall function and key components of the endocrine system
- recall the main glands of the endocrine system and some of the hormones they produce
- use a diagram to show how the stimulus–response model can be used to describe the involvement of the endocrine system in homeostasis

ICT

eBookplus Summary

eLESSON

Robotic heart surgery

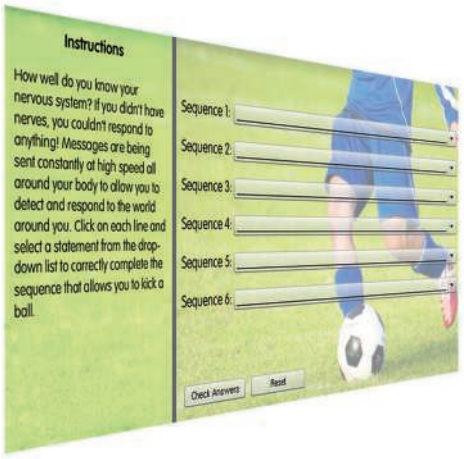
Watch an ABC Catalyst report to find out how the treatment of the heart condition atrial fibrillation is being revolutionised by the use of robotic systems.

Searchlight ID: eles-1081

INTERACTIVITIES

A nervous response

In this interactivity, your knowledge of the nervous system is tested by challenging you to identify the sequence of events required to kick a ball.



Searchlight ID: int-0670

A bundle of nerves

Learn more about your nervous system by completing this interactivity in your eBookPLUS.

Searchlight ID: int-0015

INDIVIDUAL PATHWAYS

eBookplus

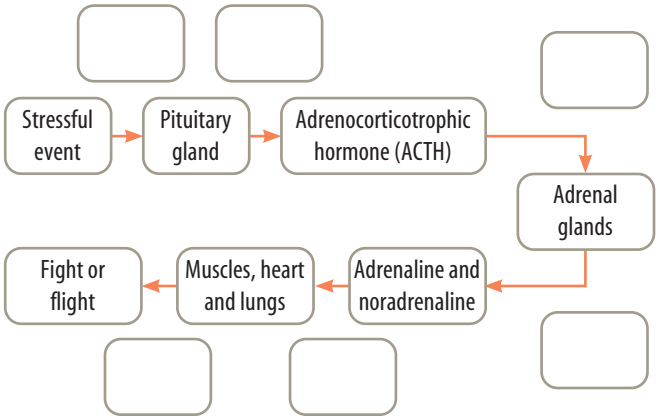
Activity 3.1
Revising control and coordination

Activity 3.2
Investigating control and coordination

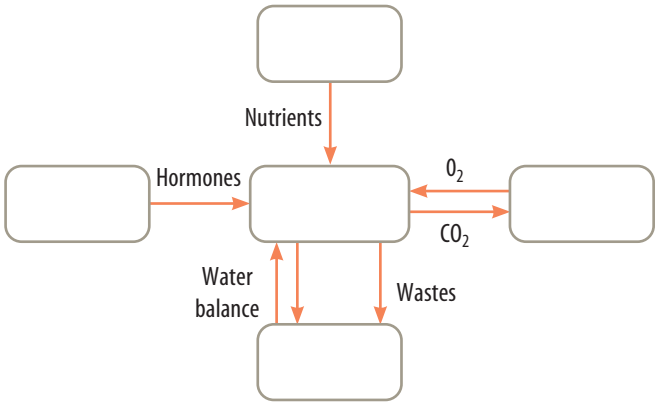
Activity 3.3
Investigating control and coordination further

LOOKING BACK

1 The flowchart below shows a series of events that may occur when you encounter a stressful event. Suggest descriptions or labels for each of the links.



2 Suggest which body systems belong in each of the blank boxes in the figure below.



3 When is 'dead enough', good enough? There have been claims in the media that some organ donations have occurred when people were in the process of dying rather than being completely dead. Is near enough, good enough? On the basis of your scientific knowledge, what do you think about this issue? What is your personal opinion on this issue? Does your opinion on this issue match that of your scientific understanding? Discuss this issue with others in the class.

4 Tasty words and colourful letters? It is thought that about 4 per cent of the population have their senses crossed and associate letters with a flavour, numbers with a gender or sounds with a colour. This is called synaesthesia. It would be hard for people with synaesthesia to imagine a world without this extra perception. Find out more about this process and suggest how it might lead to the perception of a different world. Imagine having synaesthesia and describe what the world might be like.

5 Underline the incorrect term in each sentence and replace it with the correct term. Write definitions of the incorrect words you replaced.

(a) The neuron carries hormones to target cells.
(b) The master gland of the endocrine system is the adrenal gland.
(c) The brain and spinal cord make up the peripheral nervous system.
(d) Each molecule has tissues which carry out particular functions.

6 Construct a flowchart to show:

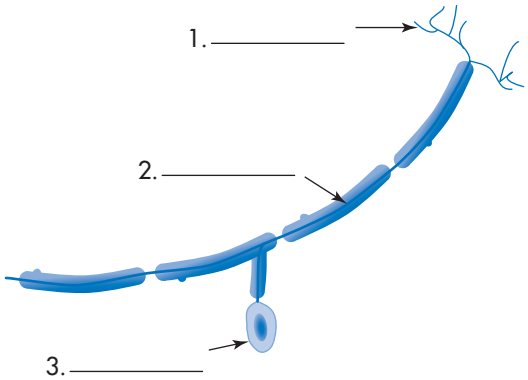
(a) the following terms in order from smallest to largest:

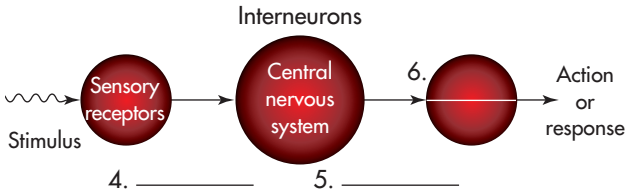
organs	tissues
organelles	systems
cells	atoms
molecules	

(b) the stimulus–response model.

7 Place the following labels in the correct places on the diagrams below.

dendrite	sensory neurons
nerve cell body	effector
axon	motor neurons





8 Construct a table to summarise the differences between the nervous and endocrine systems. Make sure you include the name of the information each system produces, how that information is carried throughout the body, and the speed and length of each system's response.

9 Draw a flowchart that outlines what happens when you sit down on a chair that has a sharp object on it. Include both nervous and endocrine responses.

work sheets
3.7 Body systems: Puzzle
3.8 Control and coordination: Summary