9

Communicating with energy

How can we better use energy to more effectively communicate with one another?

Our modern world could not function without communication and we are using faster and faster ways to communicate. Faster communication requires faster decisions and less time to consider any alternatives. In the days of posting a letter, a conversation between two people may have taken 3 months, or longer if one person were in Adelaide, and the other in London. The introduction of the telephone made it seem as though the two people were talking in the same room.

Communication technologies have developed to keep pace with the needs of society, and energy plays a big role in this.

What do you already know about energy?

Activity 9.1

Energy mind map

Use the list of terms on the right to begin a mind map about energy. Place the word 'Energy' at the centre of a page and arrange the terms and make connections to show what energy is, and what energy does.

Add to your mind map as you continue through this unit to show your developing understanding of energy and energy transfer.

WEB 2.0

You could use FreeMind, PersonalBrain, Edraw, Mindmap or XMind to produce your mind map.

Heat energy terms

gets warmer	stays the same
gets cooler	is hot
loses	is cold
gains	melts
increases temperature	freezes
decreases temperature	boils
changes	condenses
moves	liquid
moves faster	solid
moves more slowly	

Culminating assessment task

Hello? Can you hear me?

Have you ever tried to make a mobile phone call only to find that you have no reception? Mobile phone reception relies on energy transfer by waves.

Good reception requires that signal quality be maintained from its source to the final destination. Loss in quality of the signal will occur if some of the energy is redirected or dissipated (reflected, absorbed) as non-useful energy.

Method

Choose two communication technologies from the following list to compare and contrast reception in your local area.

- Mobile phone (3G, LTE, 4G)
- FM or AM radio
- Digital television
- ADSL (Asymmetric Digital Subscriber Line) or ADSL 2
- NBN (National Broadband Network) (optic fibre)

ACTIVITY SHEET

Rubric: Hello? Can you hear me?

SCI09SUAS00228

As part of your research you should do the following.

1 Explain how each of your communication technologies is part of the electromagnetic spectrum.

2 Explain how the signal gets from its source to the customer.

3 Explain what types of media the signal is transferred through.

4 Compare the signal coverage or availability in your area for your chosen communication technologies.

5 Research the advertising claims made by the companies that supply these services. Explain how you might test any of the claims made in the advertising.

Presentation

Choose how you would like to communicate your findings. Check with your teacher before finalising your choice.

WEB 2.0

You might like to create a glog, a prezi or an animation using Xtranormal.

ISBN 9780170189262

Waves – energy that travels

Figure 9.1 A wave is a disturbance in a medium such as water.

When you drop a pebble into water, ripples radiate out from the centre. These ripples are called waves. Waves are a disturbance in the surface of a medium, in this case water. A similar disturbance can occur in the air, only we cannot see it. Waves are disturbances that carry energy. They travel through space and time. We can use waves for a large number of purposes. We use radio waves, microwaves or light waves to convey messages over great distances. Our bodies use light and sound waves to detect the environment.

Anatomy of a wave

There are seven quantities that define every wave: wavelength, frequency, crest, trough, amplitude, period and wave speed.

ANIMATION
Anatomy of a wave
SCI09SUAN00229

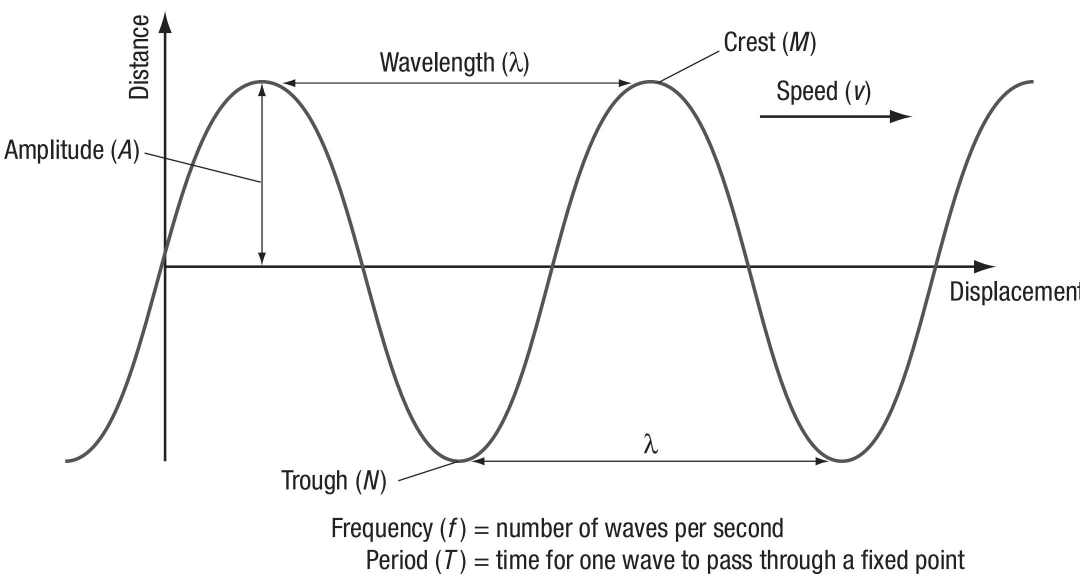

Figure 9.2 The seven quantities of a wave

glossary terms

energy
a fundamental quantity that can only be identified in terms of transfers from place to place or transformations from form to form

wave
a disturbance that moves through time and space, carrying energy

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Activity 9.2
Spider map

WORKSPACE
Spider map
SCI09SIWR00227

Create a spider map using the seven quantities that define a wave. On each of the spider's legs, write one word only that is a key word to explain what the quantity refers to. Share your spider map on the class wiki.

As a group, look at the variety of key words that others used and select the words you think are the most important. Use these to create a word cloud with Tagxedo or Wordle to help define the seven quantities of a wave. Upload these to the class wiki.

There is accepted terminology on how to describe a wave.

The length of a wave (measured in nanometres to kilometres), or its wavelength (λ), is measured from the crest of one wave to the crest of the next wave. The length of the wave indicates its energy level. A wave with a short wavelength has high energy. A wave with a long wavelength has low energy.

The frequency (f) of a wave indicates the number of waves per second. It is measured in hertz (Hz). One wave (or cycle) per second is equal to 1 Hz. A high-pitched sound such as a scream will have a large number of waves per second and is said to have a high frequency.

The crest (M) of a wave is the point at which it has its maximum upward value. A trough (N) is the opposite of a crest. It is the point at which a wave has its minimum downward value.

The amplitude (A) of a wave is the height of the wave from its rest position. A sound wave of higher amplitude is higher in volume and, conversely, a sound wave of lower amplitude is lower in volume.

The period (T) of a wave is the time (in seconds, minutes or hours) for one complete wave to move past a fixed point (for example, from crest to crest).

The speed of a wave refers to how fast the wave moves in a certain amount of time. For example, if you stand 170 m from a cliff face and shout, it would take 1 second for the echo to return to you. The speed of the wave would be 340 m/s.

WOW!
Waves in the ocean

Wind-generated ocean waves usually have periods of 5–20 seconds and wavelengths of 100–200 m. A tsunami can have a period in the range of 10 minutes to 2 hours and wavelengths of 20–500 km.

Activity 9.3
Observing wavelength

It is possible to see a wavelength.

Materials
- microwave-safe plate
- pack of marshmallows
- access to a microwave oven
- digital camera

Method
1. Arrange marshmallows on a microwave-safe plate side by side so they cover the whole plate.
2. Remove the turntable from the microwave oven and place the plate with marshmallows into the microwave oven.
3. Turn on the microwave oven to high power for about 30 seconds. Open the door and check that melted spots have appeared. If not, close the door and heat again in short bursts. Not all the marshmallows will melt. Only those at the maximum and minimum amplitudes of the wave will melt. The spots of melted marshmallows will be separated by half a wavelength.
4. Take a digital image of your marshmallows and label the wavelength. Upload your image to your blog.
5. The frequency is listed on the back of the oven. Multiply the frequency by the wavelength to calculate the speed of the microwave.

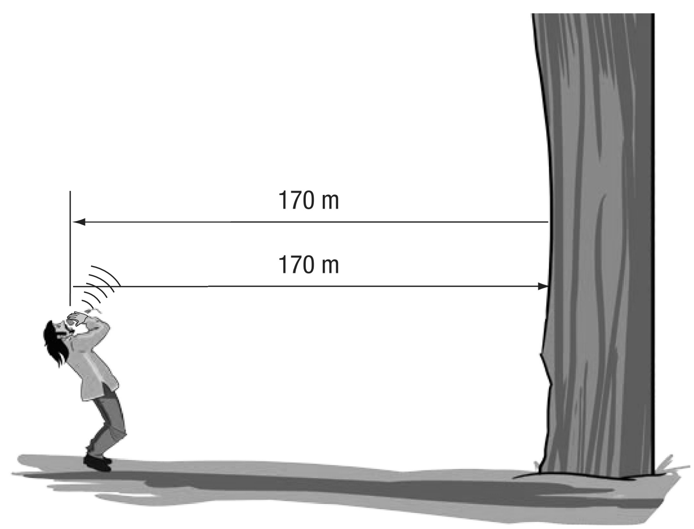

Figure 9.3 It would take 1 second for the echo to return, so the speed of the wave would be 340 m/s.

INTERACTIVE
Seeing with sound
SCI09SUIN00231

ISBN 9780170189262

Mechanical transfer of energy

You will remember that all materials are made up of atoms. When one atom in a material 'bumps' the next atom, energy is transferred mechanically. This continues and the energy is transferred to the next atom in the line. Some waves are mechanical waves, and require a medium for the wave to travel in or to propagate. Water waves and sound waves are the most commonly experienced mechanical waves.

Vibrations cause the atoms in solids and air to move and hence produce sound waves. As the density of air is less than that of a solid, air carries sound vibrations more slowly than solid objects. Different air conditions cause changes in the speed of sound. Sound travels faster in hot air than in cold air because the air particles are moving faster and the vibrations

Activity 9.4
Visualising frequency

WORKSPACE
Visualising frequency
SCI09SUWR00230

Frequency of vibration can be observed when a ruler is allowed to overhang the end of the desktop and made to vibrate when sprung.

Try this yourself and then try changing the length of the overhang of the ruler. How does this alter the frequency of vibration and the sound heard?

Activity 9.5
Oobleck dance

WORKSPACE
Oobleck dance
SCI09SIWR00232

Materials

- oobleck (mixture of cornflour and water)
- large speaker inside a plastic bag
- digital video camera

Method

1. Connect the speaker to an amplified sound source or signal generator.
2. Pour the oobleck onto the speaker cone and turn on the sound source. Play some music and change the volume. What do you notice about the oobleck 'dance' as the volume changes?
3. Record your observations with the video camera.
4. Explain your observations using the terms 'vibration', 'amplitude' and 'frequency'. Create a movie or slide show of your findings and publish it on your class wiki.

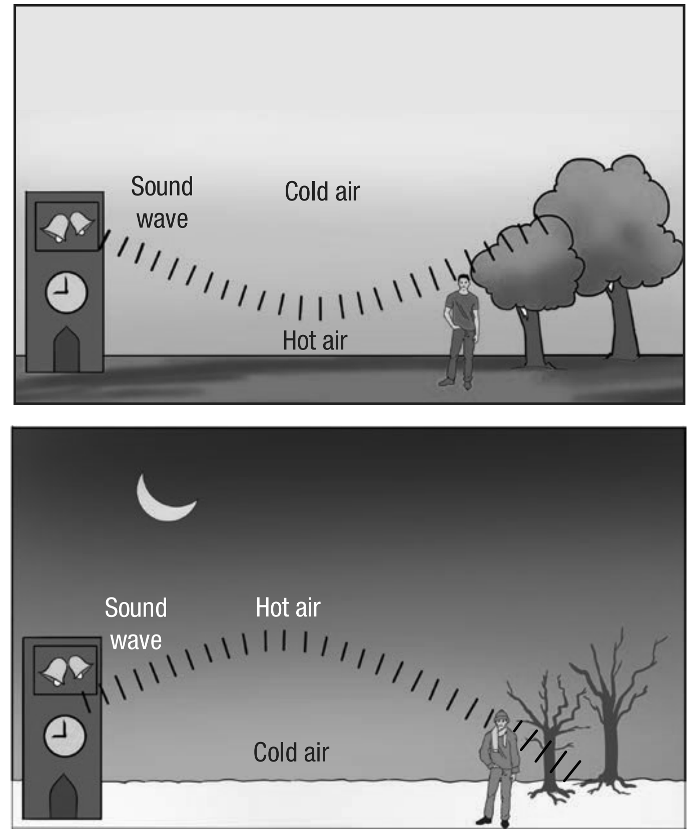

Figure 9.4 Sound travels faster in warm, foggy air. In cool air, the sound bends down and so is heard by people far away. In warm air, sound travels upwards and away, and so is not heard by people far away.

glossary terms

amplitude (*A*)
the height of a wave from its rest position

crest (*M*)
the point at which a wave is at its maximum upwards value

frequency (*f*)
the number of waves per second

hertz (Hz)
the unit of frequency: 1 Hz = one wave per second

period (*T*)
the time for a particle to move through one complete wave cycle

propagate
to begin

trough (*N*)
the point at which a wave is at its maximum downwards value

vibration
a rapid continuous movement

wavelength (λ)
the length from the crest of one wave to the crest of the next wave

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Activity 9.6
Sound waves

WORKSPACE
Sound waves
SCI09SIWR00233

1 Place your ear on the table or desktop and tap the surface. Listen for the vibration. Lift your ear from the surface and repeat the tapping. What do you observe?

2 How can you explain your observations?

3 Whales can communicate across long distances. Earthquakes can be 'heard' (or felt) at long distances because the energy travels quickly through the particles in solid rock (see P and S waves on page 194). Explain these phenomena in terms of the particle model (*Nelson iScience 8*, Unit 4).

4 Use the particle model to explain how sound waves travel in solids and liquids.

Activity 9.7
Air cannon

WORKSPACE
Air cannon
SCI09SIWR00234

Materials

- balloon
- large plastic cup with the end cut off
- thick sticky tape
- candle
- matches

Method

1 Stretch the balloon over the large end of the cup. Secure it in place with the sticky tape.

2 Stretch the balloon and quickly release it. What do you observe?

3 Find out how far the air pulse can travel by directing it towards a lit candle. How far can you place the candle away from the air cannon so that it is still blown out?

Discussion

Would an air cannon work in space? Explain.

are transmitted faster. Cool, foggy air allows the sound of a ship's foghorn to travel faster over larger distances. This creates the illusion that the ship is closer than it is. When sound travels from hot air to cold air it will refract (bend).

Slinky waves

A toy slinky can demonstrate two different types of waves. These waves can be either transverse (across) or longitudinal (along) waves. The motion of a wave and the motion of the medium that carries that wave may be different.

WEBLINK
Longitudinal and transverse waves

A transverse wave shows movement at right angles to the direction of energy flow. A water wave is a transverse wave. An object in the water moves up and down as the wave passes, the energy passes through and the object remains stationary. A surfer moves with the energy in the wave.

A longitudinal wave moves to and fro in the direction of energy flow. A longitudinal wave is sometimes called a pressure wave. A sound vibration is a longitudinal wave of pressure changes.

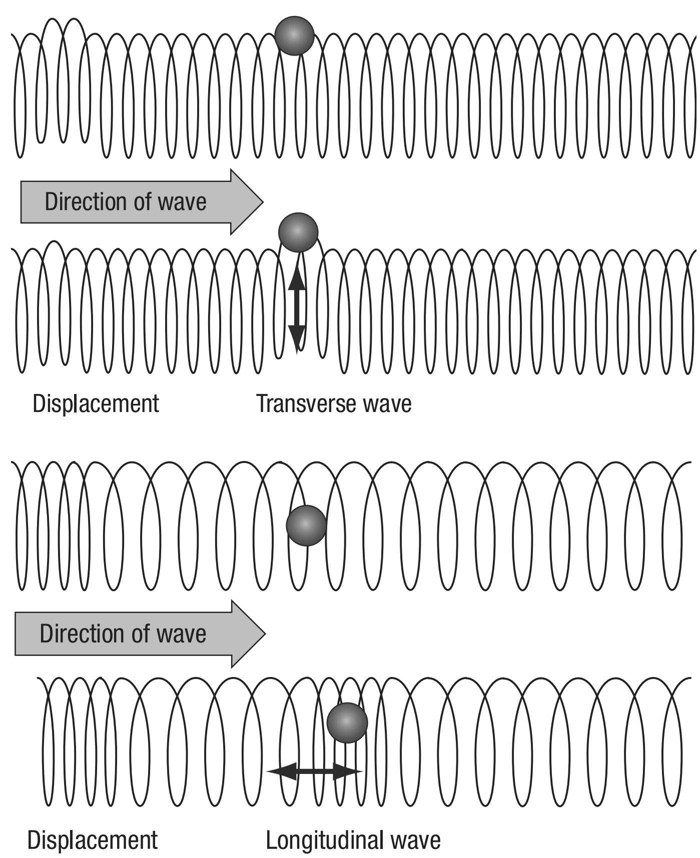

Figure 9.5 Slinky with transverse and longitudinal travelling wave

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ACTIVITY SHEET
Slinky waves
SCI09SIAS00235

VIDEO
Types of waves
SCI09SUVD00236

Electromagnetic radiation

Electromagnetic radiation (EMR) is a form of energy that shows wave-like behaviour as it travels through space. It ranges from long-wave radiation (lower energy) to short-wave radiation (higher energy).

The spectrum of radiation is known as the electromagnetic spectrum (Figure 9.6). The waves are classified according to their frequency and wavelength. You can see that radio waves and microwaves have a low frequency and a long wavelength whereas gamma rays have a high frequency and short wavelength. Electromagnetic radiation spreads out from its source in straight lines in all directions. Light for example travels in straight lines from its source.

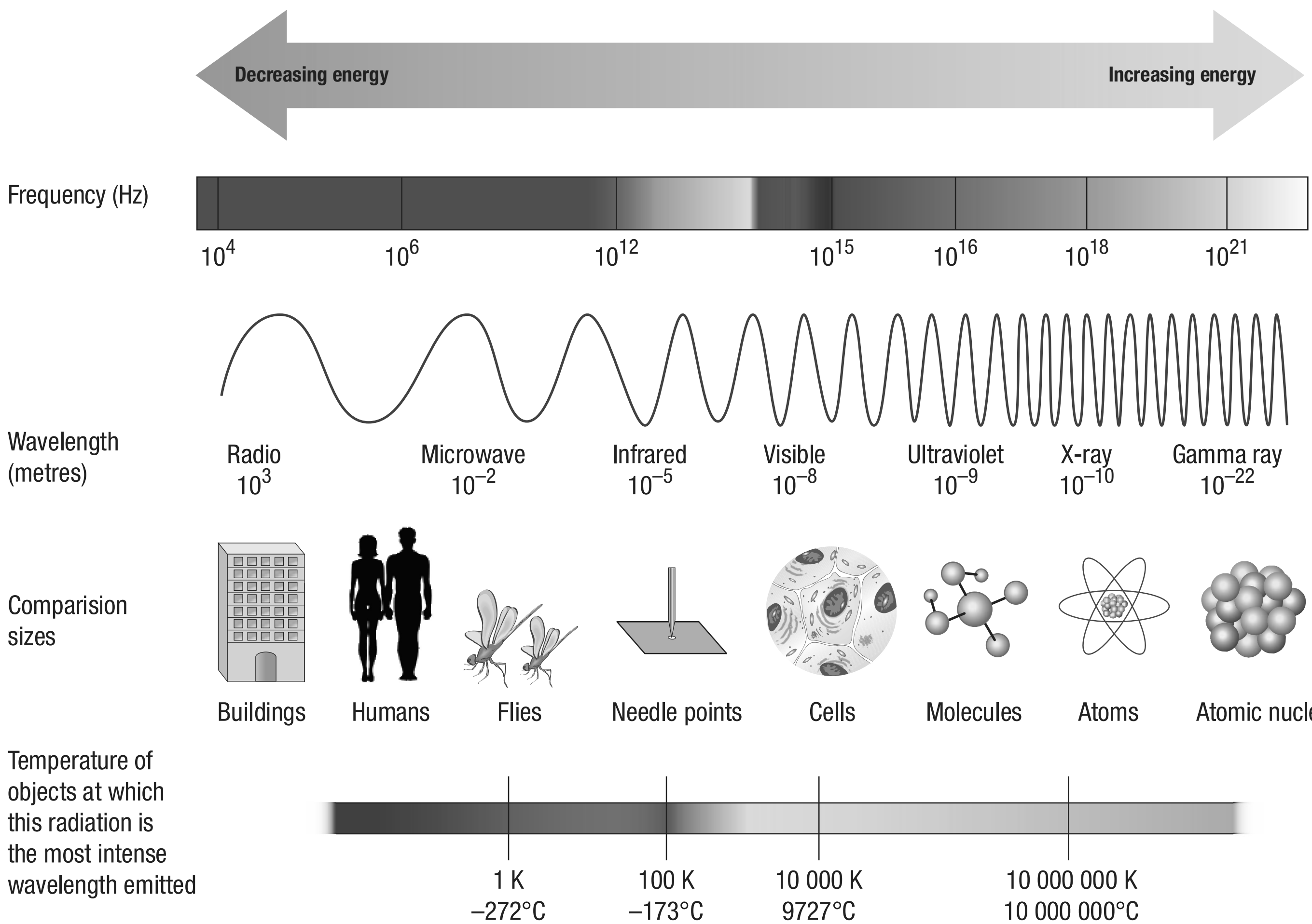

Figure 9.6 Electromagnetic spectrum

glossary terms

electromagnetic radiation (EMR)
energy that shows wave-like behaviour

electromagnetic spectrum
electromagnetic radiation classified according to frequency and wavelength

longitudinal
along the length of an object

refract
bend

transverse
at right angles to where the energy was propagated

ISBN 9780170189262

Activity 9.8

Slinky standing wave speeds

WORKSPACE

Slinky standing wave speeds

SCI09SIWR00237

The aim of this activity is to find out how fast a slinky standing wave wiggles.

Materials

- slinky (able to be stretched to 4 m)
- measuring tape
- timer or stopwatch
- calculator or spreadsheet program
- safety glasses

Method

Two people hold the slinky at either end. A long area is needed for this activity. The slinky works best on a smooth floor surface.

Part A

1 Stretch the slinky to a length of 2 m.

2 Predict the time it will take for a 'big arc' wave to travel along the slinky.

3 Measure the time for 10 cycles of a big arc wave. You will need to practise shaking the slinky so there is one peak only. Move your hand quickly to get one peak.

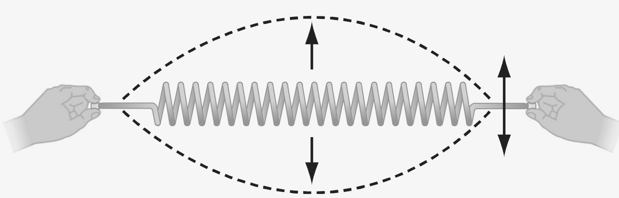

Figure 9.7 Big arc wave and wavelength

4 Record this time in your data table.

5 Repeat steps 1–4 five times.

6 How close was your prediction?

Part B

7 Stretch the slinky to a length of 3 m.

8 Predict the time it will take for a big arc wave to travel along the slinky.

9 Measure the time for 10 cycles of a big arc wave.

10 Record this time in a data table.

11 Repeat steps 7–10 five times.

12 How close was your prediction?

Part C

13 Stretch the slinky to a length of 4 m.

14 Predict the time for one cycle of a 'big arc' on a 4 m slinky.

15 Measure the time for 10 cycles.

16 Record this time in a data table.

17 Repeat steps 13–15 five times.

18 How close was your prediction?

Results

1 Construct a data table. Calculate the average time for one cycle for each slinky length.

2 Make a graph of slinky length against time.

3 What happens to the cycle time as the slinky is stretched? Predict the expected cycle time for the slinky if it were stretched to 6 m long (do not do this).

Conclusion

How does the length of the slinky change the time for one cycle?

ACTIVITY SHEET

Extension

SCI09SIAS00238

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Uses of electromagnetic radiation

X-ray radiation is short-wavelength radiation of high energy. X-rays travel through different materials differently. This property of X-rays makes them useful for medical analysis. X-rays pass through body tissue but not dense objects such as bone. Hence, they can be used to take images of bones to diagnose for breaks, dislocations and other injuries.

VIDEO
Biomedical beamline at the Australian Synchrotron
SCI09SUVD00240

Microwave radiation has a longer wavelength and lower energy than X-rays. Microwaves can pass through food. The heat energy is absorbed by the fats, sugars and water in the food. This property of microwave radiation makes it ideal for cooking and reheating food.

Microwave radiation is also used by air traffic controllers and speed limit enforcers in radars to detect remote objects.

Figure 9.8 X-rays are used to diagnose breaks such as this broken finger.

Activity 9.9
X-ray career

WORKSPACE
X-ray career
SCI09SHWR00241

1 Research on the Internet a list of careers that use X-rays. Remember that X-rays can detect abnormalities of the skeletal system and can be used at airports to examine the contents of luggage.

2 Select one of the careers. Create a blabber and record information about this career as if you were in this field of work. Discuss your education, places you work, hazards involved in your type of work and safety precautions you take. Upload the link to your blabber in your blog.

WEBLINK
Blabberize

Figure 9.9 Microwaves are used in speed detection radars.

Radio waves have the longest wavelengths (they can be longer than a football oval) and low energy. They travel at the speed of light (3×10^8 m/s or 300 000 km/s) as does all electromagnetic radiation. They were first discovered by James Clerk Maxwell in 1865. In 1887 Heinrich Hertz demonstrated that they could be used for communication.

VIDEO
Microwaves and radio waves
SCI09SUVD00242

ISBN 9780170189262

Questions 9.1

What have you learnt?

WORKSPACE
What have you learnt? 9.1
SCI09SUWR00243

Understand

1 What is a wave?

2 List the seven quantities that define a wave.

3 What is electromagnetic radiation?

4 Put these examples in order of wavelengths, starting with long waves: red light, ultraviolet radiation, radio wave, X-ray, microwave, blue light, television, green light.

5 How is electromagnetic radiation classified using the electromagnetic spectrum?

6 How is wavelength related to energy?

7 What is the speed of light in metres per second? Show this using scientific notation and in long form.

8 List two ways that we use the different properties of radiation in the electromagnetic spectrum.

Apply

9 Draw a wave that has a:
   a short wavelength and low amplitude
   b long wavelength and high amplitude
   c long wavelength and low amplitude.

10 The speed of sound is 340 m/s.
   a In a thunderstorm, why is the lightning seen before the thunder is heard?
   b If the thunder arrives 7 seconds after the lightning is seen, how far away was the lightning strike?
   c How much faster is light than sound?

Analyse

11 Use a double bubble map to compare and contrast period and wavelength.

Synthesise

12 Create a set of flashcards to help you remember what you have learnt so far. Create your flashcards using Quizlet. Share your quizlet with a friend and then write about your friend's quizlet on your blog.

WEBLINK
Quizlet

13 Go back to your mind map and add your understanding of waves, electromagnetic radiation and the electromagnetic spectrum to it.

Energy as heat transfer

The particle model of matter (*Nelson iScience 8*, Unit 4) describes the three states of matter. The particles in the solid state are tightly packed and only able to vibrate. The particles in the liquid state are less closely packed and able to freely move over each other. The particles in the gas state are far apart and can move freely.

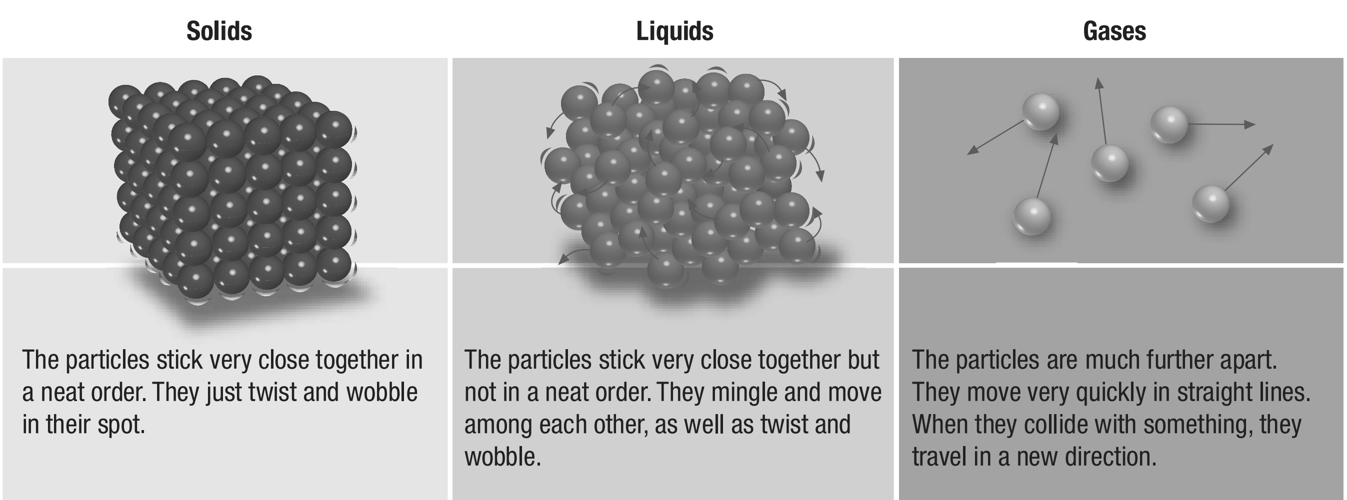

Figure 9.10 The three states of matter – solid, liquid and gas

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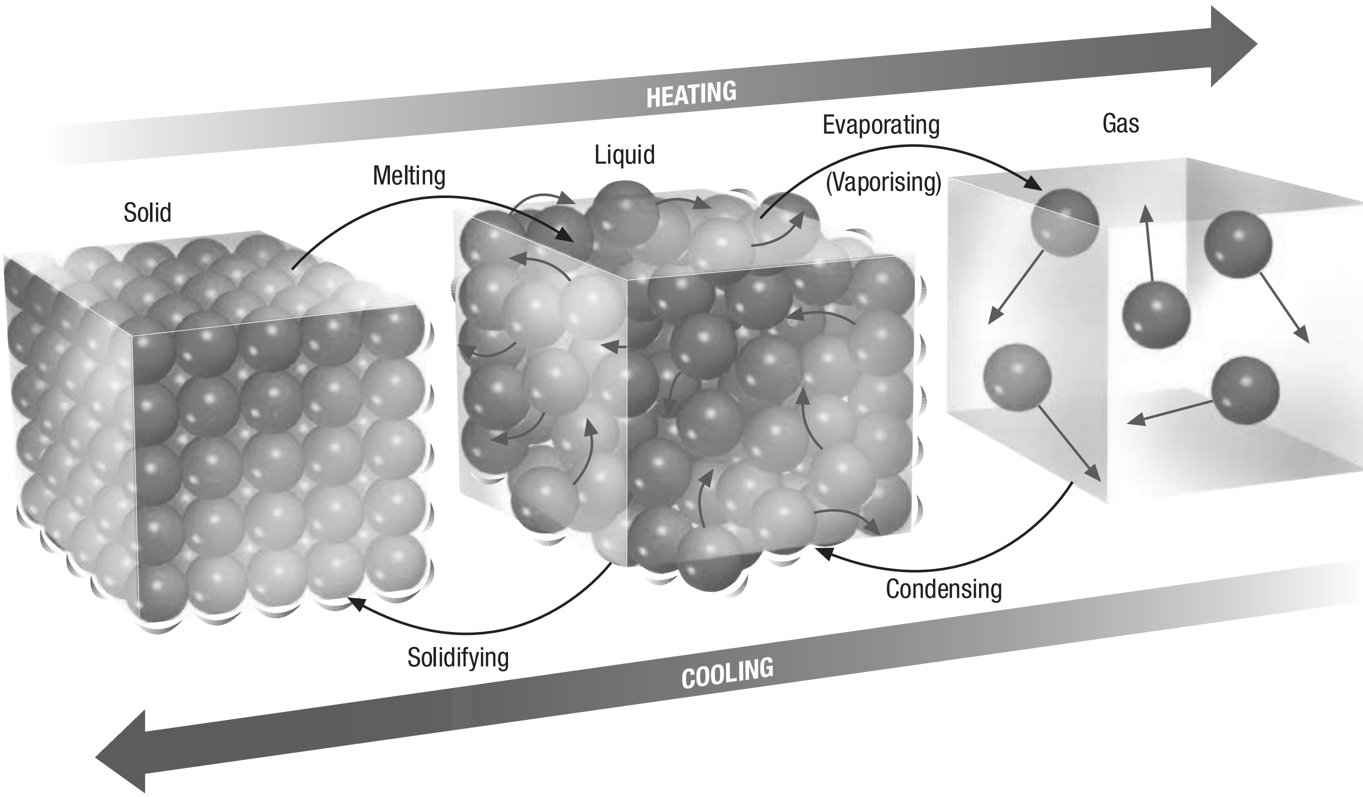

Figure 9.11 Transformation of the three states of matter

Activity 9.10

What can you remember?

Working in groups, develop a role-play or create an animation that demonstrates your understanding of how particles change state. Upload your creation to the class wiki.

The idea of heat energy is incorporated into this particle model as the amount of vibration or movement of the particles. If heat energy is supplied to a substance, then the particles in the substance move or vibrate faster. This also explains the change from one state to another. Increased vibration breaks the bonds between the particles and they move further apart, so a solid changes into a liquid (melting) and a liquid changes into a gas (evaporation). If energy is removed from the substance, the particles move closer together and move more slowly. The gas will change into a liquid (condensation) and the liquid will change into a solid (freezing).

If electromagnetic radiation comes into contact with a material, the radiation can be reflected away or changed to heat energy. When light from the Sun meets a particle, the radiation can be reflected, and the substance looks shiny, or the radiation can be absorbed and the temperature of the substance increases.

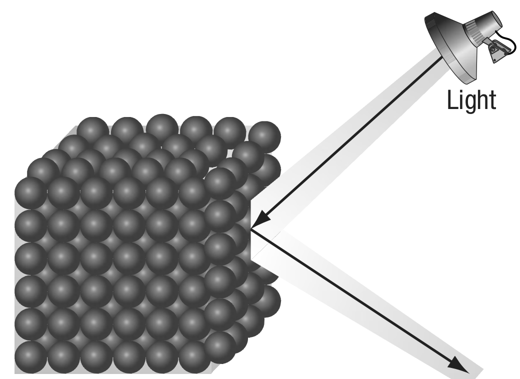

Figure 9.12 When light hits a particle, radiation is reflected away.

When a solid is exposed to electromagnetic radiation, the solid's surface gains energy and the temperature increases and the particles vibrate faster. Each particle in turn 'bumps' or transfers energy to its nearest particle neighbour. These nearby particles increase their vibration, which is detected as an increase in temperature. This is known as conduction.

glossary term

conduction
the transfer of energy through a solid object or objects

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When heat energy travels quickly through a substance, the substance is described as a good conductor of heat energy. When energy travels slowly through a substance, it is described as a poor conductor of heat energy or an insulator.

WOW!

Conductor and insulator confusion alert!

Electricity is the movement of an electric charge through a material. Electrical conductors and insulators are different from heat conductors and insulators. Some substances such as metals are good conductors of both heat energy and electricity. Some plastics are poor conductors but good insulators of heat energy and electricity.

a

b

Figure 9.13 **a** Metal is a good conductor of heat. **b** Wool is a good insulator.

Heat energy can also cause the particles in air or fluids to gain energy and displace the next particle. This is called convection. Convection occurs when gravity is present. The heated fluid (liquid or gas) expands and becomes less dense. The more dense material above pushes downwards and forces the hot fluid upwards. A candle in space is a good example. On Earth, the flame rises into its familiar shape because the hot gases are lighter than the surrounding cool air. But in orbit, where the effects of gravity are minimal, the hot gas does not rise above the cool air and so the flame is a small sphere (Figure 9.14).

a

b

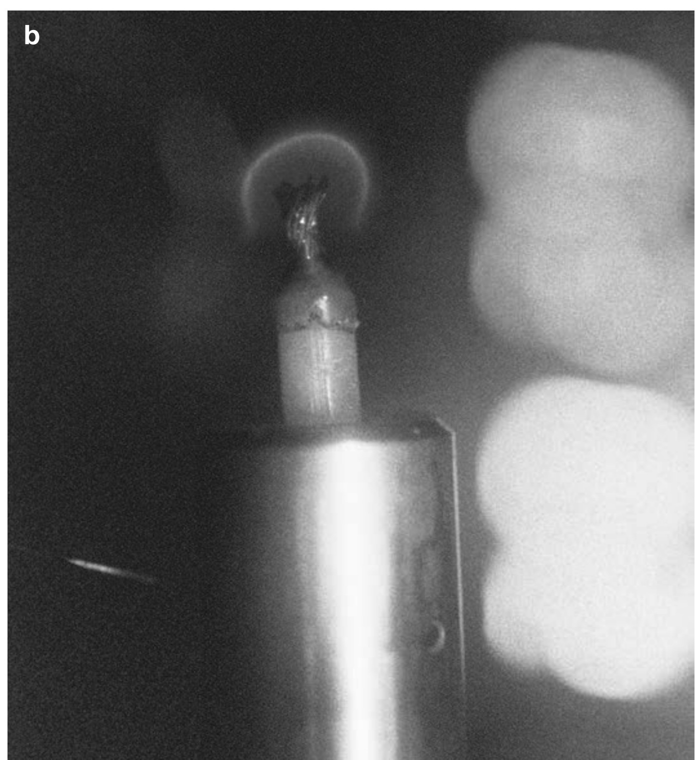

Figure 9.14 **a** Candle on Earth, **b** candle on the International Space Station

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Heat exchangers

Heat exchangers are an important part of every mechanical system (Figure 9.15). They either transfer excess heat energy away from the system or distribute heat energy more evenly within a system.

Heat exchangers are found in:

- the back of refrigerators
- car radiators
- reverse-cycle air conditioners
- evaporative air conditioners
- cooling gaps above LCD and plasma TVs
- the black metal grills around wood fire burners
- heat sinks in notebook computers, usually near the bottom of the screen
- heat vents behind a microwave oven
- exhaust fan outlets of vacuum cleaners
- cooling towers.

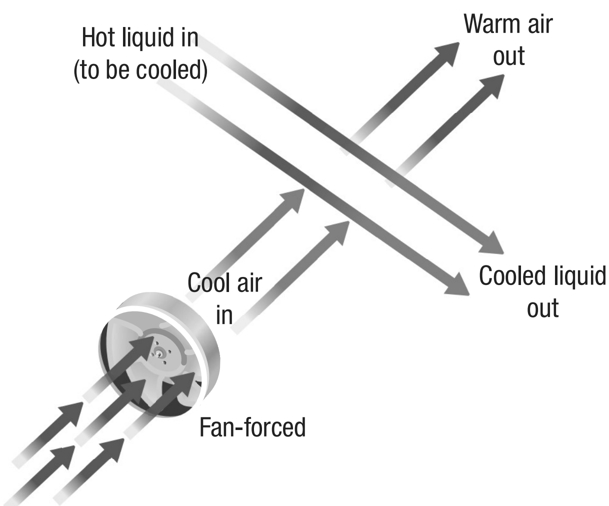

Figure 9.15 How a heat exchanger works

Vertical systems use convection to remove the hot air. Horizontal systems use a fan to force cool air to the heat exchanger.

Figure 9.16 A car radiator is a type of heat exchanger.

Investigation 9.1
Heat exchangers

WORKSPACE
Heat exchangers
SCI09SIWR00244

Aim

To investigate the best way to transfer heat energy from one material to another.

Method

1 Choose a heat energy exchange system from the list above or another system that you can describe.
2 Describe what the heat exchanger is doing. Is it heating or cooling? Where does the heat energy come from or go to?

glossary terms

conductor
a substance through which heat travels quickly

convection
transfer of energy through a gas or fluid

insulator
a substance through which heat travels slowly

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3 Observe and list the properties of the materials involved in assisting the heat energy transfer.

4 Draw a diagram of the heat exchange system.

5 Label the diagram and indicate the direction of heat energy movement with arrows (red arrow for hot, blue arrow for cool).

6 Construct a flowchart that shows the start and finish of the available heat energy.

7 Post your summary diagrams on the class wiki.

Extension

8 Use an infrared thermometer (non-contact thermometer) to measure the temperature of different locations of a heat exchanger. Annotate these temperatures as labels on your diagram or picture. Do not attempt to touch the heat exchanger because the temperatures may be greater than 60°C.

Figure 9.17 An infrared thermometer

Questions 9.2

What have you learnt?

WORKSPACE

What have you learnt? 9.2

SCI09SUWR00245

Understand

1 Why can radiation travel through space, but convection and conduction cannot?

2 Why do we place a lid on a saucepan being heated on the stovetop?

3 Write three possible questions for each of the following answers.

a Convection

b Conduction

c Radiation

Apply

4 Explain why candle flames have a pointy shape on Earth.

5 Explain why a candle on the space station has a flame that is round and very small.

Analyse

6 Use either a double bubble map or a Venn diagram to compare and contrast convection and conduction.

7 Complete a five whys analysis for the question: 'Why do we need to understand convection, conduction and insulation?'

Synthesise

8 How would you demonstrate energy transfer in solids, liquids and gases to a Year 7 student?

9 Space satellites are sometimes covered in a very thin, and very expensive, gold foil. Gold is a very good conductor of heat.

a Explain why there is a problem with heat and cold when space satellites are in orbit.

b What is the purpose of the gold foil?

10 Go back to your mind map and add your new understanding of energy transfer.

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Communication

Humans have always needed to convey messages to one another. Talking is the most common form of communication between humans (Figure 9.18). However, talking only allows you to communicate to people in your immediate area.

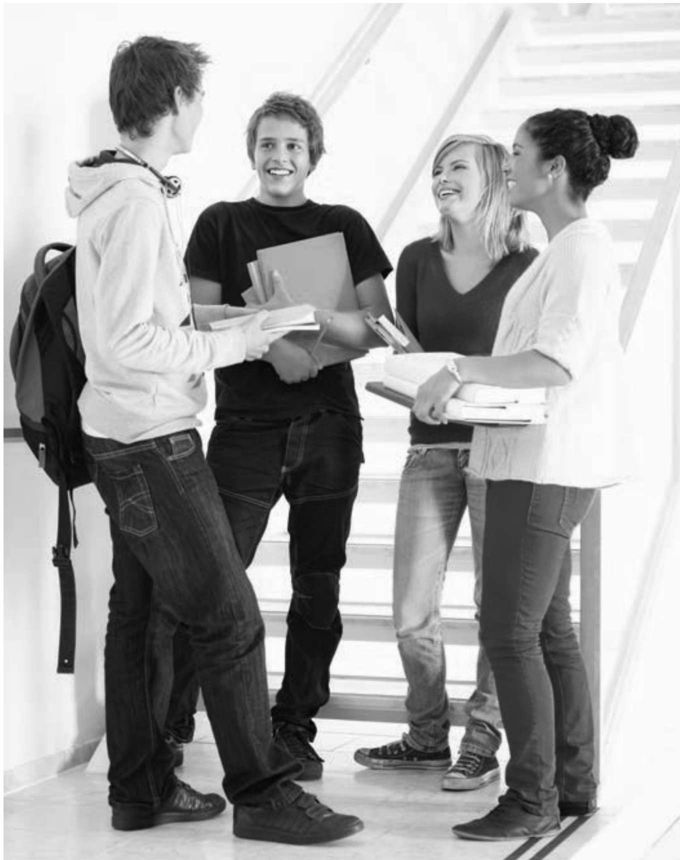

Figure 9.18 Talking is the most common form of communication.

Activity 9.11
Stages for communication

WORKSPACE
Stages for communication
SCI09SUWR00246

Imagine you need to get a message to your best friend who lives in the next suburb without using technology. Create a diagram, concept map or flowchart that shows some possibilities of the method (type) and the stages (sequence that the events occur in) for that communication to successfully occur.

WEB 2.0

You could use Gliffy to create your diagram, concept map or flowchart.

Methods of communication

There are a variety of different methods in which we can communicate. These include physically carrying the message and transferring it to the recipient, or transferring an electronic signal along a wire or by radio (wireless) from the sender to the recipient.

A message such as a phone call may be communicated direct and live in real time, which allows an interactive response or conversation. Or it could be a one-way recorded message, such as a letter. The message could be recorded by writing on paper or typing on a keyboard to a screen, or it could be an audio or video (and audio) recording.

Getting the message across

Successful communication requires there to be a sender, a message and an intended recipient of that message who is able to interpret the message. If a person sent you a written message in a language that you could not understand, then we cannot say that communication has occurred.

Over human history, a variety of methods have been used to communicate messages over long distances. In ancient Greece the first marathon runner, Pheidippides, travelled from the town of Marathon to Athens. He delivered a message that the Persians had been defeated in the Battle of Marathon (490 BCE). The distance that Pheidippides ran to deliver his famous message has been estimated to be 42.2 km, the distance of the modern marathon.

Table 9.1 Sequence of communication

Encode message	Transfer message	Decode message
Write on paper	Post or carry from point A to point B Scan and facsimile transfer by telephone network	Read message on paper
Type to screen	Electronic transfer on telephone network (ADSL)	Read message on screen
Record video	Electrical signal	Displayed and read on a screen
Record audio	Electrical signal	Changed to sound by speakers

glossary term

communication
conveying a message from a sender to a recipient

ISBN 9780170189262

Paul Revere was an American who is famous for communicating a message during the War of Independence in 1775. His famous midnight ride warned American troops of British troop movements. As he rode through Massachusetts, he relayed his message. As a result, many more set out on horseback to deliver the message. By the end of the night, over 40 riders were warning of British troop advances.

CONNECTION
English: Evolution of our language
SCI09SHCN00247

Figure 9.19 This bronze statue of Paul Revere in Boston, USA, commemorates his midnight ride in 1775 to alert troops of British movements.

Flagstaff Gardens in Melbourne was the location of the first astronomical observatory in Victoria. One of the daily duties of this observatory was to drop the timeball at precisely 6 pm. This was a signal to the ships in the bay so they would know the correct local time. Another timeball tower was situated in Williamstown, Victoria (Figure 9.20).

CONNECTION
History: Morse code
SCI09SHCN00248

Carrier pigeons were used in World War I to send information between command and the front lines. Messages were written onto waxed paper that was tied to a pigeon's leg or inserted into a small cylinder attached to the pigeon's leg.

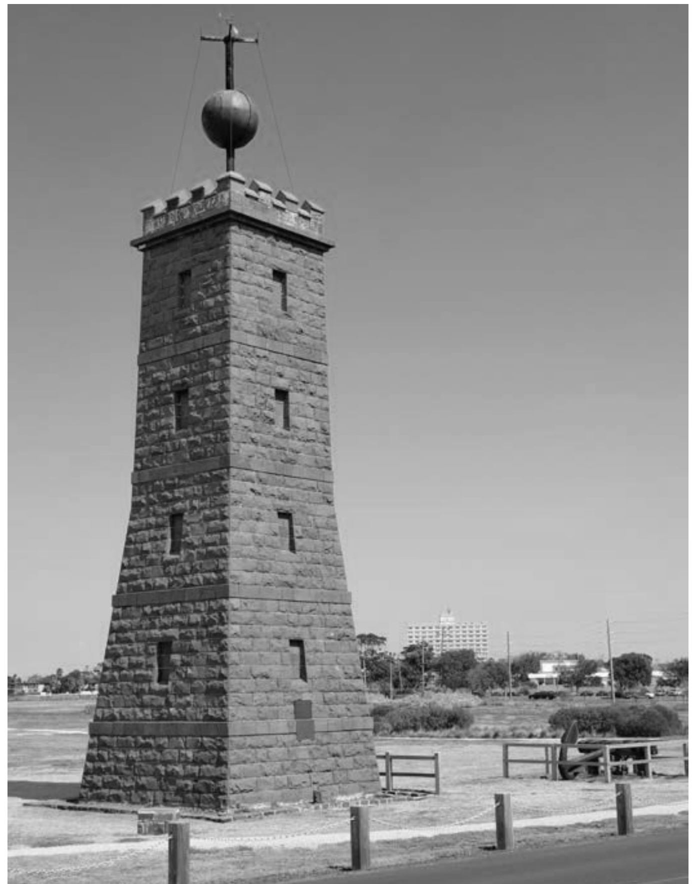

Figure 9.20 This timeball tower in Williamstown, Victoria, was used to signal to ships and operated until 1926. The large ball on the top was dropped at 1 pm every day to allow ships' captains moored offshore to set their chronometers.

Figure 9.21 A carrier pigeon transferred a message from the sender to the recipient.

ACTIVITY SHEET
A new pigeon carrier system
SCI09SUAS00249

ISBN 9780170189262

Activity 9.12

Communication systems

Part A

Choose one of the following methods of communication.

- Semaphore
- Pony Express
- Cobb and Co.
- Telegram
- Morse code

For your chosen method conduct some research and find out:

- when it was popular
- how it worked
- whether it is still used
- the stages in the communication process
- what energy was needed to make this type of communication work.

Devise three more questions to answer as part of your research.

Part B

Upload the following table to the class wiki. As a class, complete the table by adding the above forms of communication.

Means of communication	Method	Energy required	Estimated speed	Possible problems to delay or stop communication
Carrier pigeon	Message written on waxed paper and tied to pigeon's leg	Chemical energy in the form of seed Kinetic energy	Can fly up to 90 km/h	Pigeon could be killed by a hawk

Questions 9.3

What have you learnt?

WORKSPACE
What have you learnt? 9.3
SCI09SUWR00250

Understand

1 What is meant by the term 'communication'?

2 List five different methods of communication that have been used over human history.

3 What three stages does successful communication rely on?

Apply

4 What role does energy play in communication? Give two examples.

5 You are on the battlefield and have been asked to write an urgent request for reinforcements. This message has to be carried by carrier pigeon. What would you write?

Synthesise

6 Invent a new form of communication that your grandchildren might use.

7 Go back to your mind map and add your new understanding of communication.

ISBN 9780170189262

Communication using waves

In our modern world, it is essential that we have fast and reliable forms of communication. We can no longer rely on carrier pigeons or marathon runners to convey messages from one person to the next. We expect instant messaging and communication technologies (Figure 9.22). We have a vast array to choose from depending on the message we want to convey and the recipient.

Figure 9.22 SMS allows instant communication.

Activity 9.13

Modern communication technologies

WORKSPACE

Modern communication technologies

SCI09SIWR00251

1 Rearrange the following modes of communication in order from fastest to slowest.

- Telephone (fixed line)
- Twitter
- Facebook
- Mobile phone
- Fax
- Email
- SMS
- Satellite phone
- Post-it note

2 Identify some of the hardware requirements for each of these methods of communication.

3 What assumptions are made about each method when getting a message from the sender to the recipient?

4 What problems could occur with each method of communication?

5 Complete the following table to show which method of communication (from the list in Question **1**) you would use if you wanted to get a message to someone in the location listed.

The next room	The next suburb	The next city	The next state	Another country

ISBN 9780170189262

Activity 9.14
Whispers

WORKSPACE
Whispers
SCI09SIWR00252

Method

1 As a class, form one straight line.
2 The first person in the line receives a written message from the teacher. They read the message once and turn to a neighbour and whisper the message once. (Do not pass on the written message.)
3 The neighbour turns to the next person in the line and whispers the message once. This continues until everyone in the line has received and conveyed the message. The final person in the line receives and writes the message onto a piece of paper.
4 The starting and ending messages are then read aloud to the class.

Discussion

1 Are the two messages the same?
2 Why might the messages be different?
3 What happened to the message along the way?
4 When an analogue signal is received and re-sent, a small change is introduced each time. After several repeats, the signal can be dramatically changed or distorted. How does this activity simulate an analogue signal?

Communication and energy

Modern communication systems use different wavelengths of the electromagnetic spectrum to transfer messages. Each system uses an electronic process of coding the signal to construct a message. Messages can be sent by either a continuous signal (analogue) or discrete packages of data (digital).

Analogue signals

Communication relied on analogue signals up until 2009 when analogue signals were phased out and replacement by digital signals began.

WOW!

Confetti

One of the consequences of analogue TV is the confetti (or fuzzy) distortion displayed on the screen. Confetti is the random signals displayed as coloured dots anywhere on the screen and not part of the message. Bad weather, sunspots, passing aircraft and trucks or even someone walking across the room all contribute to a poor analogue picture in weak signal areas. We can usually detect the program signal through the confetti and still make sense of the picture.

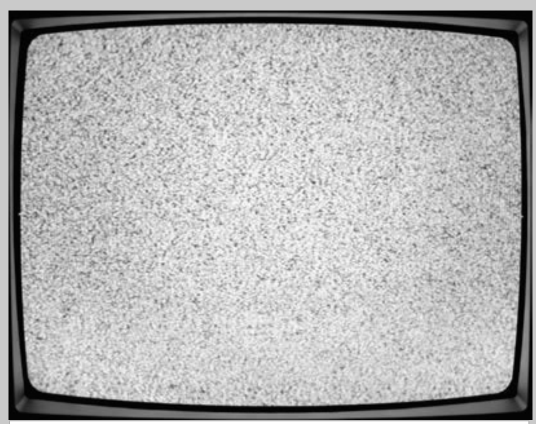

Figure 9.23 Confetti on an analogue television

glossary terms

analogue
continuous signal
digital
discrete packages of data

ISBN 9780170189262

Mobile phones

Mobile phones were first introduced for general use around 1973 when a Motorola executive made the first mobile phone call using a prototype model. They were big and bulky, weighing more than half a kilogram. They were dubbed 'bricks', offered voice-only services and cost more than $4000 each. Analogue mobile phones used electromagnetic radiation in the radio wave range.

A 1G (first generation) mobile phone network was launched in Japan in 1979 and 23 base stations were built to provide the entire population of Tokyo with coverage. 1G networks quickly spread to other countries such as the UK, Canada and the USA.

Figure 9.24 An analogue mobile phone from around 1983 and a modern smart phone

Digital signals

During the 1990s, 2G (second generation) networks emerged that used digital transmission instead of analogue. Digital networks convert your voice into binary information (either 1 or 0) by using computers. This allows the message to be compressed and decompressed with little loss of quality or speed. Digital signals can also be repeated many times without loss of quality or signal.

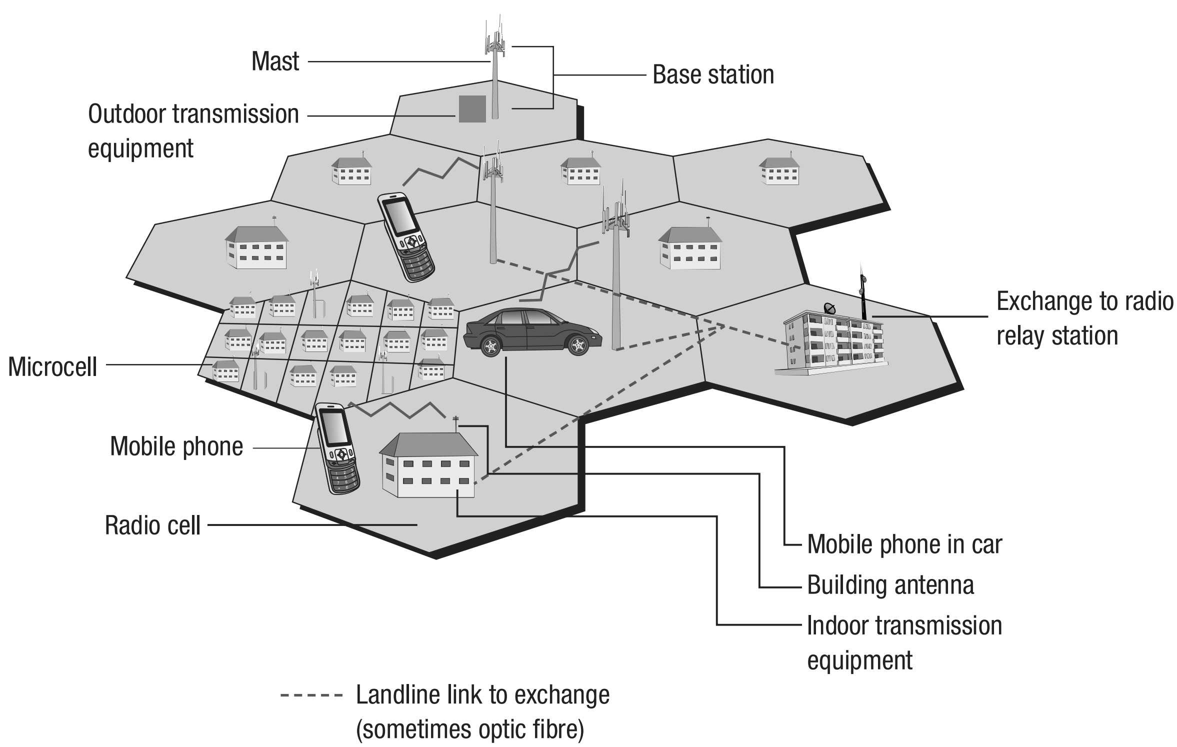

Figure 9.25 A cellular network

ISBN 9780170189262

ACTIVITY SHEET
From old to new
SCI09SIAS00253

Digital networks are microwave networks that cover an area of land called a cell. Cells are smaller in cities than in rural areas. Each cell has a base station that receives and transmits large numbers of messages at a time. As you move away from one cell, you connect to the next base station in the next cell. This maintains continuous coverage. However, loss of signal can occur if the signal is blocked by hills or buildings that microwaves cannot penetrate or if there is excessive distance to the base station. These areas are called dead zones. Each cell is connected to other cells by fibre-optic cable landlines.

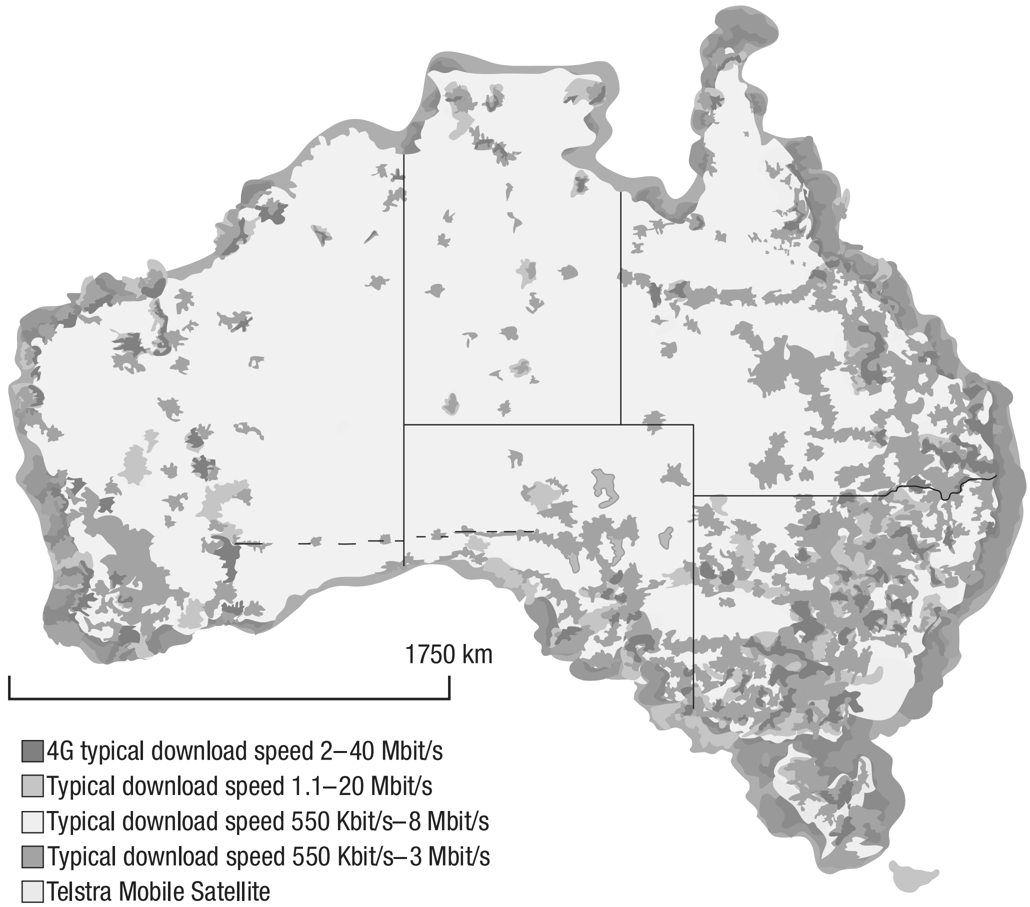

Figure 9.26 Mobile phone coverage across Australia. Coverage and performance depend on where you are and the device you are using and can be improved by adding an external antenna.

glossary terms

base station
an antenna at the centre of a mobile phone network

cell
a separate area of land serviced by a base station

dead zone
an area where microwave radiation cannot penetrate so no mobile phone reception is available

ISBN 9780170189262

Activity 9.15

Mobile phone coverage

WORKSPACE
Mobile phone coverage
SCI09SIWR00255

Signal strength on your mobile phone can be seen as a set of five bars usually in the top right- or left-hand corner of the screen (Figure 9.27). More coloured bars means greater signal strength. Each mobile phone system calculates the bars differently. The signals cannot be compared easily.

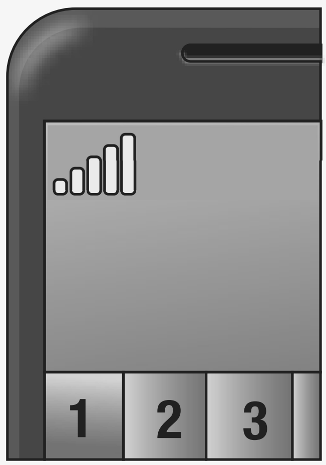

Figure 9.27 Signal strength on your mobile phone is indicated by a set of five bars.

Method

Part A The location

1 Choose a location in which you want to test signal strength. This could be where you live or where your school is situated.

2 Download a Google satellite map for your chosen area or take a screen image. On this map locate the cell phone towers.

3 Identify any local geographic features, such as hills, that would affect the mobile phone coverage.

Part B The coverage

4 Record the signal strength observed on your mobile phone in your chosen location. Record the signal strengths as you move around your location. Show this on your map.

5 Are there any dead spots (also known as 'not-spots') in your area?

6 Use the weblink to find five interesting key facts about Australians' use of information and communications technology (ICT).

WEBLINK
Key facts

ACTIVITY SHEET
Investigation: Decoding the TV controller
SCI09SIAS00254

Dangers of mobile phones

When microwave radiation meets a solid material, it is transformed into heat energy. If a person holds the antenna of an active mobile telephone to their head for several hours, there will be localised heating. The medical evidence for biological interference with cell development is inconclusive. The effect, if any, is so small that very few people out of millions are immediately affected. However, young adults and children are advised to minimise their time on a mobile handset, and all users should use a hands-free cable, choose a device that does not rest against the head, or keep the antenna 2 cm from the head.

A greater danger may be caused by the distraction when operating a phone. Pedestrians and cyclists are advised to be alert when wearing earbuds in traffic. Car drivers must use 'hands-free' phones, but even this is a distraction when driving.

Radio communication

Commercial AM radio was first transmitted in Sydney in 1923 and the simple AM signal was quickly adopted across all major Australian population centres. The FM signal was first broadcast in 1980 and digital radio was introduced in 2009 in Sydney, Melbourne, Adelaide, Perth and Brisbane. Currently, only the major cities are provided with digital radio due to the high costs of re-equipping both broadcasters and listeners with new digital equipment. The digital radio signal is of high quality but has a short range as it travels in direct straight lines from the transmitter. Digital radio signal does not vary in quality with changes in distance or weather conditions.

AM radio has the greatest range but suffers the most from interference from other radio sources. Any electrical spark will create a radio signal, which will interfere with the quality of the message and introduce noise.

ISBN 9780170189262

Regional television

There are several major television broadcasters common to the major capital cities in Australia. However, away from the capital cities, regional stations have been allocated a restricted area to provide a television signal. The AUSSAT satellites are used to provide signals to many remote locations. A special satellite dish is required to receive the AUSSAT signal (Figure 9.28).

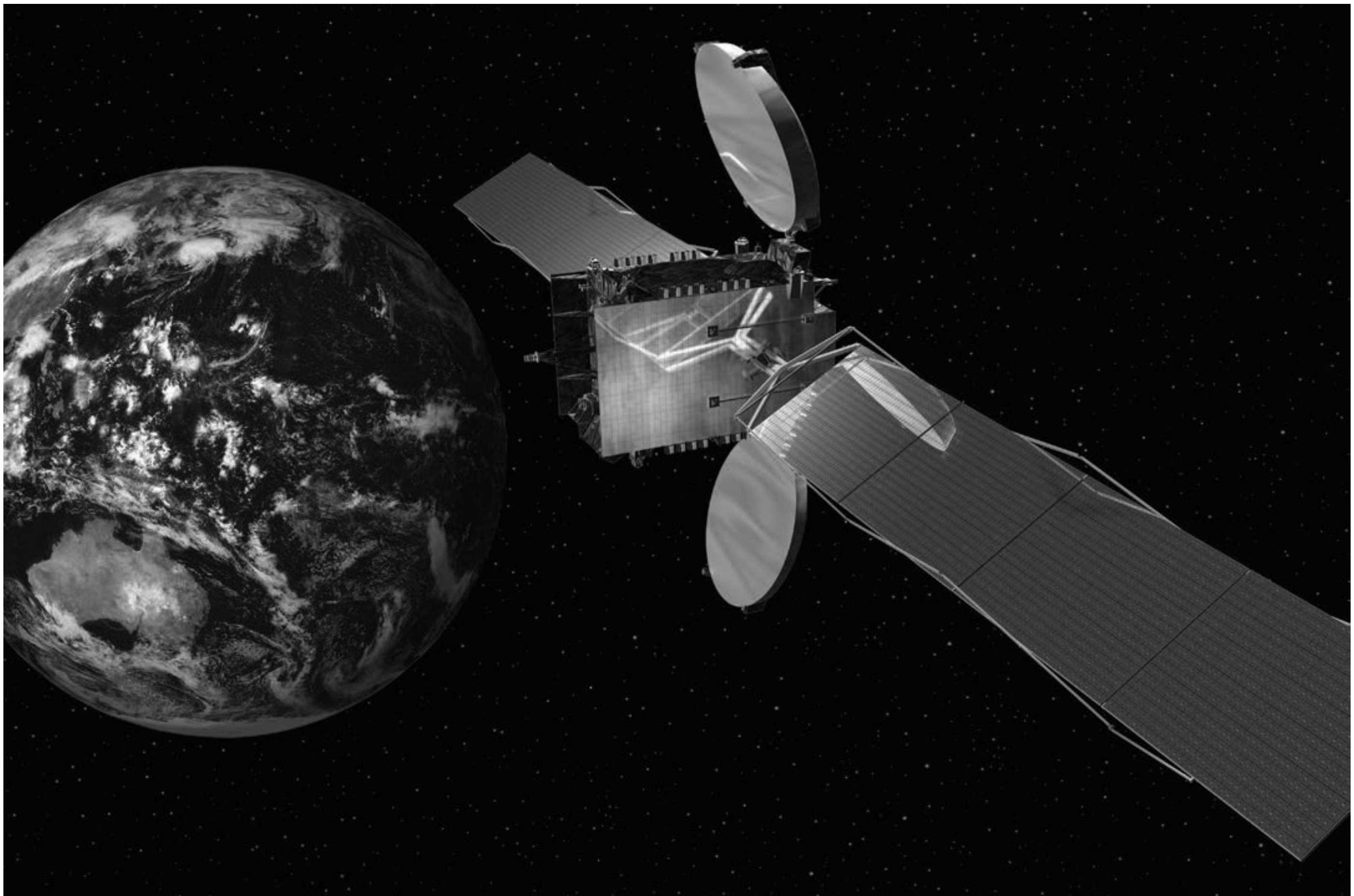

Figure 9.28 AUSSAT satellites provide television signals to remote locations in Australia.

Activity 9.16
Digital radio reception

WORKSPACE
Digital radio reception
SCI09SIWR00256

Find out if there is a correlation (relationship) between the quality of digital radio reception and the geography of the landscape.

WEBLINK
Coverage maps

1 Go to the weblink and find the satellite map for your capital city.
2 Identify the conditions that affect the digital radio coverage in your capital city.
3 Where is the transmitter?
4 Why is such a small area in green?
5 What is significant about the green area?
6 Switch to the 'terrain' view. How do signal coverage and terrain coverage correlate?

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Activity 9.17
Regional TV coverage

WORKSPACE
Regional TV coverage
SCI09SIWR00257

1 Go to the weblink.
2 Describe the TV coverage map.
3 Click on the area where you live.
4 Who delivers your TV in the area where you live?
5 What happens to the signal in Western Australia?

WEBLINK
Regional TV coverage

National Broadband Network

The National Broadband Network (NBN) is a major construction project that aims to connect every major population centre (93% of the population) directly to an optical fibre network. The optical fibre can transfer huge amounts of digital data. The optical fibre is made from a type of glass and the signal is a switched laser light. The signal travels at the speed of light, and does not need as many repeater signal boosts as the copper electricity cable that it will replace. The NBN with optical fibre will be able to consistently offer high speed to all connected users independent of location and time of day.

The limitations of the current copper network restrict high-speed connections to only 2 km from the nearest switching exchange. The copper network suffers from overloading during peak times when too many users are connected at the same time.

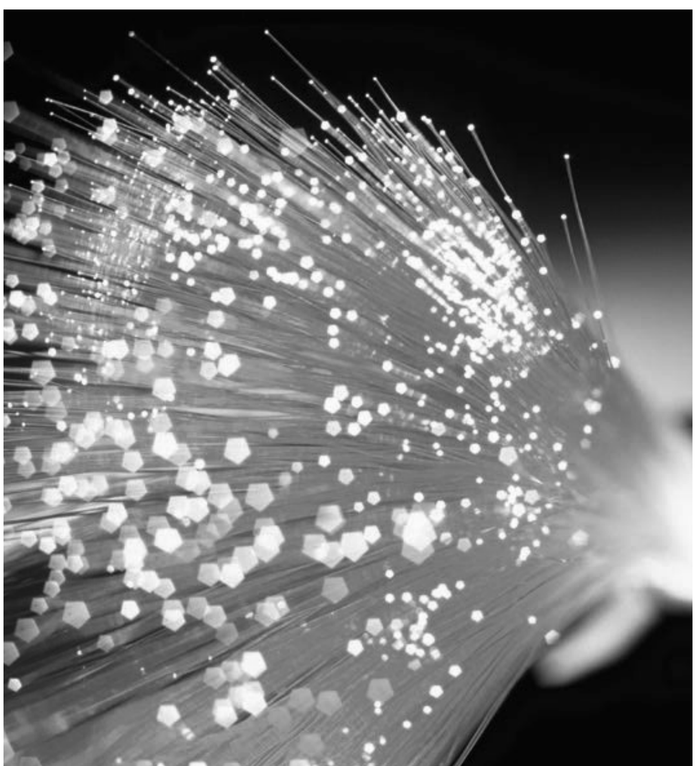


Figure 9.29 Optical fibres can transfer huge amounts of data.

Activity 9.18
Plus delta NBN

WORKSPACE
Plus delta NBN
SCI09SIWR00258

1 Create a plus delta chart for the topic 'Does Australia need a National Broadband Network?'
2 Choose the plus or the delta side of the argument and write a persuasive text, based on fact, to convince the public of your point of view.

Activity 9.19
NBN coverage

WORKSPACE
NBN coverage
SCI09SIWR00259

WEBLINK
Coverage and timing of rollout across Australia

1 Go to the weblink.
2 Give reasons for the locations of the areas of coverage.
3 Click on the dot closest to where you live.
4 When is the NBN due to be rolled out in your area?

ISBN 9780170189262

Questions 9.4
What have you learnt?

WORKSPACE
What have you learnt? 9.4
SCI09SUWR00260

Understand

1 Compare and contrast the speed and distance a signal can travel in optical fibre and copper wire.

2 Explain why a digital signal is able to deliver a better-quality signal than an analogue signal.

3 Explain how a cellular network is set up.

4 Brainstorm a list of reasons why countries might take a long time to adopt digital technologies.

Apply

5 Examine each of the Australian states in Figure 9.26 (page 223). Can you identify any obvious causes for the variation in coverage?

Evaluate

6 A variety of communication technologies have been described. Which one do you think is the greatest achievement? Give your reasons.

Synthesise

7 Go to your mind map and add in your new understandings of modern communication technologies.

Energy transfer in an electric circuit

An electric circuit is a pathway along which electrical current flows. Just like a rock rolling down a hill, energy flows from places with high potential energy to places with low potential energy. It is possible to arrange an electric circuit so that one end has higher energy potential than the other. This energy potential difference is often called a voltage. A greater potential difference provides greater energy to the circuit.

ACTIVITY SHEET
Investigating electric circuits
SCI09SIAS00261

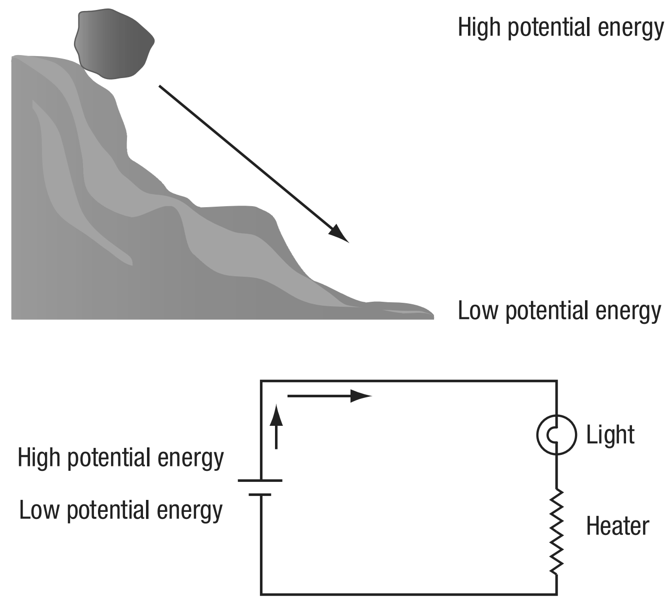


Figure 9.30 There is greater energy potential at the top of the hill than at the bottom of the hill, and so the rock rolls down the hill. Similarly, energy in a circuit flows from where there is greater energy potential to where there is less.

Extra energy can be added to a circuit with a battery. A battery stores chemical potential energy, which can be transformed into electrical energy. One side of the battery has high potential energy; the other side has low potential energy or zero voltage. The amount of potential energy decreases around the circuit, until it is regarded as zero at the low potential side of the battery.

Current transfers energy around the circuit. As the current travels around the circuit, the energy is shared with the metal circuit elements, which offer resistance to the current. Resistance will cause the material to increase temperature. If the material is chosen carefully, the temperature will rise to several hundred degrees and glow white-hot. A material such as tungsten is used inside light globes, while a special non-flammable gas fills the glass envelope. Mobile phones use complex electronic circuits to carry the electrical energy needed to make them operate.

glossary terms

current
flow of electrical charge through a medium

electric circuit
a pathway along which electric current flows

resistance
a measure of how hard it is for an electric current to flow through a material

voltage
potential difference between two points in an electric circuit

ISBN 9780170189262

Figure 9.31 Mobile phones are made up of complex electronic circuits, which include computer chips.

Every element within a circuit has a symbol (Figure 9.32). Thus, circuit diagrams can illustrate how a circuit can be constructed.

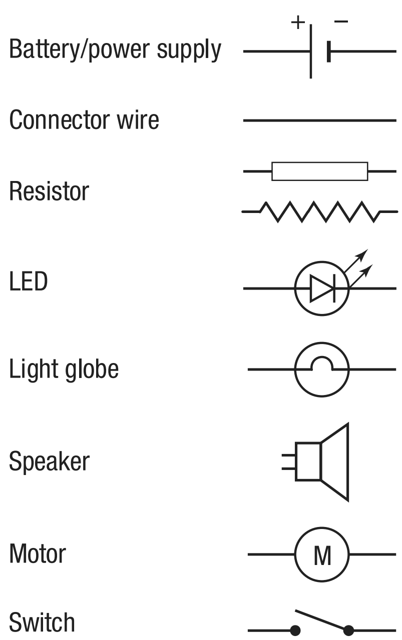


Figure 9.32 Symbols used when drawing electric circuits

Figure 9.33 shows a circuit diagram for the switches on a hairdryer. You can see that there are two speeds.

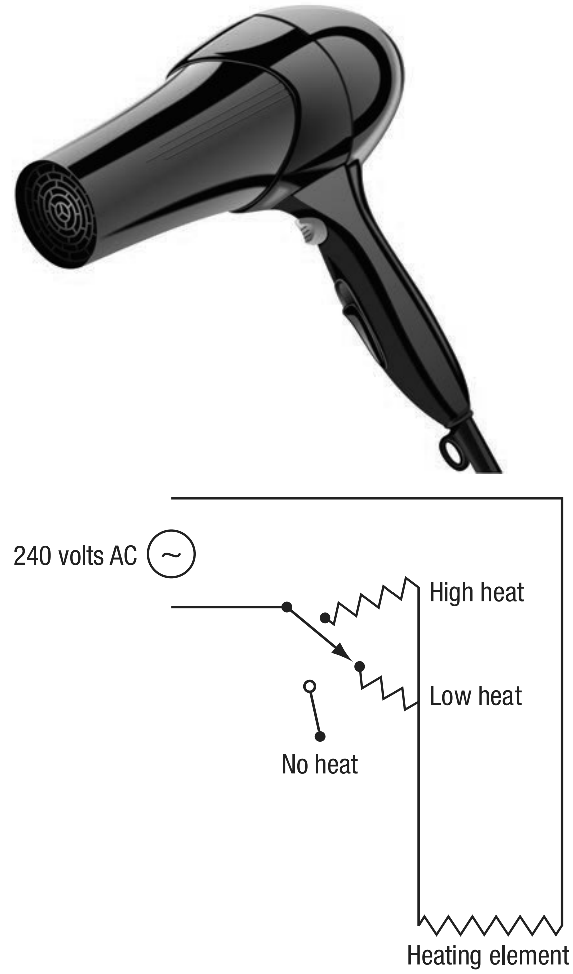


Figure 9.33 A hairdryer and the heater circuit. A different circuit controls the speed of the air blower fan.

Sometimes the electrical energy in a circuit is converted into other forms of energy. A hairdryer loses some energy as sound. This energy is 'lost' during the conversion.

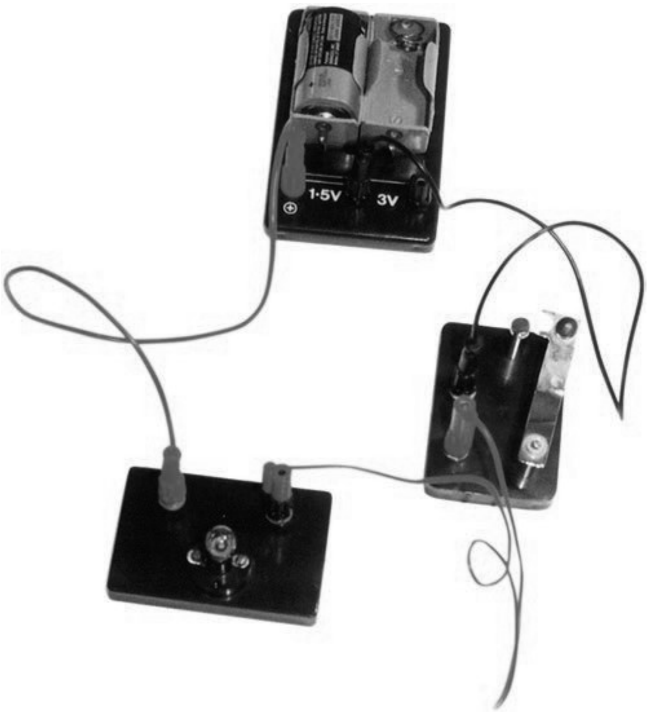
Table 9.2 Energy lost in a circuit

Circuit element	Energy given off
Light globe	Light
Resistor	Heat
LED	Light
Speaker	Sound
Motor	Movement
Magnet	Magnetism

ISBN 9780170189262

Parallel and series circuits

Circuit elements can be connected to make a circuit in two different ways. A series circuit has one path for the current to follow. Every circuit element connected in series experiences the same amount of current. If one element breaks the current flow, no current is available to any other circuit element. The voltage is shared over all the elements so that the total supplied is the total used.



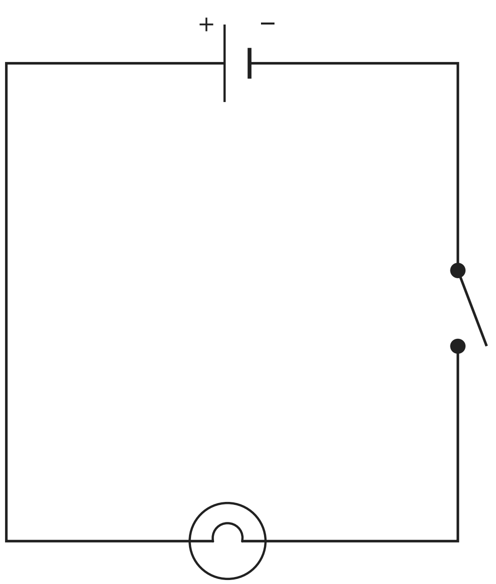


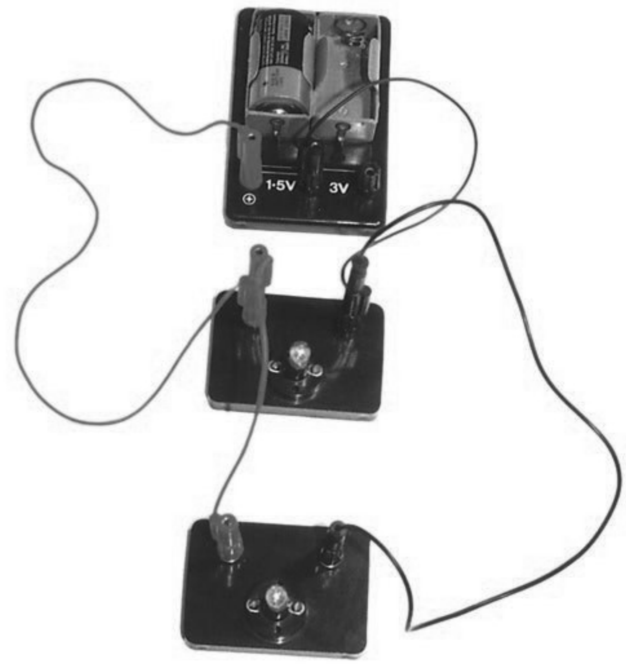
Figure 9.34 A simple series circuit and its diagram

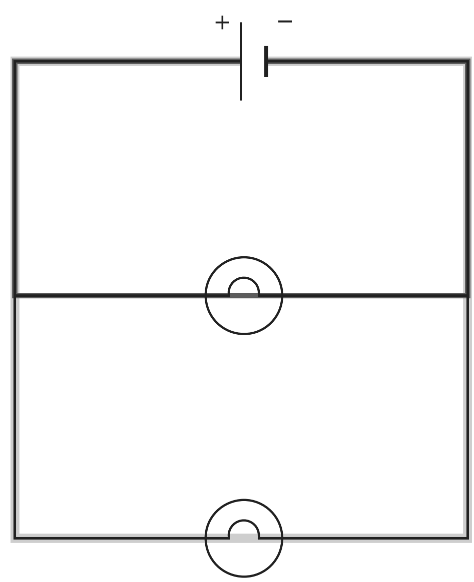
INTERACTIVE

Wiring: the parallel circuit

SCI09SUIN00264

A parallel circuit has at least two pathways available for the electric current. The circuit elements all have the same voltage available. If one circuit element breaks the flow of electric current, there is an alternative pathway, so the other circuit elements can keep operating.





Key: The two pathways

Figure 9.35 A parallel circuit and its diagram

glossary terms

parallel circuit
an electric circuit in which the current can travel through different pathways

series circuit
an electric circuit in which the same current flows through all components

ISBN 9780170189262

A short circuit, or 'short', is when the current escapes the circuit pathway via an unintended path. All the available energy can be released across a small distance, causing heating and sometimes sparks if the current is very high. Plastic is a poor conductor of electricity so it is used as insulation to cover wires. This prevents wires touching each other or other parts of the circuit. The high potential energy of active wires must be kept isolated from low potential energy wires or a short circuit will occur. Sometimes a person can complete a circuit by touching the active or live parts of the circuit and connecting to an earth of zero potential.

ACTIVITY SHEET
Safety switches
SCI09SIAS00265

Questions 9.5
What have you learnt?

WORKSPACE
What have you learnt? 9.5
SCI09SUWR00266

Understand

1 How is electrical energy in an electronic circuit similar to a rock rolling down a hill?

2 Write two possible questions for each of the following answers.
   a Voltage
   b Current
   c Resistance

3 How is extra energy added into an electronic circuit?

4 How can energy be lost from an electronic circuit?

Apply

5 Draw a diagram to show the energy flow that occurs when you recharge your mobile phone by plugging it into a power point.

6 Compare and contrast parallel and series circuits.

Synthesise

7 List several ways a mobile phone battery can be recharged. Create a PMI (plus, minus, interesting) chart for each method. Which would you choose, and why?

8 Create a single-sentence safety message to warn people about short circuits.

9 Draw an electronic circuit for a battery-operated torch, using the correct symbols.

10 Go back to your mind map and add in your new understandings of electronic circuits.

Evaluate

11 What do you think about the following statement?

'People should have a choice as to whether or not to have a safety switch.'

ISBN 9780170189262

Energy transfer and transformation in the human body

Mammals can detect only a small section of the electromagnetic spectrum. Humans detect infrared radiation as heat by the temperature-sensitive nerve endings in our skin. Our eyes detect the visible light wavelengths between 380 nm and 760 nm.

The eye

The workings of the eye baffled ancient philosophers and physicians. Ancient Greek philosopher Plato, in the fourth century BCE, believed that light came out from the eye and seized objects with its rays (the extra-transmission theory of vision). However, Aristotle, a student of Plato's, believed that the eye took in rays (the intra-transmission theory of vision). Theophrastus, a student of Aristotle, believed that there was a fire within the eye and seeing was caused by something coming out of the eye. In the 15th century, Leonardo da Vinci also believed that something came out from the eye to cause vision. By the 1490s, he had reversed this position and aligned himself with the Aristotelian view.

Figure 9.36 Leonardo da Vinci's early drawings of the visual system

Table 9.3 The main parts of the eye

Part of the eye	Description
Cornea	Transparent coating over the front of the eye
Sclera	White, fibrous coating around the sides and back of the eyeball
Aqueous humour	Jelly-like liquid that fills the space just below the cornea
Iris	Coloured part of the eye. The amount of light entering the eye is controlled by the muscles of the iris
Pupil	Opening at the centre of the iris that allows light to enter the eye
Eye muscles	Muscles that attach to the lens and are able to change the shape of the lens
Lens	A transparent structure that lies just behind the iris. It is flexible and can change shape to focus light coming from different sources on the retina
Vitreous humour	Jelly-like liquid that fills space between the lens and the retina
Retina	Layer containing light-sensitive neurons on the inside surface of the back of the eye
Fovea	Cup-shaped indentation in the retina that enables acute vision
Optic nerve	Made up of the axons of the neurons in the retina. It transmits information in the form of electrical energy from the retina to the brain
Blood vessels	Supply the cells of the eye with nutrients and oxygen and remove wastes such as carbon dioxide

glossary terms

earth
a safety device connected to an electric circuit so electricity will be drained to the Earth

short circuit
when a current travels along an unexpected pathway in an electric circuit

ISBN 9780170189262

Structure of the eye

Light waves can be absorbed or reflected by objects. It is these reflected light waves that are detected by our eyes. The structure of the mammalian eye is ideally suited to detecting these reflected light waves. Table 9.3 summarises the main structures in the eye.

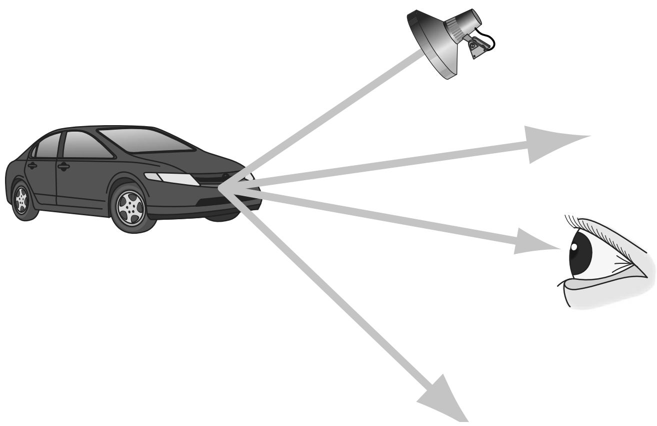


Figure 9.37 Our eyes detect light waves that have been reflected off an object.

Function of the eye

Reflected light waves pass through the transparent cornea and enter the eye through the pupil. The size of the pupil depends on the amount of light in the environment. On a bright sunny day, the pupil is small so that less light enters and the retina is protected from damage. At night the pupil enlarges to allow more light through. This ability allows us to move quickly from light to dark places and still be able to see, while still controlling the amount of light entering the eye.

The light waves are transferred from the pupil through the jelly-like aqueous humour to the lens. The lens refracts (bends) the light rays. The amount of refraction depends on the shape of the lens, which can be changed by the eye muscles (Figure 9.39). If the object being looked at is far away, then the muscles contract, which stretches the lens to make it long and thin. If the object being looked at is close, then the muscles relax to squash the lens to make

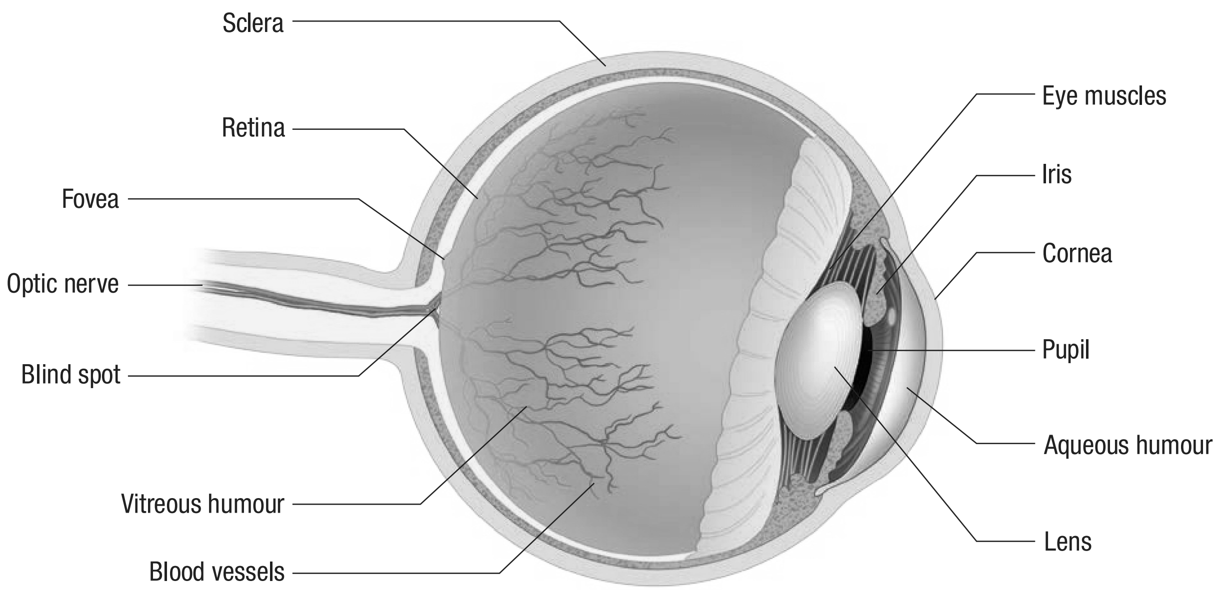


Figure 9.38 Structure of the mammalian eye

WEBLINK
Virtual eye dissection

ACTIVITY SHEET
Structure of the eye
SCI09SUAS00267

ISBN 9780170189262

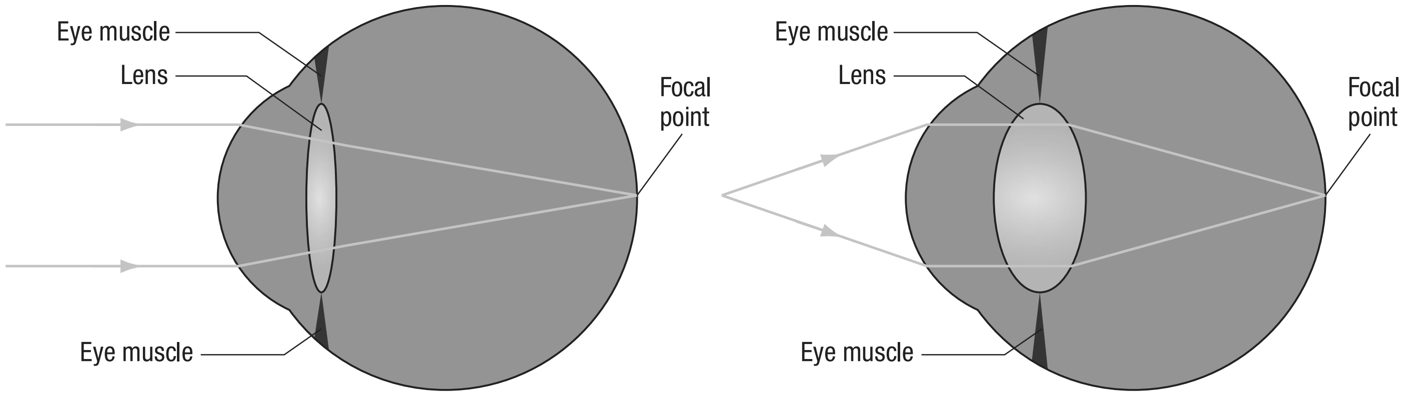


Figure 9.39 The lens can change shape to focus light onto the retina according to whether an object is near or far away.

WOW!

Fred Hollows (1929–93)

Professor Fred Hollows was born in New Zealand in 1929. He arrived in Australia in 1965. By 1971 he had helped to set up the first Aboriginal medical centre. In 1976 he established the National Trachoma and Eye Health Program, providing treatment to more than 450 remote Aboriginal communities.

Professor Hollows started looking overseas to see how he could help some of the world's poorest people. He set up an intraocular lens factory in Eritrea and established blindness prevention programs in Asia, Africa and South America.

Professor Hollows said: 'To my mind, having a care and concern for others is the highest of the human qualities.'

Fred Hollows received the Australian of the Year Award in 1990.

Figure 9.40 Professor Fred Hollows holding an Australian-made intraocular lens used on Eritrean patients in February 1990

it short and fat. Changing the shape of the lens causes the light rays to be clearly focused at a focal point on the retina at the back of the eye.

ACTIVITY SHEET
The function of the lens
SCI09SIAS00268

Once through the lens, the refracted light passes through the jelly-like vitreous humour and is focused onto the light-sensitive cells on the retina. The retina is made up of two types of light-sensitive cells, the rods and the cones.

Rod and cone cells

There are approximately 100 million rod cells in each of your eyes. Rod cells detect shorter wavelengths of light. They are responsible for night vision, black and white vision and peripheral vision.

There are approximately 6.5 million cone cells in each of your eyes. Cone cells are mostly concentrated in a small cup-shaped area of the retina called the fovea. Vision is sharpest when the lens focuses the light on this area. Cone cells function best in high light and are responsible for colour vision and daylight vision.

glossary terms

focal point
a point at which light rays meet
fovea
a part of the retina responsible for colour vision
peripheral
on the side

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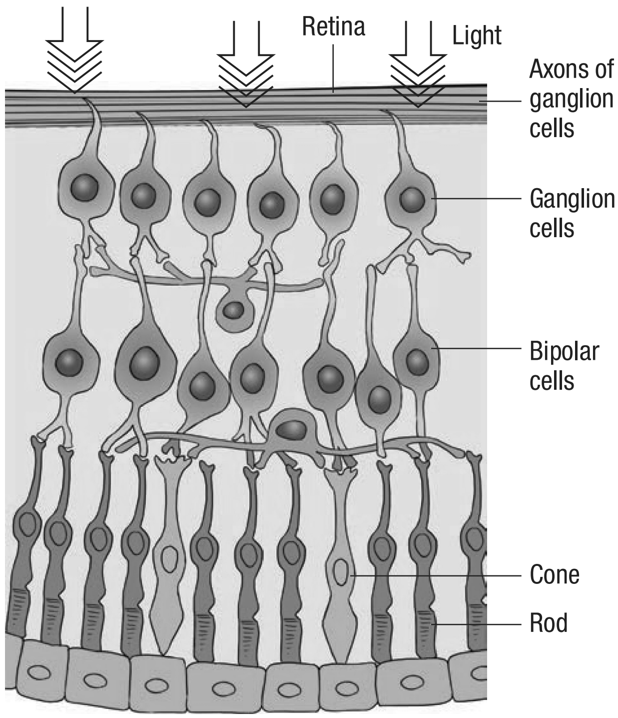

Figure 9.41 A section of the retina showing the rods and the cones

When rod and cone cells are stimulated with light waves, they start 'firing'. It is here that the light energy is transformed into electrical energy. The electrical energy is transferred from the rod or cone cell to nerve cells (see Unit 1, page 23) called bipolar cells. It passes to the dendrite of the nerve cell, along the axon to the synapse. At the synapse, the electrical energy is transformed into chemical energy, in the form of neurotransmitters (see Unit 1, page 24). The neurotransmitters cross the synaptic gap and cause the next neuron, the ganglion cell, to transform the chemical energy into electrical energy and start 'firing'.

Blind spot

The axons of the ganglion nerve cells gather together to form the optic nerve (Figure 9.38, page 232). The optic nerve leaves the eyeball at the blind spot, an opening in the retina. There are no light-sensitive cells in this area. It is via this pathway that the visual information is taken to the brain for interpretation.

Activity 9.20
Finding your blind spot

WORKSPACE
Finding your blind spot
SCI09SIWR00269

Materials

- blank index card
- black texta

Method

1 Make a dot and an X on the index card 8 cm apart as shown in Figure 9.42.

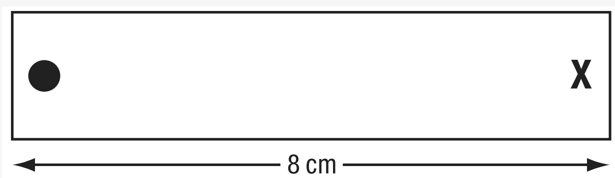

Figure 9.42

2 Hold the card at eye level about an arm's length away, making sure the X is on the right.

3 Close your right eye and look directly at the X with your left eye. Notice that you can also see the dot.

4 Focus on the X, but be aware of the dot, as you slowly bring the card towards your face. At some point the dot will disappear. This is when the dot falls into your blind spot.

5 Now close your left eye and look directly at the dot with your right eye. This time the X will disappear.

Results

1 Record what you found. Explain this in terms of eye structure and function.

2 Why do we not see a hole (where our blind spot is) in everything we look at?

Stereoscopic vision

Humans and other animals have two eyes that point forward. Their fields of view overlap, but you actually see a different view out of each eye. Where the fields of view overlap, you have stereoscopic, or 3D, vision.

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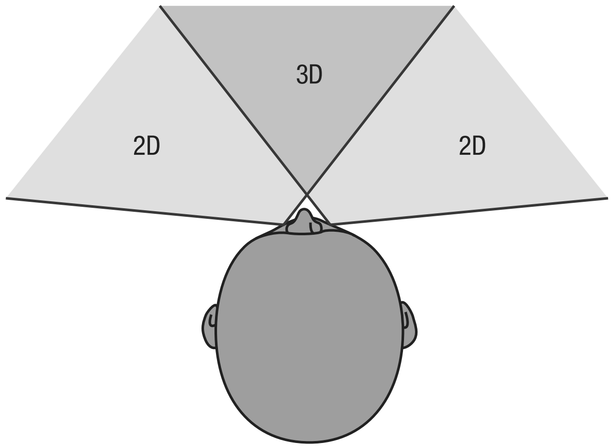

Figure 9.43 Your fields of view overlap.

Activity 9.21
Stereoscopic vision

WORKSPACE
Stereoscopic vision
SCI09SIWR00270

1 Close one eye and hold one arm straight out in front of you.
2 Point with your finger at the corner of the room where the ceiling and walls meet.
3 Keep your finger pointing at that spot but now switch eyes.
4 Record your observations. How do you explain your observations?

ACTIVITY SHEET
What is the use of 3D?
SCI09SUAS00271

Tricking the eye

Hermann von Helmholtz (1821–94) was a German scientist who contributed much towards our knowledge of how we see. In referring to the eye, he once stated that he could make a much better optical instrument but not a better eye. In other words, the eye is a far from ideal optical instrument but is a wonderful eye.

Visual illusions

Illusions occur when our brain perceives (makes sense of) information from the outside world in a way that is different from reality.

WOW!

3D movies

3D movies are made by using two cameras to film the same image from slightly different positions. Two projectors project the two views onto the screen at the same time. 3D glasses allow only one of the images into each eye. Our brain puts both images together to create the 3D sensation.

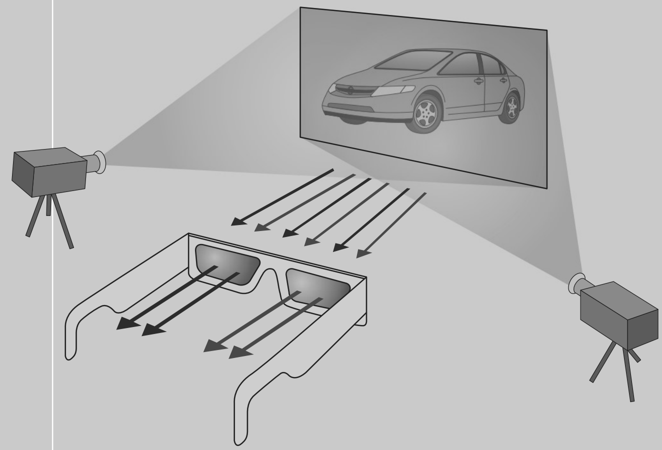

Figure 9.44 How 3D glasses work

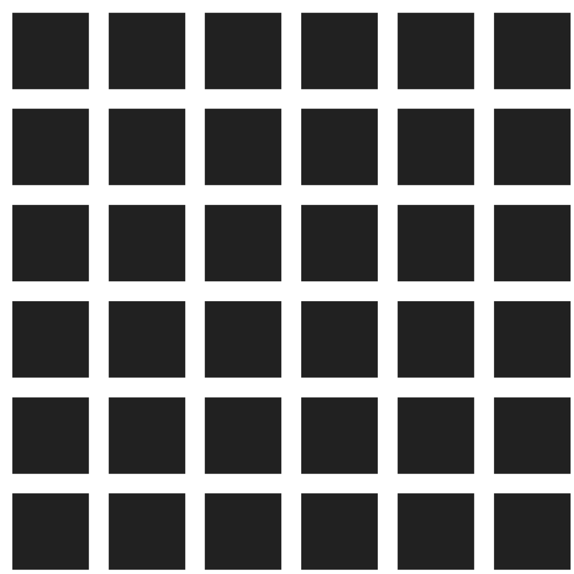

Figure 9.45 In this illusion, our brain tries to adjust to the contrast between the black and white light. This causes the areas where the black and white meet to appear grey.

glossary terms

blind spot
the point at which the optic nerve leaves the retina
optic nerve
the nerve that transports electrical information from the eye to the brain

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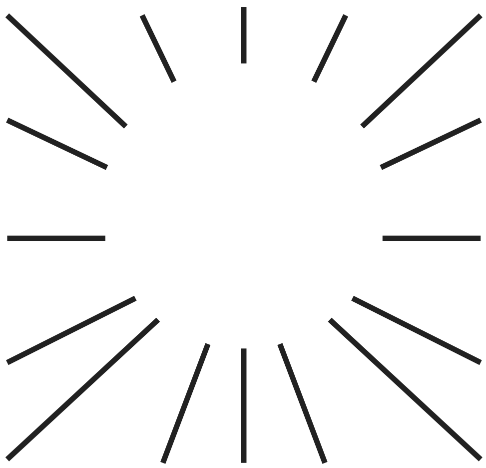

Figure 9.46 In this illusion, most people see a circle that does not exist. This is because our brain completes partial images so we don't see gaps in things that we look at.

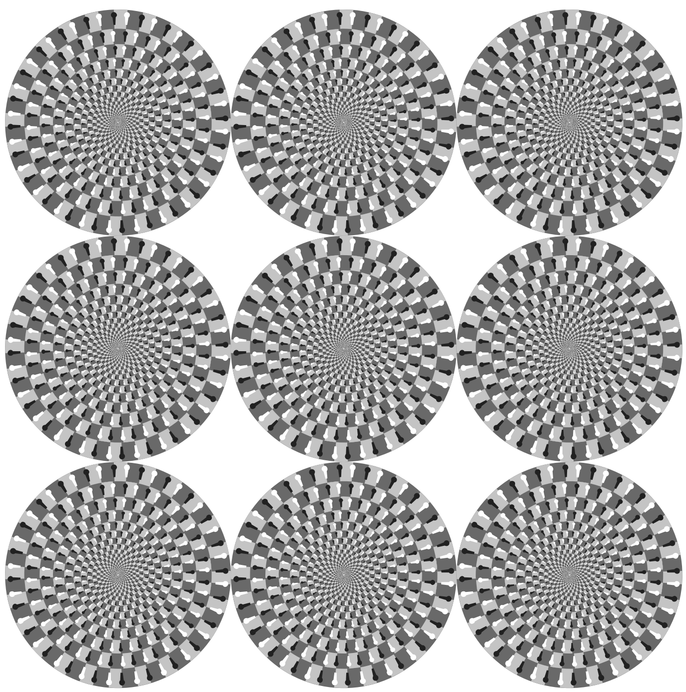

Figure 9.47 How do you explain this illusion?

WEBLINK
More visual illusions

ACTIVITY SHEET
Science career – optometrist or ophthalmologist
SCI09SHAS00272

Problems with the eye

Just like any other part of the body, the eye is susceptible to problems and diseases. The most common problems are short- and long-sightedness (myopia and hyperopia respectively). These problems are usually caused by a faulty lens or a misshaped eyeball and can be corrected with glasses or surgery.

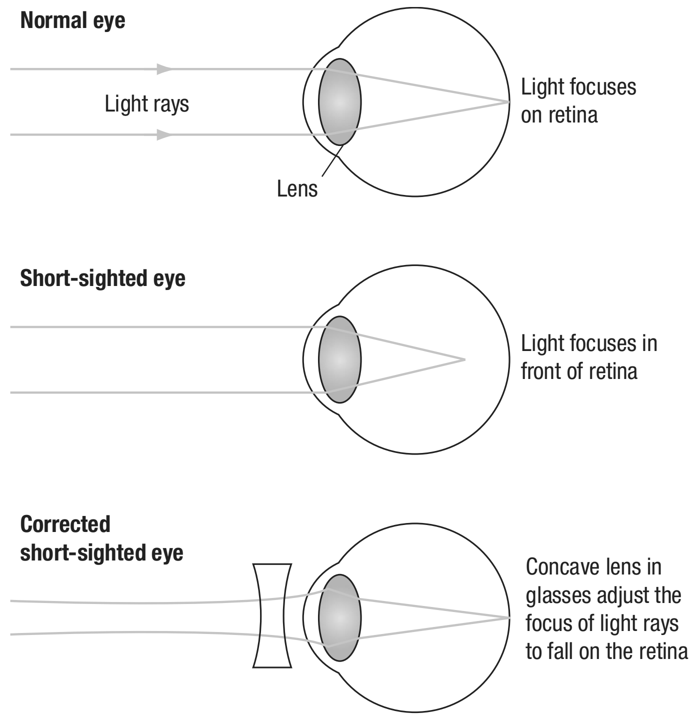

Figure 9.48 Correcting short-sightedness with a concave lens

Bionic eye

Medical conditions such as *retinitis pigmentosa* and age-related macular degeneration slowly rob people of their vision. Until now it has not been possible to restore vision in people suffering from these conditions. The bionic vision system consists of a camera attached to a pair of glasses. The glasses transmit high-frequency radio wave signals to a microchip implanted in the retina. Electrodes on the implanted chip convert these signals into electrical impulses to stimulate cells in the retina that connect to the optic nerve. These impulses are then passed along the optic nerve to the vision-processing centres of the brain, where they are interpreted as an image. To benefit from this technology, patients need to have a functional optic nerve, as well as some intact retinal cells.

WEBLINK
Bionic Vision Australia

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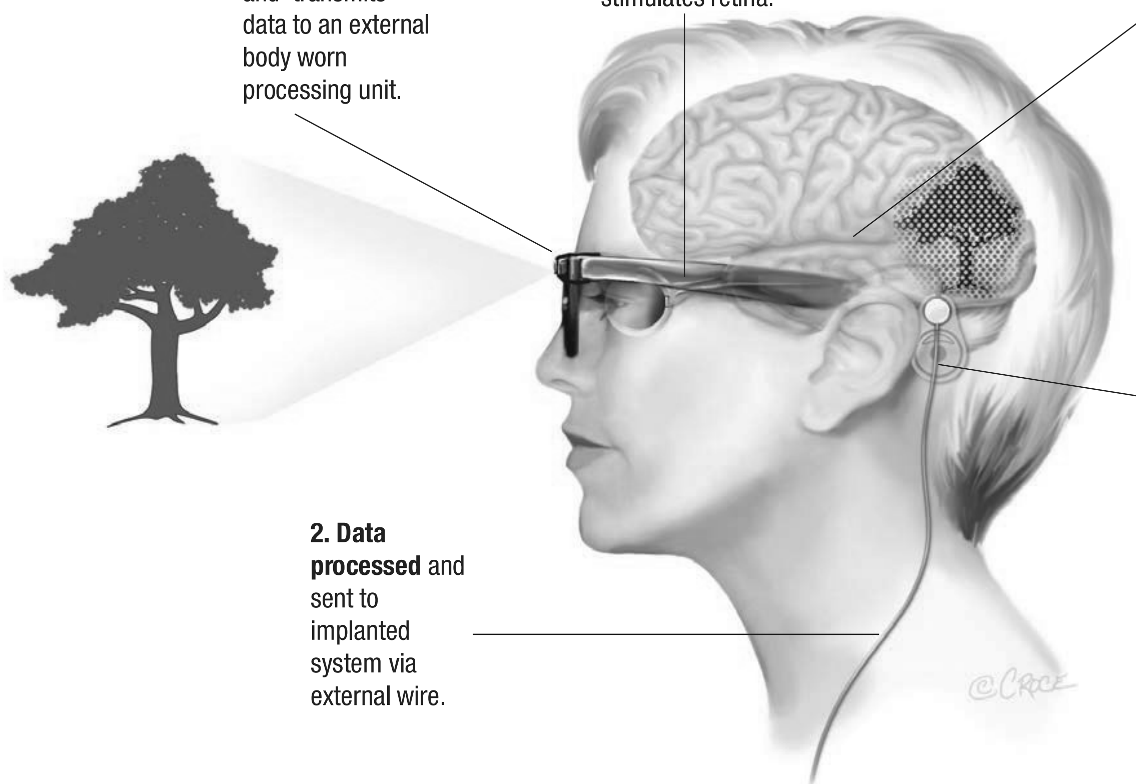

Figure 9.49 The bionic vision system

Questions 9.6
What have you learnt?

WORKSPACE
What have you learnt? 9.6
SCI09SUWR00273

Understand

1 How do our eyes detect objects in our environment?

2 Label the following diagram of the human eye in your workspace.

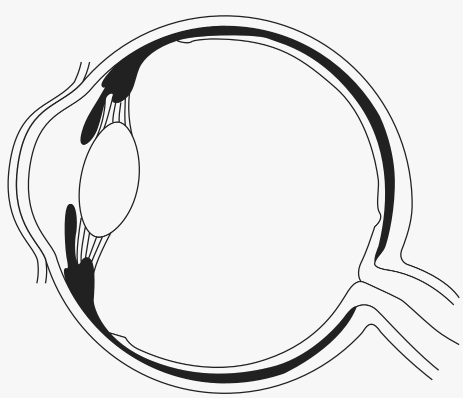

Figure 9.50

3 Why do light rays need to be refracted in order for us to see clearly?

4 Where in the eye is light energy transformed into electrical energy?

5 Explain why we can 'trick' our eyes with visual illusions.

Apply

6 Draw a diagram to show how lenses can correct long-sightedness.

7 Compare and contrast the human eye with an electronic circuit.

Synthesise

8 Go back to your mind map and add in your understanding of the structure and function of the human eye.

The ear

Sound waves pass through the air as mechanical waves. Particles of air move from the sound source as a wave. They pass energy onto surrounding particles until the wave reaches and enters our ears.

VIDEO
What is sound?
SCI09SUVD00274

Figure 9.51 Particles of air move from the sound source as a wave.

Structure of the ear

The ear is ideally structured to receiving sound waves. Table 9.4 summarises the main structures in the ear.

WOW!

Ossicles

The ossicles are made up of three small bones called the malleus (hammer), incus (anvil) and stapes (stirrup). They are the three smallest bones in the human body.

Function of the ear

Sound waves enter the ear as moving air particles. Because they are moving, they have mechanical energy. This energy is transferred to the eardrum, which starts to vibrate. As the eardrum vibrates, the first ossicle, the malleus or hammer, receives the mechanical energy and starts to move. This causes the attached incus, or anvil, to move, which in turn causes the stapes, or stirrup, to move. The pressure of the stirrup pushing on the oval window transfers the kinetic energy to the fluid in the cochlea. This causes the fluid to flow, moving the hair cells. It is here that the mechanical energy is transformed into electrical energy as the hair cells start firing. This electrical energy travels along the auditory nerve to the brain, where it is interpreted as sound.

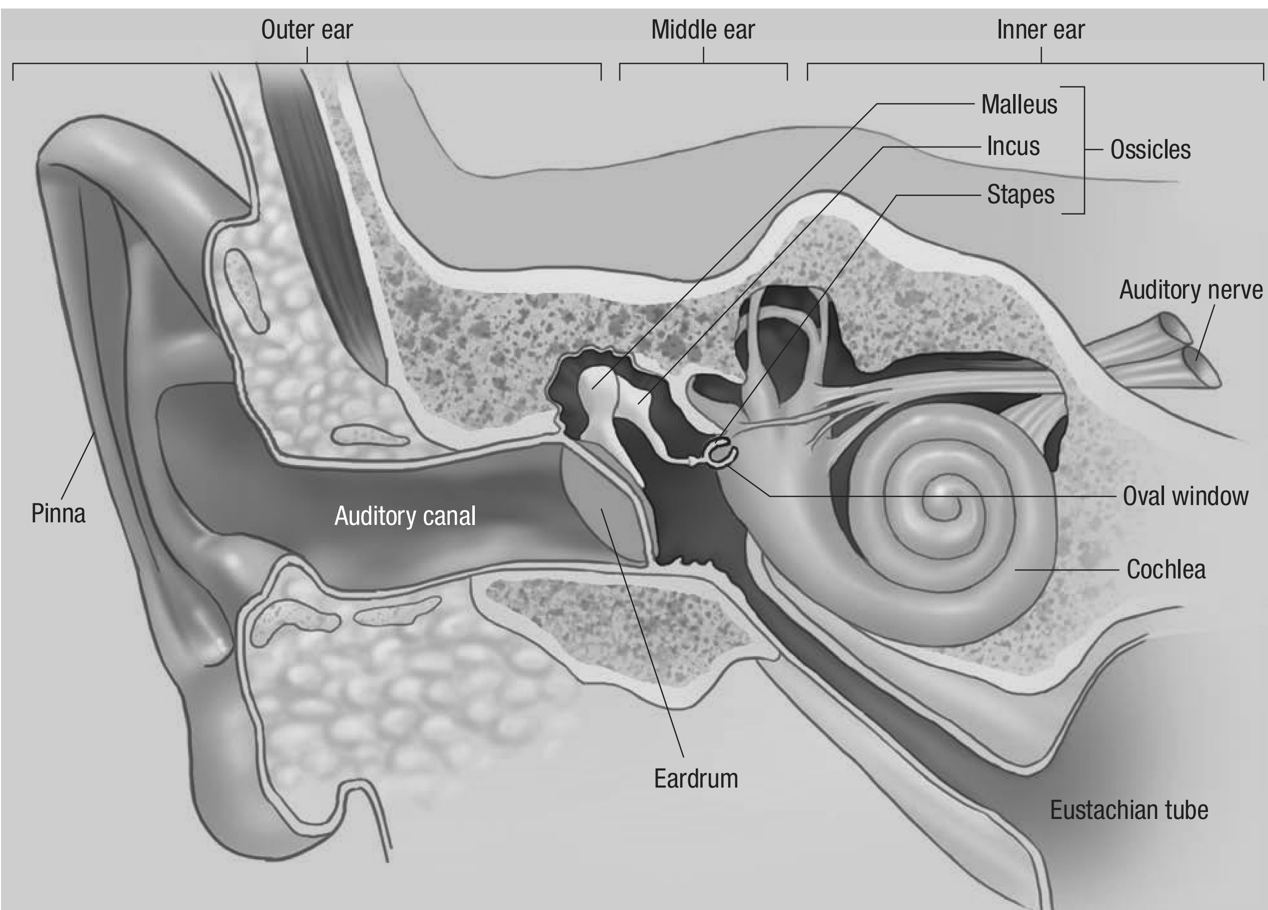

Figure 9.52 The structure of the human ear

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Table 9.4 The main parts of the ear

Part of the ear		Description
Outer ear	Pinna	Acts like a funnel to direct sound waves into the auditory canal
	Auditory canal	A canal that leads sound waves to the eardrum
Middle ear	Eardrum	A thin membrane that vibrates when struck by sound waves
	Ossicles	Three small connected bones that amplify the vibration from the eardrum. The stapes pushes into the cochlea, thereby transforming the vibration to the fluid in the cochlea.
	Eustachian tube	A tube connected to the throat that helps equalise the pressure in the middle ear to the outside
Inner ear	Oval window	A small oval section of the cochlea where the ossicles connect to the cochlea
	Cochlea	A fluid-filled snail-shell-like structure. As the ossicles transfer the vibration to the fluid, it begins to flow and moves hair cells. Hair cells start firing and electrical signals are sent to the auditory nerve.
	Auditory nerve	The nerve that transfers the electrical signals from the hair cells to the brain for decoding

VIDEO
How the ear hears sounds
SCI09SUVD00275

WEBLINK
How the ear works

Diseases of the ear

Just like the eye, the ear is subject to problems and diseases. Deafness occurs when part or all of the ability to hear is lost. The most common cause of deafness is exposure to continuous loud noises. The constant exposure to loud noises damages the hair cells in the cochlea. Deafness acquired through work has been a large problem

Figure 9.53 It is important to protect against hearing loss when working in noisy environments.

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in the industrialised era. Many people are now suffering the effects of working alongside loud machinery. In 1995, 22% of all workplace injuries were related to complete or partial deafness. A total of 85% of all deaf people lost their hearing due to work-related conditions.

It is only in recent years that a damaged cochlea can be replaced by a cochlear implant. This is an electronic device that does the work of damaged parts of the inner ear (cochlea) to provide sound signals to the brain.

WEBLINK
Cochlear implant

Student research
Workplace regulations

Investigate workplace safety practices that can be used to reduce or avoid deafness.

1 What industries are most prone to workplace deafness?
2 What are safe noise levels?
3 What is the maximum amount of time workers can be exposed to these noise levels?
4 What safety protection can workers utilise to reduce noise levels?

Activity 9.22
Hearing loss in teens

WORKSPACE
Hearing loss in teens
SCI09SIWR00276

1 Go to the weblink and read the article.
2 Why are teenagers at risk of deafness?
3 What is tinnitus and how many 18–24 year olds suffer from it?
4 What precautions can you take now to protect your hearing in the future?
5 What percentage of Australians have their headphones or headsets turned up too loud?
6 Can damaged hearing recover without intervention?

WEBLINK
Hearing loss in teens

Questions 9.7
What have you learnt?

WORKSPACE
What have you learnt? 9.7
SCI09SUWR00277

Understand

1 Describe how sound energy moves from the sound source to our ears.
2 Label the diagram of the human ear in your workspace.

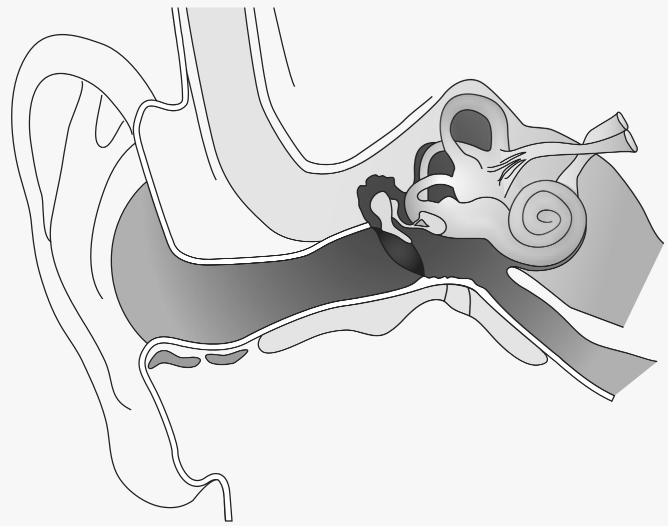

Figure 9.54

3 What is the most common cause of deafness in Australia?

Apply

4 During an accident your malleus is broken and no longer functions. What might be the consequences for the functioning of your ear?
5 Compare and contrast the structure and function of the eye and the ear.

Synthesise

6 Draw a flowchart to show how mechanical energy is passed through the structures of the ear.
7 Go back to your mind map and add in your understandings of the structure and function of the human ear.

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Unit review

ACTIVITY SHEET
Unit 9 checklist
SCI09SUAS00278

REVIEW QUIZ
Unit 9 review quiz
SCI09SURQ00279

WORKSPACE
Unit 9 review
SCI09SUWR00280

Understand

1 Label the following wave diagram in your workspace.

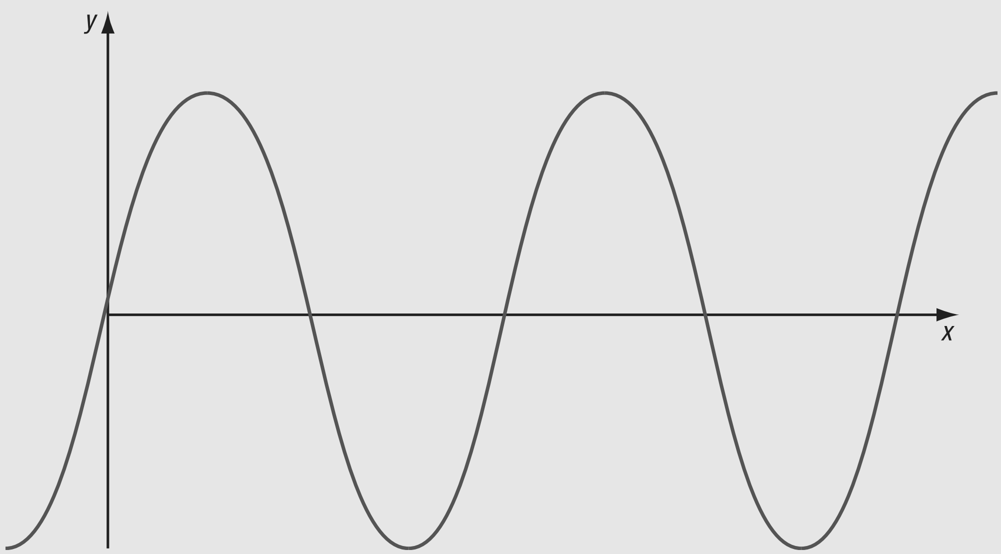

Figure 9.55

2 Explain how a microwave oven heats food.

3 Why does your nose get sunburned when you wear sunglasses?

4 What would happen in an electric circuit if the battery was flat?

5 Explain what is meant by a 'short' or short circuit. Why is it a problem? What can be done to prevent short circuits?

6 Many bathrooms have a hairdryer left plugged in and 'on' at the wall. Why does the hairdryer appear to be 'off'? What would happen if that hairdryer fell into the water in a sink or a bath?

7 Describe the pathway of light waves through the human eye by listing, in order, the structures that they pass through. Where is the light energy transformed into electrical energy?

8 How do the eyes and ears contribute to successful communication?

9 Describe the pathway of sound waves through the human ear by listing, in order, the structures that they pass through.

10 In the human ear, the eardrum transforms sound energy into what type of energy?

11 Which parts of the human ear can be damaged by continuous loud sounds?

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Apply

12 Would an air cannon work in space? Explain. You might like to do an Internet search for 'air cannon airzooka'.

13 If you had to move something very hot, what precautions would you take?

14 The standard treatment for a burn is to place the burnt area under cold running water for 20 minutes. Why so long? Why cold water? Would ice do the same thing? Why does ice introduce new problems if it is held on skin for 20 minutes?

15 When you place a plate of food to be heated in a microwave oven, do you place the plate in the centre or towards the outside (off-centre)? Explain why.

16 Explain why very dry food is unsuitable for reheating in a microwave oven. Why is a little water added to rice before it is reheated?

17 When a person is rescued, why are they often wrapped in a foil-covered blanket?

Analyse

18 Describe the flow of heat energy if you were to grab a hot metal handle of a pot on the stovetop. Describe the flow of heat energy as you treat the burnt area.

19 Infrared cameras are used by firefighters looking for bushfire hotspots, and emergency rescue workers looking for lost bushwalkers or skiers. How do these IR cameras work? Why do these cameras work best in winter and at night when looking for lost people?

20 How do 'noise cancelling' earphones work? How is this different from sound-proofing in a classroom or theatre?

21 How can you cool off quickly in summer? Explain the science behind your choice.

22 Glaucoma is characterised by damage to the optic nerve that causes loss of peripheral vision. What would a person see if they suffered from glaucoma?

Synthesise

23 Construct a safety message for teenagers who use MP3 players and ear buds.

24 Create an electronic crossword for which the parts of the eye and ear are the answers and the functions are the clues. Upload your crossword to the class wiki so someone else can complete it.

Evaluate

25 Cataracts are caused when the eye lens becomes cloudy or opaque. UV radiation contributes to this condition. How can people be advised that they are in danger from bright sunlight? Should the slogan 'Slip, slop, slap' include sunglasses? Not all sunglasses have UV protection. Should these be removed from sale to children? Explain.

26 MP3 players (including iPods and iPads) are sold with health warnings in many European countries. In Australia, the volume control limit is automatically off. Do you think that Australia should have music protection rules for MP3 players?

Reflect

27 What are the three most important things that you have learnt from this unit? How will they influence the way you live your life or view the world?

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