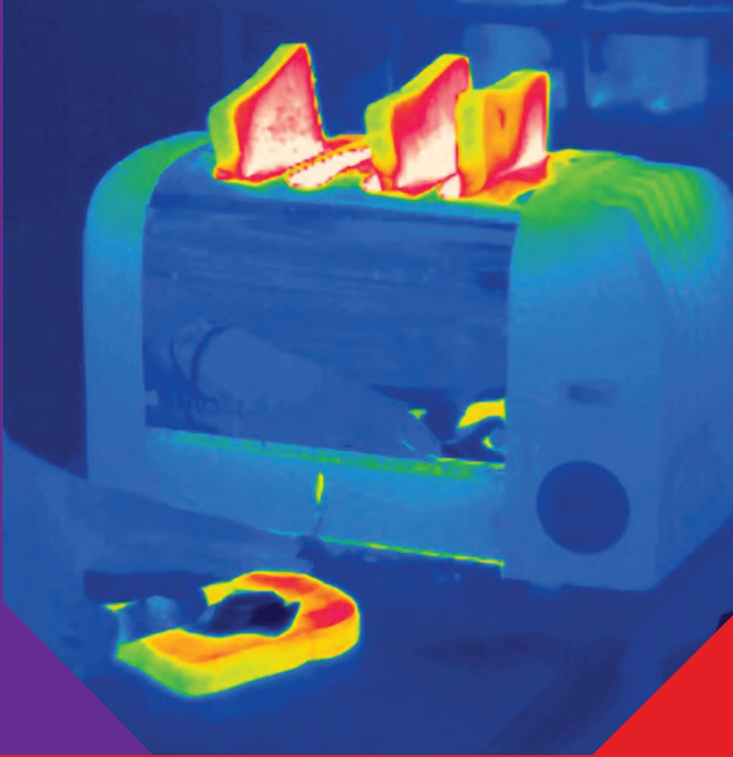
8

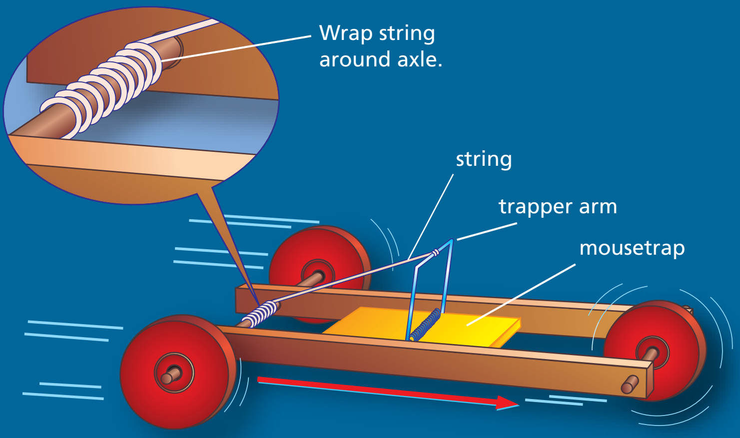


Using energy

PROBLEM SOLVING

Building a mousetrap racer

You can use the spring of a mousetrap to power a model racer. You attach one end of a piece of string to the mousetrap's trapper arm and the other end to the rear axle, as shown below. As you wind the string onto the axle you pull back the trapper arm. Then, when you release the arm, the string is pulled off the axle causing the wheels to rotate.



Your task is to build a mousetrap racer that will go as fast as possible. Really fast ones can go 5 m in less than 2 seconds. Or you could see how far your racer will go. The record is about 100 m.

There are many variables you can alter to make your racer go fast or a long way. Some of these are:

- number of wheels
- type of wheels
- mass of racer
- distance between axles
- the way the string is attached to the rear axle.

By the time you have finished the chapter you will be able to explain how your racer works in terms of energy changes.

Focus for learning

INQUIRY 1 What is energy?

We have already used the word *energy* in this book, but what is energy? Are your ideas about energy the same as other people's ideas? A good way to sort out your ideas is by *brainstorming*. To do this you need to follow these six steps.

1. Get into groups of six.
2. Select someone to write down all the ideas thought of by the group.
3. Everyone should try to give at least one idea about energy. The more ideas the better. Here are a few suggestions to get you started.
   - Write a sentence with the word 'energy' in it.
   - Draw something with a lot of energy.
   - What do we use energy for?
   - How do our bodies get the energy they need?
   - What are the different types of energy?
4. Don't discuss the ideas yet, and don't criticise anyone else's idea.
5. After a few minutes of brainstorming, discuss the ideas you have written down. Write or draw them on a large sheet of paper and present them to the class.

By the end of this chapter you will be able to ...

Science Understanding

- recognise that kinetic energy is the energy possessed by moving bodies
- recognise that potential energy is stored energy, such as gravitational, chemical and elastic energy
- give examples of how heat energy is produced as a by-product of energy transfer, e.g. in a car engine
- use energy chains to show changes between different forms of energy

Science as a Human Endeavour

- discuss the work of Maria Skyllas-Kazacos in developing the vanadium battery

Science Inquiry Skills

- work in a team or by yourself to complete a science project

LITERACY FOCUS

battery
efficiency
elastic potential energy
energy chain
energy converter
fossil fuels
gravitational potential energy
investigate
joules
kinetic energy
law of conservation of energy
non-renewable
nuclear
renewable
research
thermometer
transferred
transformed
uranium
vibration

8.1 Forms of energy

What is energy?

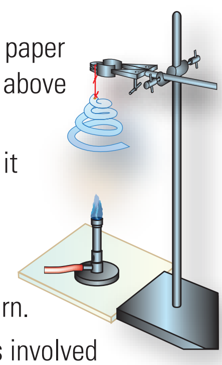
How do you feel when you have lots of energy? How are new batteries different from 'flat' ones? Put them into a CD player or a torch and you can certainly tell the difference. Energy makes things happen.

You can't see energy. You can't weigh it, and it doesn't take up space as matter does. Everything you do needs energy. In fact, everything that happens needs energy. Without it nothing will go. It simply makes things happen when it changes from one form into another.

INQUIRY 2 Hot air rises

You will need: Bunsen burner, scissors, cotton thread, retort stand and clamp

1. Draw a spiral on a sheet of paper and cut it out. Then hang it above a Bunsen burner as shown.
2. Light the burner and adjust it to a small blue flame. You will probably need to adjust the height of the spiral so that it does not burn.



- How do you know energy is involved here? What energy change occurred?

Energy changes can make things move, as you saw in Inquiry 2. The hot air above the burner rose, causing the paper spiral to turn. In this way the heat energy was changed into movement energy.

The energy you get from food enables you to ride a bike. The energy from petrol makes a car move, and energy from rocket fuel can move a spacecraft into space. All objects have energy, and one object can transfer some of its energy to another object. For example, when you hit a golf ball with a club some of the club's energy is transferred to the ball. And when you pour hot water into a cup, some of the energy in the water is transferred to the cup.

Energy changes can do more than make things move. For example heating is caused by some other form of energy, such as the energy stored in gas, changing into heat. That heat can warm our homes and cook our food. Other energy changes produce electricity, light and sound.

There are many different forms (types) of energy. You can classify them into two groups—energy in action and stored energy.

Energy in action

Kinetic energy

Any moving object has **kinetic** (kin-ET-ic) **energy**. When you run you have kinetic energy. A moving train has a large amount of kinetic energy, and in a crash that energy can cause a lot of damage. The kinetic energy of the strong winds in a cyclone can cause enormous damage.

Darwin was destroyed by cyclone Tracy on Christmas Eve 1974. The wind, travelling at up to 200 kilometres per hour, had enormous kinetic energy.

The amount of kinetic energy an object has depends on its speed. The faster the object is moving, the more kinetic energy it has. For example, a car travelling at 100 km/h has much more kinetic energy than one travelling at 60 km/h. As a moving object slows down, it loses kinetic energy. And when it stops it has no kinetic energy at all.

Kinetic energy also depends on the mass of the moving object. The larger the mass, the more kinetic energy the object has. A cyclist and a bus may be travelling at the same speed, but the bus has much more kinetic energy because it has more mass.

Light energy

Burning chemicals, very hot objects and stars all release light energy. It travels through space in waves (as do radio and TV waves, microwaves and ultraviolet waves). It will even travel through a vacuum where there is no air. Light energy from the sun, called *solar energy*, is used by plants in the process of photosynthesis to make food.

Sound energy

Sound is a form of kinetic energy caused by vibrating objects such as a guitar string or the skin of a drum. The bigger the vibrations, the louder the sound. The sound travels from place to place as waves, but it needs a solid, a liquid or a gas to carry it. It won't travel through space where there is no air, because there are no particles to vibrate and carry the sound energy.

Heat energy

Heat energy is energy that an object has because of its temperature. The hotter the object is, the more heat energy it has. Heat energy moves from a hotter object to a colder one. When you put your cold hands around a hot cup of tea, heat energy moves from the cup to your hands, making them warmer.

Electrical energy

Electricity has electrical energy and is widely used because it is easily transmitted by wires to the place where it is needed. It can be changed into other forms of energy by electric lights, computers, hair dryers, TV sets, washing machines, toasters etc.

Stored energy

Stored energy is called **potential energy** because it is not making anything happen, but it has the *potential* to do so. There are four types of stored or potential energy.

Chemical energy

Energy can be stored in chemicals as chemical energy. It is stored in the chemical bonds between atoms. When fuels such as wood and petrol are burnt, this stored energy is released as heat and light. When you switch on a torch the chemical energy stored in the battery is changed to light energy. Food also contains stored energy which can be used by your body.

Nuclear energy

Energy is also stored inside atoms as nuclear energy. It can be released from some atoms, for example uranium atoms, in nuclear power stations. Nuclear energy stored in hydrogen atoms is the source of the sun's energy.

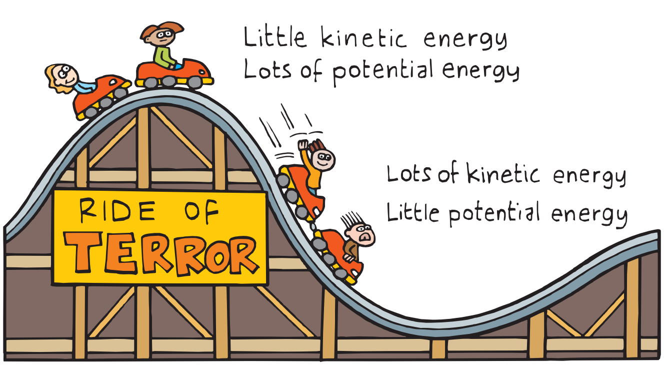
Elastic potential energy

When you jump on a trampoline, what pushes you up into the air? Try to visualise what happens in slow motion. The trampoline has a frame with a flexible mat attached by springs. When you jump on the mat, it is pushed down, stretching the springs and storing energy called **elastic potential energy** in them. As the stretched springs return to their original size and shape, they release their stored energy. The mat is pulled back up, and you are thrown into the air. A wind-up toy also stores elastic potential energy. So does a stretched elastic band. The more it is stretched, the more elastic energy it has.

The elastic potential energy stored in the stretched trampoline springs allows them to throw you into the air when they spring back into place.

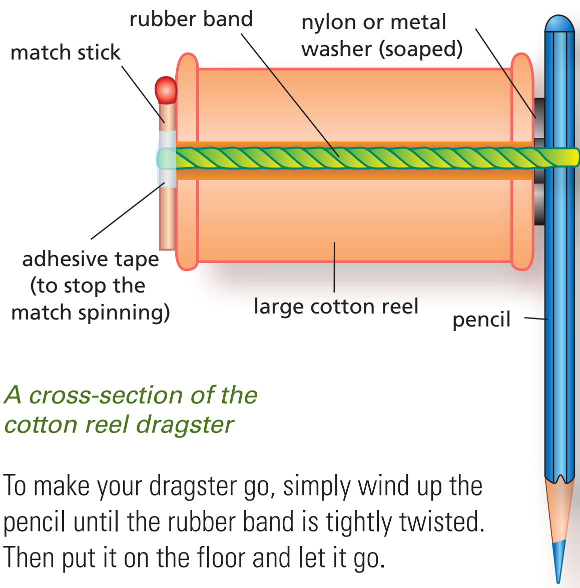
Gravitational potential energy

Gravitational potential energy is the potential energy that an object has because of its height and mass. The higher an object is, the more gravitational potential it has. And the more mass an object has, the more gravitational potential energy it has. When you are at the top of a roller-coaster ride, you have a lot of gravitational potential energy but not much kinetic energy. As you come down again, the gravitational potential energy is converted into kinetic energy, so the cart gets faster and faster. At the bottom of the ride you have much more kinetic energy but much less gravitational potential energy. Energy can be easily changed back and forth between potential and kinetic energy in this way.



INQUIRY 3 Cotton reel dragster

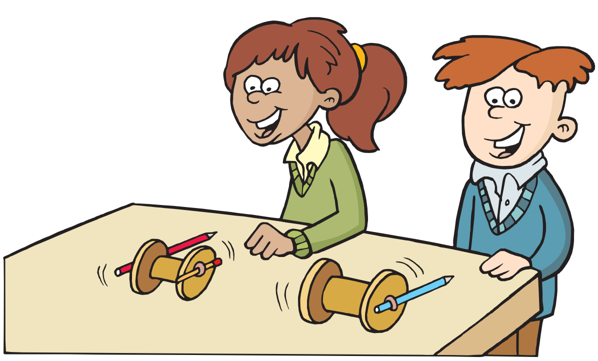
You will need: large cotton reel, rubber band, matchstick, nylon or metal washer, soap, adhesive tape, pencil



A cross-section of the cotton reel dragster

To make your dragster go, simply wind up the pencil until the rubber band is tightly twisted. Then put it on the floor and let it go.

- Which type of energy does the dragster have when you let it go?
- Which type of energy did it have before you let it go?
- Energy is needed to wind up the dragster. Where did this energy come from?



Over to you

1 Copy and complete each of these sentences.
   - **a** Energy makes things ______.
   - **b** A moving object has ______ energy.
   - **c** Energy which is stored is called ______ energy.
   - **d** Burning a log of wood changes ______ energy into ______ and ______ energy.
   - **e** A large rock rolling downhill is losing ______ energy, but gaining ______ energy.

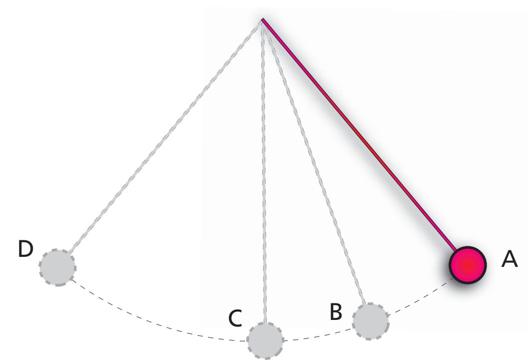
2 What are the four types of stored energy?

3 What form(s) of energy do the following have?
   - **a** an apple
   - **b** a bent ruler
   - **c** a burning log
   - **d** a flash of lightning
   - **e** a glowing firefly
   - **f** a loose rock on top of a hill
   - **g** ocean waves
   - **h** a piece of chocolate
   - **i** a TV set (turned on)
   - **j** a warm pizza
   - **k** the water in a waterfall
   - **l** a wound-up toy

4 Give an example of something that has
   - **a** gravitational potential energy due to its high position
   - **b** elastic potential energy because it has been stretched
   - **c** chemical energy.

   In each case explain how the energy can be used to produce movement.

5 The diagram shows a pendulum. It was pulled to point A and released. C is the lowest point of its swing and D is the highest point at the other end of its swing.



   - **a** At which point was the pendulum's kinetic energy greatest?
   - **b** At which point was its potential energy greatest?
   - **c** At which point did the pendulum have kinetic energy and potential energy?

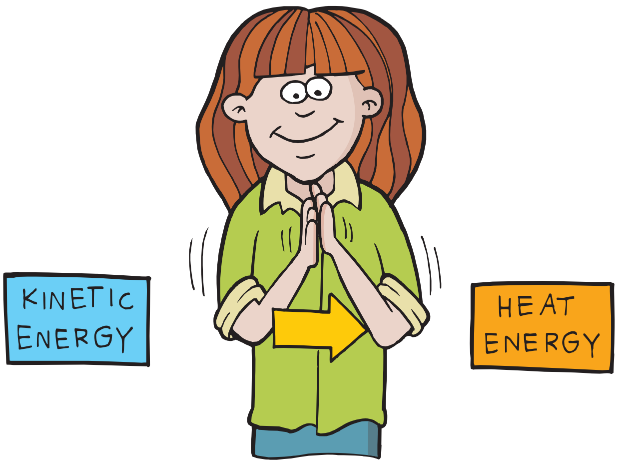
6 In Inquiry 1 on page 165 Emily said that to cause a change you need to supply energy. For example, a kettle boils when you supply heat energy. Give as many examples as you can to illustrate Emily's idea.

7 How do you know if something has energy? Give an example.

8.2 Energy changes

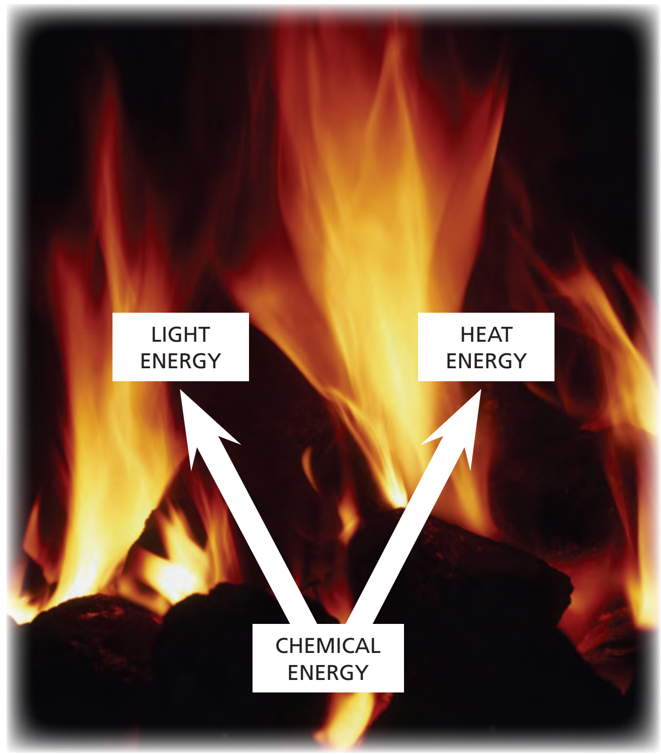
Energy transformations

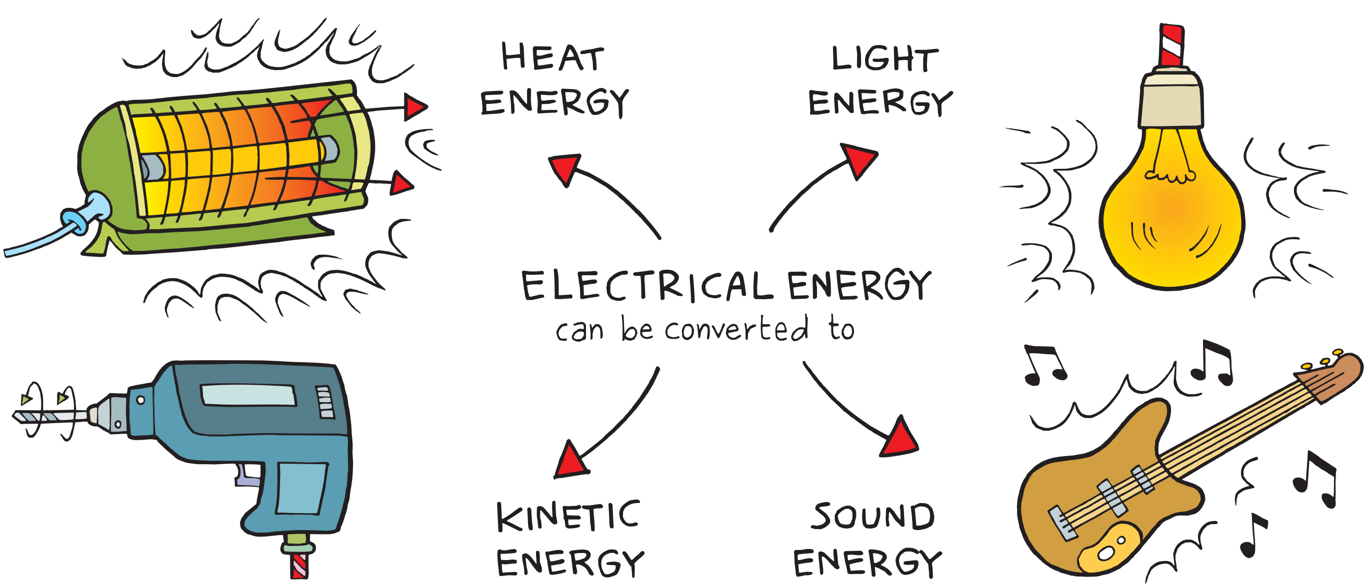
Energy can be *transformed* or *converted* from one form into another. For example, if you rub your hands together they become warm. You have converted the kinetic energy of your moving hands into heat energy. You can describe this change with an arrow, as shown below.



The things you do every day depend upon energy changes. Your body converts the energy stored in food into heat energy to keep you warm and kinetic energy as you move. Electrical energy is very important because you can turn it into many different forms of energy, as shown below. Devices that can convert energy from one form to another are called *energy converters*.

Sometimes more than one form of energy is produced when an energy change occurs. For example, a camp fire converts the chemical energy stored in the wood into light and heat. When you use an electric drill, not all of the electrical energy is converted to the kinetic energy of the drill. Some is lost as sound energy and some as heat energy. This is why the drill is noisy and soon becomes hot.

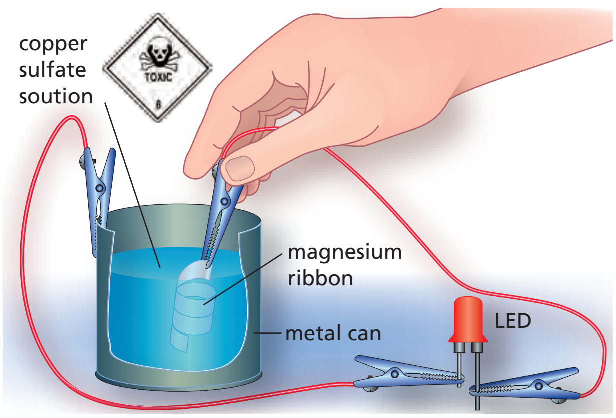




INQUIRY 4 Generating electricity

You will need: piece of magnesium ribbon (about 15 cm), small empty metal can (e.g. baby-food can), low voltage light-emitting diode (LED), 2 connecting wires with alligator clips, steel wool, copper sulfate solution

1. Clean the magnesium ribbon with steel wool until it is shiny. If the can has a coating on the inside, scratch this off in several places.
2. Curl up the magnesium ribbon by winding it around a pencil. Use a connecting wire with alligator clips to connect it to the long leg of the LED, as shown.



3. Three-quarters fill the can with copper sulfate solution.
4. Use the second connecting wire to connect the short leg of the LED to the edge of the can, as shown.
5. Finally, dip the magnesium ribbon into the copper sulfate solution. *Make sure that it doesn't touch the can or the other alligator clip*. Feel the can with your fingers.
   - What energy conversions have occurred?
   - Why did the LED glow only for a short time?

INQUIRY 5 Solar cells

You will need: solar cell kit (consisting of several solar cells connected to an electric motor, preferably fitted with a propeller)

What happens when you connect up the kit and put it in bright sunshine? What happens if you cover all or some of the solar cells?

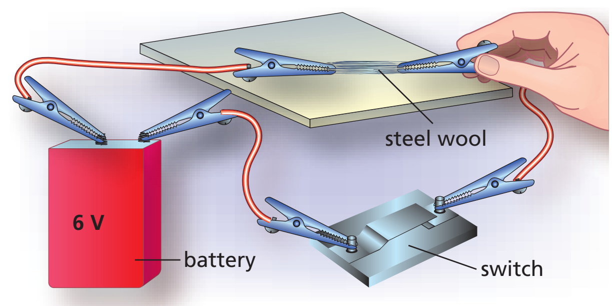
- What energy conversions occur?

INQUIRY 6 Steel wool

You will need: 6 volt battery or power pack, 3 connecting wires with alligator clips, heatproof mat, small piece of steel wool, switch

Use the wires to connect the battery and switch as shown. Put the steel wool on the heatproof mat and connect the wires to it. Close the switch for a few seconds only. Observe what happens.

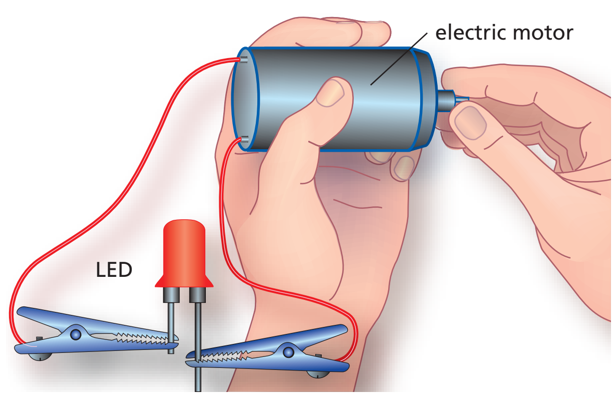
- What energy conversions occur?



INQUIRY 7 Electric motor

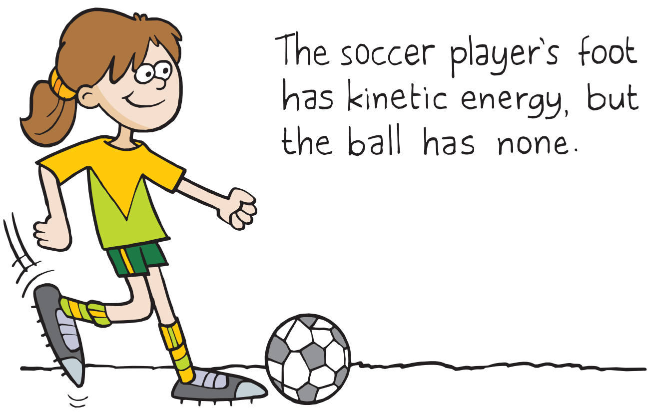
You will need: small electric motor with connecting wires and alligator clips, low voltage light-emitting diode (LED), 1.5 volt battery or power pack

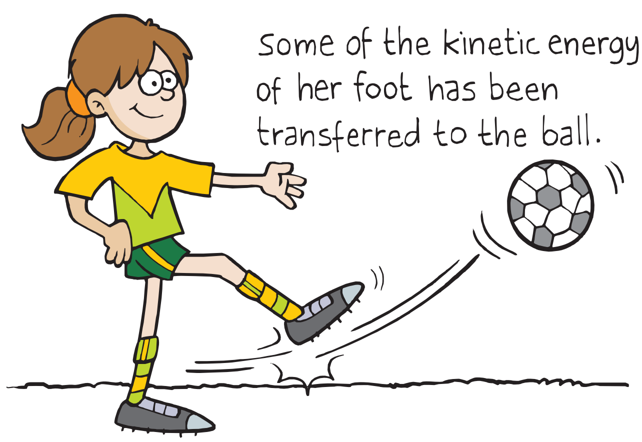
1. Get the motor to work by connecting it to the battery.
2. Get the LED to glow by connecting it to the battery (long leg to the positive terminal).
3. Connect the LED to the motor as shown. Can you get it to glow briefly by giving the shaft of the motor a sharp twist?
   - What energy conversions have occurred in this activity?



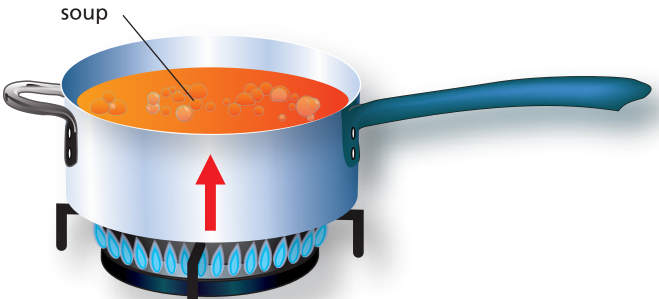
Energy transfers

Energy can be transferred from one object to another without changing its form. For example, when a soccer player kicks a ball, some of the kinetic energy of her moving foot is transferred to the ball, which also moves.





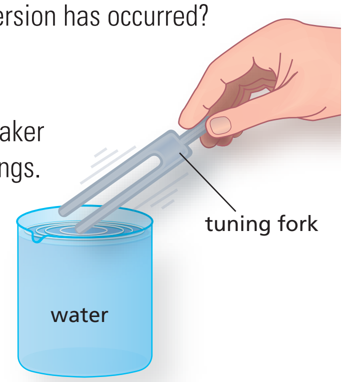
Another everyday energy transfer occurs when you heat soup on a stove. Heat is transferred from the gas flame or the electrical heating element to the soup, making it hot.



INQUIRY 8 *Tuning fork*

You will need: beaker of water, tuning fork

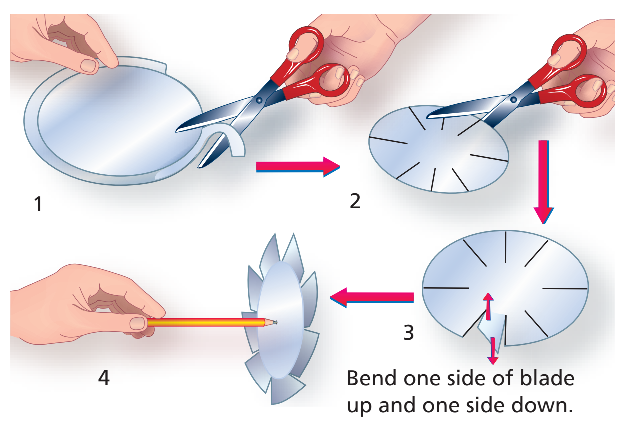
1. Strike the forked end of the tuning fork gently on the heel of your shoe (not on the bench). Hold the fork near your ear. Strike the fork again, but this time look closely at the prongs.
   - What energy conversion has occurred?
2. Strike the fork again, and touch the surface of the water in the beaker with the vibrating prongs.
   - How does this illustrate the transfer of energy?



INQUIRY 9 *Wind-wheel*

You will need: foil pie plate, scissors, pen or pencil

1. Cut the sides from the foil plate and cut slits as shown. Turn up the same side of each of the sections.



2. Make a small hole in the centre of the wheel and push the point of the pen through the hole.
3. Blow on your wind-wheel to make it turn. If it doesn't turn easily, increase the size of the hole or bend the blades more. You may have the blades facing the wrong way.
   - Explain how energy was transferred to the wind-wheel.

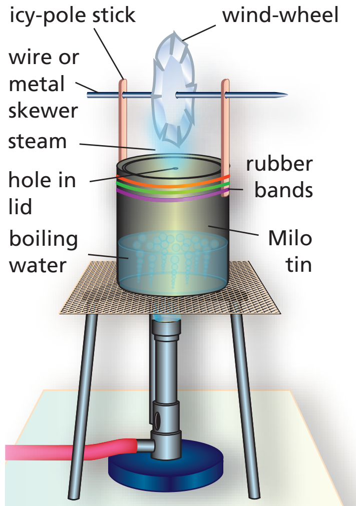
Save your wind-wheel for Inquiry 10.

INQUIRY 10 Steam turbine

You will need: equipment pictured

Instead of blowing on your wind-wheel you can use steam. Set up the apparatus below. You may need to modify it a bit.

Don't put your hand near the steam, and don't let the water in the can boil dry.

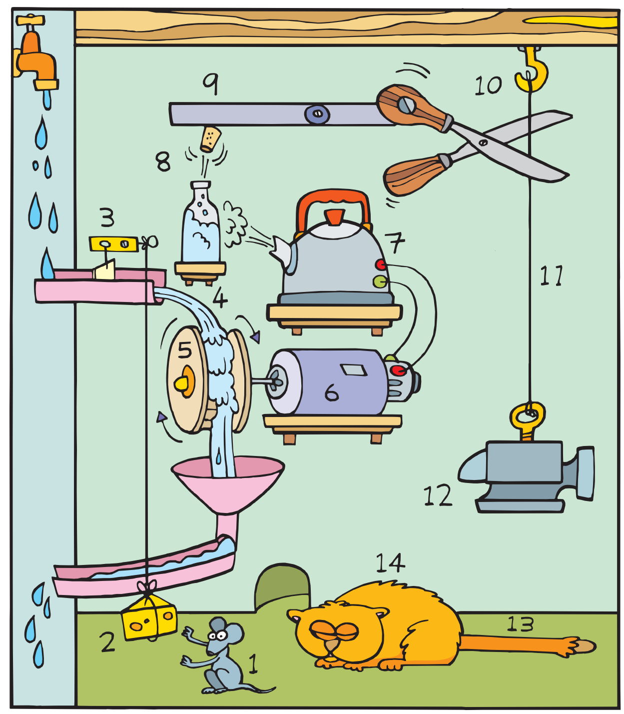


INQUIRY 11 Mousetrap

Study the cartoon mousetrap below.

- List the energy converters.
- Where do energy transfers occur?
- Write an energy chain like the ones on this page to describe all the energy conversions and transfers.

Design your own mousetrap.



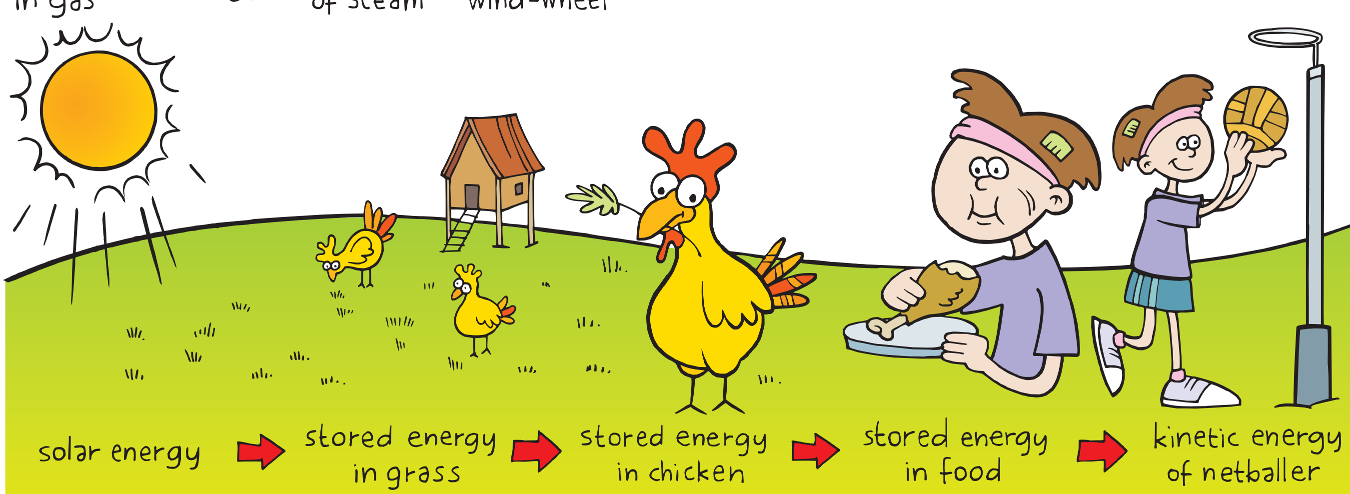
Energy chains

Sometimes one energy change follows another. Theses changes can be transformations or transfers. The series of changes is called an **energy chain**.

Consider what happened with the steam turbine you made in Inquiry 10. As the gas burns in the Bunsen burner, its chemical energy is converted to heat energy. This heat energy is converted to the kinetic energy of the moving steam. This kinetic energy is then transferred to the wind-wheel, causing it to spin.

chemical energy in gas → heat energy → kinetic energy of steam → kinetic energy of wind-wheel

In biology you will learn about food chains. These are also energy chains. In the example below, solar energy is converted to stored energy in the grass. This energy is then transferred to the person who converts it to kinetic energy as she plays netball.



Over to you

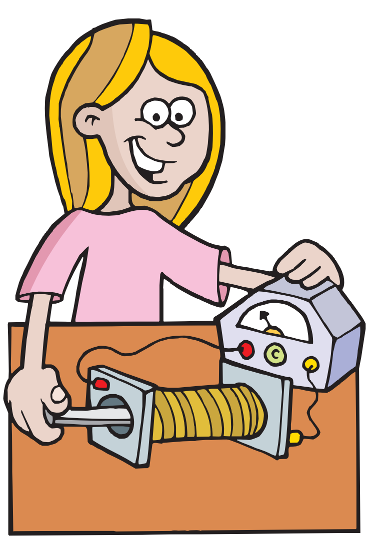
1 Pair up these lists correctly in your notebook.

Object	**Main energy conversions**
car battery	chemical to heat and light
CD player	electrical to light and sound
electric motor	electrical to sound
gas light	chemical to kinetic
nuclear power station	electrical to kinetic to potential
ski lift going up	chemical to electrical to light
solar cell	electrical to kinetic
torch	nuclear to electrical
truck	chemical to electrical
TV set	light to electrical

2 Copy and complete the table below.

Energy used	Energy converter	Energy produced
....	chainsaw	....
....	electric fan	....
kinetic	....	electrical
....	hydrogen bomb	....
....	light bulb	....
....	microphone	....
electrical	....	heat
....	slingshot	kinetic
....	steam engine	....
kinetic	....	sound
....	waterwheel	....

3 Grace connects a coil of wire to an electrical meter, as shown. When she plunges a bar magnet into the coil the meter shows there is an electric current flowing. When she holds the magnet still, no current flows. Write a sentence or two describing what is happening in terms of energy changes.

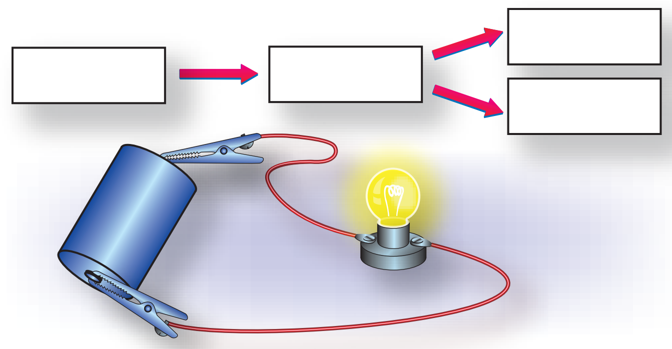


4 Into what forms of energy does your body convert the chemical energy in food?

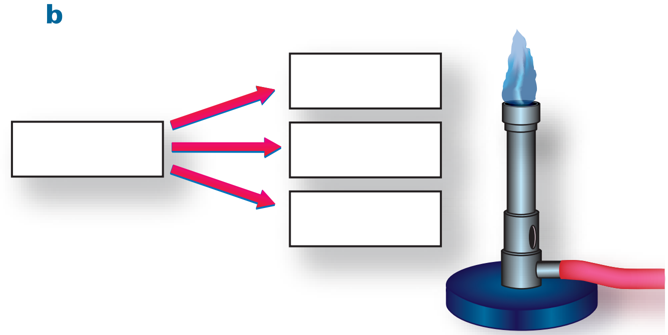
5 What is the difference between an energy transfer and an energy conversion? Give several examples of each.

6 Copy the boxes and complete the two energy chains below.

a



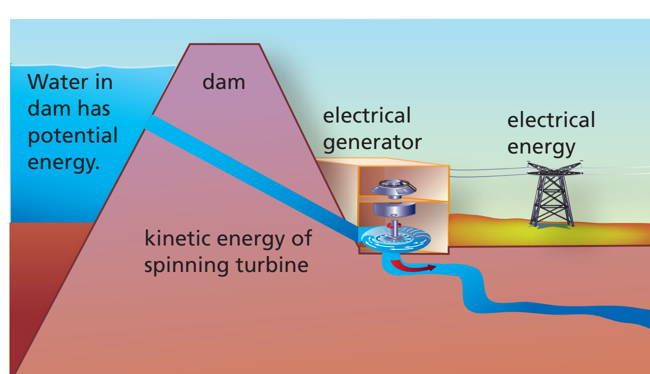
b



7 What energy change takes place in a solar water heater?

8 What is the energy conversion that takes place in a green plant during photosynthesis?

9 The diagram below shows how a hydro-electric power station works. Write an energy chain to show the energy changes that occur.



An electric generator is like an electric motor in reverse (see Inquiry 7). Spinning the shaft generates electricity.

8.3 Energy from food

A car gets its energy from petrol. When the petrol tank is empty the car stops. It has run out of energy. We need energy to keep us alive, to grow and to move. We get this energy from the food we eat. The more we move about the more food we need. Our bodies can change this food into energy that we can use. The triathletes in the photo need to eat a high-energy meal before the race and perhaps eat high-energy snacks and drinks during the race.

The more active we are the more energy we use.

Measuring energy

Energy is measured in **joules**, and the symbol for joule is J. This unit was named after a British scientist called James Joule who did experiments with heat. The amounts of energy in food are quite large so they are measured in *kilojoules* (kJ), where one kilojoule is 1000 joules.

All foods have *energy values*. For example, a 250 mL glass of milk contains 670 kJ of energy. A medium-sized banana contains 380 kJ. The table on the right gives the energy values of some common foods.

On average, a 12-year-old boy needs about 12 000 kJ of energy every day, and a 12-year-old girl needs about 10 500 kJ. Adults need less than this. Different activities require different amounts of energy. For example, walking requires 18 kJ per minute and freestyle swimming requires 125 kJ per minute. See the table on the right.

INQUIRY 12 *Brigitte's energy*

It is important to start your day with a healthy, nutritious breakfast. Brigitte therefore starts her day with an orange, corn flakes with milk, two boiled eggs, two slices of toast with butter (a large spoonful) and a glass of milk.

- How many kilojoules of energy does this meal give her?
- Suppose Brigitte swims in the 1500 m freestyle at the swimming carnival. She takes 2 minutes. How much energy does she use up during the race?

Food	Energy value (kJ)
Apple	300
Banana	380
Bread or toast (slice)	340
Butter (large spoonful)	460
Chocolate bar (45 g)	1100
Chocolate cake (medium slice)	1200
Cheese, cheddar (30 g)	460
Corn flakes (1 serving)	445
Egg, boiled	300
Egg, fried	400
Milk, full-cream (250 mL)	670
Orange	200
Peanuts, salted (45 g)	1100

Activity	Kilojoules required per minute
Riding a bicycle	29
Climbing stairs	47
Playing football	78
Doing homework	8
Jogging	69
Riding a motorbike	15
Singing	9
Sleeping	6
Standing	8
Swimming, freestyle	125
Swimming, backstroke	156
Walking	18
Washing up	15

INVESTIGATION

1 Energy from food

Aim

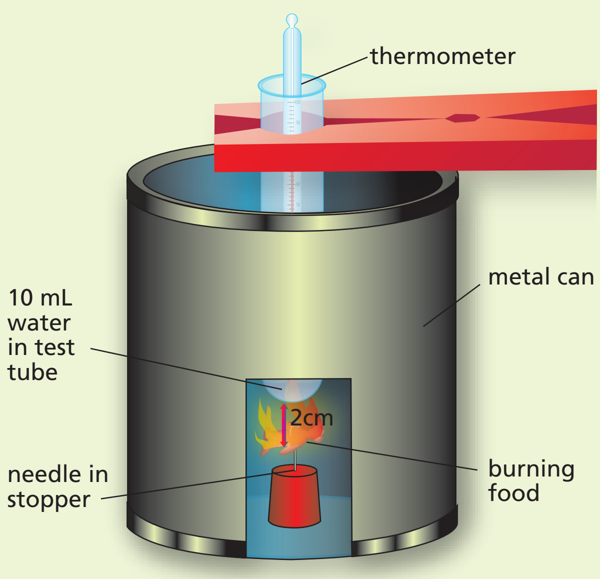
To find out how much energy is released when a small piece of food burns.

Risk assessment and planning

1 Read through the experiment, then describe to your partner what you have to do, measure and record.
2 What safety precautions will be necessary?
3 What data will you need to record?

Apparatus

- large test tube
- test-tube holder
- small piece of food, e.g. Nutri-Grain or Tiny Teddy
- needle
- stopper
- Bunsen burner
- heatproof mat
- thermometer
- metal can
- measuring cylinder (25 mL)



Method

1 Cut the top and bottom out of a metal can, and also cut a door as shown so that you can see the food burning. Put the can on a heatproof mat.
2 Pour exactly 10 mL of water into the test tube and hold it in the can with a test-tube holder as shown.

Measure and record the starting temperature of the water.

3 Push the blunt end of the needle into the stopper and then stick the sharp end into the piece of food.
4 Slide the stopper and food under the test tube. There should be a space of about 2 cm between the test tube and the food.
5 Get the food to burn in a Bunsen flame and immediately put it back under the test tube.
6 When the food stops burning, stir the water *gently* with the thermometer, and measure the final temperature.
7 If you have time, repeat the experiment with other foods, e.g. nuts, bread, rice, spaghetti. Note that some people may be allergic to burning peanuts.

Record all your results in your data table.

Results

1 By how many degrees did the temperature of the water increase?
2 It takes 4.2 joules to raise the temperature of 1 mL of water by 1°C. So, to calculate the heat energy gained by 10 mL of water, multiply the temperature rise by 42. Your answer will then be in joules. This is the energy released by the burning food.
3 Which of the foods you tested contained the most energy?

Discussion

This is a new section of your report where you analyse your experiment by answering these questions.

a Were the results what you expected?
b If they were, say *why* you expected these results.
c If the results were not what you expected, try to explain them.
d Were there any problems or errors in the experiment? If so, describe them. For example, in Step 7, were you able to accurately compare the energy released by different foods? Why or why not?
e What could be done to improve the experiment?

Write your report

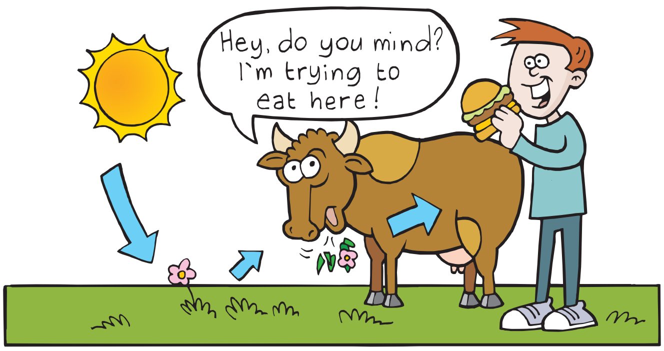
Use the usual headings, including a conclusion, but this time add a discussion after your results and before your conclusion.

8.4 Energy comes and goes

Where does energy come from?

You use a lot of stored energy without really thinking about where it comes from. You get food from the supermarket, petrol from the service station and gas through pipes. But how did the energy get into these things in the first place?

During photosynthesis green plants store the energy of sunlight in their bodies as chemical energy. Animals that eat these plants use some of this energy and store the rest. So when you eat food that comes from plants and animals you are using stored energy that came originally from the sun.



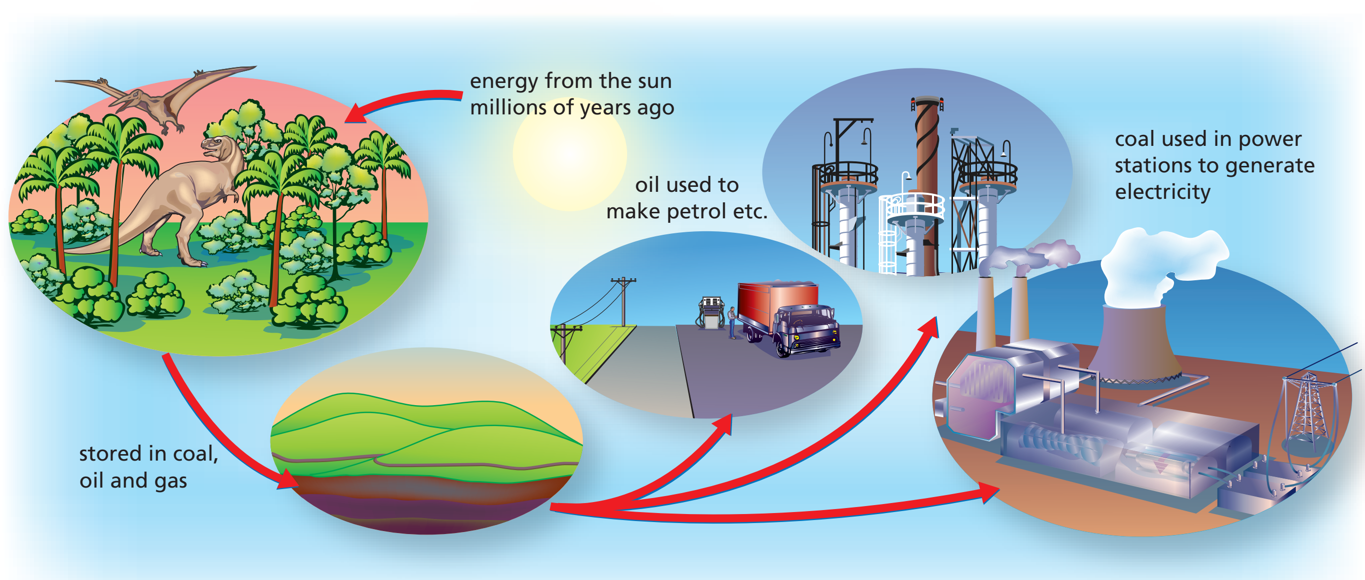
Millions of years ago plants and animals also turned the energy of the sun into stored energy. When they died their bodies were sometimes buried under mud and sand before they decayed. In this way their stored energy was trapped. Slowly the remains of these plants and animals changed to coal, oil and gas. These are called **fossil fuels**. When we burn them we are releasing their stored energy.

If the sun did not shine on the Earth there would be no green plants, and without the plants there would be no animals. Also, if the sun had not shone for millions of years, there would be no fossil fuels. In fact, without the sun there would be no life on Earth.

Renewable and non-renewable

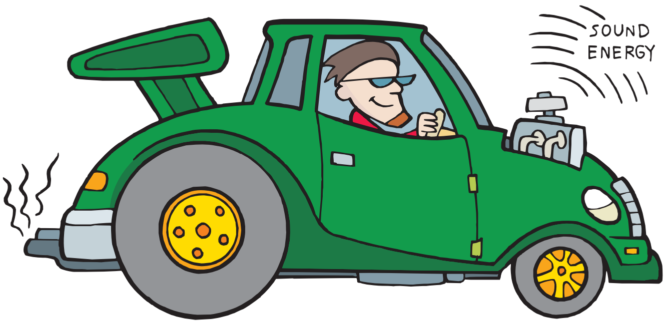
Fossil fuels are our main source of energy, but they are **non-renewable**. They have taken millions of years to form from sunlight falling on the ancient Earth. Yet once we have used them to make petrol or to generate electricity, they are gone forever. This is why we say they are non-renewable. Also, the amount of energy stored in fossil fuels is very small compared with the amount of solar energy reaching the Earth. In fact, it is estimated that there is more energy in the sunlight reaching the Earth in 10 days than in all the fossil fuels on Earth!

Our supplies of fossil fuels are very limited and it makes much better sense to use **renewable** energy sources that can be replaced. We now have the technology to capture the sun's energy directly for our use. For example, panels of solar cells mounted on the roof can supply enough electricity for your house. Hydro-electricity and wind power are other renewable energy sources.



Wasted energy

Look at the energy chain below for a moving car.



chemical energy stored in petrol → heat energy released as petrol burns → kinetic energy of moving engine parts → kinetic energy of wheels and car

Each step in the chain involves some loss of energy. Friction between the moving parts of the engine produces heat. This heat is then transferred to the air around the car. Also, as the engine parts move they produce sound energy that is also transferred to the air. So not all the stored energy in the petrol is used to make the car's wheels turn. In fact, engineers have calculated that if you start with 100 joules of chemical energy, you end up with only 20 joules of kinetic energy. The other 80 joules is wasted as heat and sound and is not useful because it cannot be used again. Note that the *total* amount of energy you end up with is the same as the amount you started with. It has merely changed its form.

All energy converters waste energy—usually as heat. And the longer the energy chain, the more energy that is wasted. The **efficiency** of an energy converter is the percentage of the input energy which is turned into useful energy.

$$\textbf{Efficiency} = \frac{\textbf{useful energy}}{\textbf{input energy}} \times 100$$

For example, the efficiency of a car is about 20%. Because there is always some waste energy, the efficiency of an energy converter is always less than 100%.

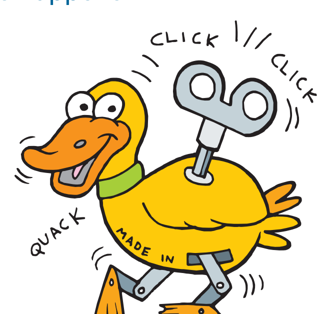
Energy never disappears

You have looked at many examples of how energy is transformed and transferred. After thousands of such observations, scientists decided that there is a special rule or *law* that describes energy changes. The law of **conservation of energy** says that energy cannot be made, destroyed or lost—it can only be converted from one form to another. This means that the universe always has the same amount of energy, even though this energy is constantly being converted from one form to another and being transferred from one place to another.

To help you understand the law of conservation of energy, think about a board game such as Monopoly, in which money can be used for buying and selling. The money is transferred between players and the bank, but the total amount is always the same. If at the end of the game all the cash is added up, the total should be the same as at the beginning, although it will be distributed differently. The same applies to energy. It may move around and change its form, but the total amount is always the same.

Over to you

1. When using a hacksaw to cut a piece of metal, the blade and the metal both become hot. Explain in energy terms why this happens.
2. Suppose you wind up a toy duck and let it go.
   - **a** Where did the energy needed to wind up the duck come from?
   - **b** Where has this energy gone when the duck stops moving?



3. To charge a battery you have to supply electrical energy. But you never get as much energy from the battery as you use to charge it. Why is this?
4. A hot water system is 65% efficient. If it is supplied with 3000 joules of electrical energy, how much heat energy does it produce?
5. What is the difference between renewable energy and non-renewable energy? Give several examples of each.
6. Explain in your own words how the energy stored in the petrol you use in your car originally came from the sun.

INVESTIGATION

2 Colliding ball bearings

Aim

To investigate the efficiency of energy transfers between colliding ball bearings.

Risk assessment and planning

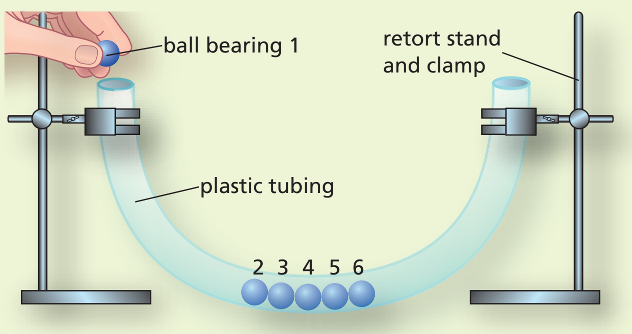
Read through the investigation and do a risk assessment.

Apparatus

- piece of plastic tubing, about 80 cm long
- 6 ball bearings or marbles, to fit inside the tubing
- marking pen
- 2 retort stands and clamps
- metre rule

Method

1 Use the stands and clamps to set up the plastic tubing as shown.



2 Place 5 ball bearings in the tube. Then drop another ball bearing in one end of the tube.

- Use what you have learnt in this chapter to explain what happened.

3 Use a metre rule to measure the vertical distance that ball bearing 1 fell before it hit the other ball bearings in the tube.

- Record this distance.

4 Remove ball bearing 1 from the tube. Drop it into the tube as before, but this time use the marking pen to mark how far up the tube ball bearing 6 goes. Repeat the measurement several times.

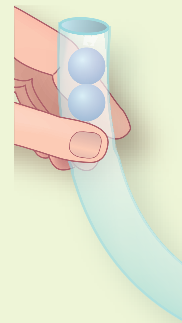
- Record your measurements and calculate the average distance.

5 Calculate the efficiency of the colliding ball bearing device as follows:

$$\text{Efficiency} = \frac{\text{distance ball 6 rises}}{\text{distance ball 1 falls}} \times 100$$

- Why do you think the efficiency of your device is less than 100%?
- Was any energy wasted? If so, what do you think happened to it?

6 Predict what will happen if you drop two ball bearings into the tube together. Try it.

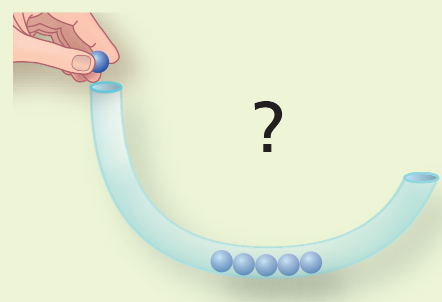


To release two ball bearings together you can pinch the tubing with your fingers. Then, when you are ready, let the tubing go and the ball bearings will fall together.

- Was your prediction correct? Explain.

7 What will happen if you drop *three* ball bearings into the tube together? Check your prediction.

8 Suppose you change the position of the plastic tube as shown, then drop in a ball bearing? Will ball bearing 6 come out of the end of the tube?



Clamp the tube in position where you think ball bearing 6 will just stay in the tube after collision. Use your results from Steps 1–5 and make any measurements you think are necessary.

- When you have chosen a position, explain why you picked that particular position.

9 Now for the moment of truth. Drop ball bearing 1 into the tube.

Was your prediction correct? If it wasn't, you may need to rethink the problem.

Discussion

Write a discussion using the questions on page 175 as a guide.

Conclusion

Write your own conclusion, summarising what you found out about the colliding ball bearing device.

SCIENTISTS AT WORK

Maria Skyllas-Kazacos

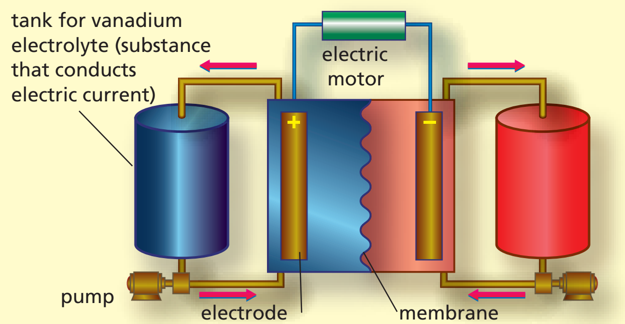
Maria Skyllas (SKY-las) was born in Greece in 1951 and came to Australia with her parents when she was only 2 years old. She went to Fort Street Girls' High School in Sydney. She chose easy subjects but after about a month her maths teacher said 'Maria, you should be doing advanced maths', to which Maria replied 'Oh no, I can't. It's too hard. I'm going to fail!'. But the teacher insisted she do it and she was soon top of the class.

Maria is fourth from the left in the front row.

Maria went to the University of New South Wales to do a degree in industrial chemistry and she had to study hard in order to do well. There were only two or three females in her chemical engineering classes but that didn't worry her as the male students and professors were all very supportive.

In 1976 Maria married Michael Kazacos (ka-ZAR-cos) and she now has three sons. She has managed to combine being a mother with her research at the University of New South Wales. Her third son Anthony arrived just as she was organising a major international conference, but she managed to look after her new baby as well as run the conference.

Maria has always wanted to apply science to real-life problems. Because petrol and diesel-powered vehicles cause so much air pollution, a lot of research is being done on electric vehicles. However, these vehicles are limited because they have to use heavy bulky lead batteries to store electrical energy. Maria was also very interested in renewable energy and was aware that its widespread use was limited by the lack of a suitable energy storage system. So she got together a team to develop a new type of battery. Her husband Michael worked with her too. They had little money for research and had to be very resourceful, using many borrowed or recycled materials and equipment. After only two years of research, Maria and her team developed the vanadium battery. However it took others 15 years of development before the technology was manufactured commercially.



The vanadium battery is up to 90% efficient and can be recharged thousands of times, making it ideal for electric vehicles. You recharge it overnight using off-peak electricity, or you can replace the electrolyte solutions. In the future Maria believes you may be able to have your vanadium battery recharged by replacing the electrolyte—just like filling up the petrol.

Once Maria showed that her new battery would work, the patents were sold by the University of New South Wales to a manufacturer. Vanadium batteries are now being used all around the world for solar and wind energy storage. For example, a large vanadium battery is used to store wind energy for King Island in Bass Strait. And the battery has been used to power a golf buggy.

Questions

1 Why was Maria keen to develop a new type of battery?

2 Why does the vanadium battery need recharging? How can you do this?

3 How did Maria show determination and perseverance in achieving her goals?

8.5 Doing a project

In science you will sometimes be asked to do a project. How do you go about this?

First, you could turn one of the chapter problems into a project. Second, there are many ideas for projects in *Thinking skills*. Third, you could extend one of the Inquiries. For example, you could investigate how energy is changed in electric circuits (see page 170).

If you do a *student research project* like this, you will not simply be following instructions in a book. A project involves you deciding what needs to be done, then doing it, and reporting your results to others.

On a trip to India Christopher Bentley wondered whether chilli in food kept away diseases. So he did a CSIRO CREST project to see what affect various parts of chilli plants have on micro organisms.

INQUIRY 13 Choosing a project

1 Look through this textbook and note down the things that interest you the most and that you would like to know more about. In particular, check the problems, inquiries, and investigations. Which do you think would be suitable for a student research project? Write these down.

2 Most projects start with a question to investigate. Some that students have investigated are:
- Can dogs see colours?
- Do all your fingernails grow at the same rate? Do fingernails grow faster than toenails?
- How can I make a better cleaning device for our fish tank?
- How can I make a device to alert you when it is raining so that you can get the washing off the line?
- How can soil erosion in our area be reduced?
- How can you keep the house cool in summer and warm in winter?
- How can you make the bubbles in a bubble bath last longer?
- What affect does oil have on water plants?
- Which materials make the strongest bricks?
- Is it true that people with low blood pressure are not bitten by mosquitoes as much as people with higher blood pressure?

3 Check these two websites for further ideas to get you started.

Do-it-yourself science

www.csiro.au/resources/DIYScience.html

Science fair projects

www.all-science-fair-projects.com

You could also check BHP Billiton, CSIRO CREST and the Science Teachers' Associations for details of the competitions they run.

4 Consider each of your ideas in turn. You will probably ask yourself questions like these:
- Which project do I like the most? Which is the most interesting?
- Can I get the equipment and materials I need?
- Can I find the information I need to do the project?
- Can I complete the project in the time available?

Talk with teachers and other people about your ideas. Finally, pick the project you think would be best for *you*.

Gathering information

You can gather information in three main ways:

a from libraries, magazines, newspapers, TV programs and the internet (see Inquiry 14).

b by talking to a few people who know a lot about the topic, or by doing surveys of many people. For example, you could use a questionnaire to find out which brands of washing-up liquid people use.

c by doing experiments yourself to try to answer the question under investigation, e.g. Which of these materials is the best insulator?

PROBLEM SOLVING

Have you made a successful mousetrap racer? How far did it go? How fast did it go? What problems did you have to solve? Can you explain how it works in terms of energy changes?

You may want to keep working on it. For example, you could investigate its motion using a datalogger and motion detector. If you make it into a project you may be able to use some of the ideas in this section.

You may be able to enter your racer in a competition. You could check the internet for information on this.

INQUIRY 14 *Using the internet*

Answer the questions below by investigating the following science websites.

Nova: www.science.org.au/nova

Australia Advances: www.csiro.au/promos/ozadvances

ABC Science: www.abc.net.au/science

New Scientist: www.newscientist.com

Double Helix: www.csiro.au/helix

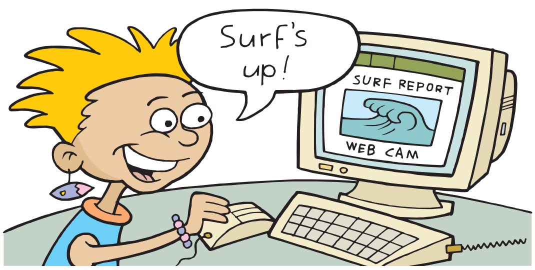
How Stuff Works: www.howstuffworks.com

1. Which of the general science sites listed above are Australian?
2. Which site would be best for doing research on Australian discoveries in science and technology?
3. The *Nova* site lists topics under six categories. What are they? Check out a topic that sounds interesting, including the Activities page.
4. Investigate the *How Stuff Works* site. They have a wide range of things you might be interested in.
5. What is in the latest issue of *New Scientist* magazine? Pick an article or news item that interests you.
6. On the *Double Helix* site you can work with some of Australia's leading scientists doing real research. Which project(s) are they working on at present?
7. Think of a science topic you might need to research. Then do a search for it in one of these science sites.
8. Check out the *ABC Science* site. Look for possible project ideas.

Surfing tips

Here are some tips to help with your web surfing project research.

- If you get an error message after typing in a web address, first check that you have the address exactly right. If this doesn't work try deleting the last part of the address, back to the first /.
- Searching using key words takes a bit of practice. If you use only one word like *hovercraft* you often get too many sites. When this happens you need to narrow your search by adding a word or two to describe more precisely what you are looking for; for example *how to make a hovercraft* or *hovercraft + balanced forces.*
- When you are researching a topic it is best to use several different sites. The information on one site may be inaccurate or not up to date. Some sites are also biased, that is, they only present one side of the story.
- Instead of doing a general search using a search engine such as *Google*, it is sometimes a good idea to go into a general science site such as one of those on the left and search within it.



Hints on doing your project

1 Plan what equipment and materials you will need for your project. Check what is available at school, what you can get from home and what you can borrow. You don't always need proper laboratory equipment. For example, you could use glass jars instead of beakers, or measuring jugs instead of measuring cylinders.

2 Write a brief outline of what you plan to do. This outline should include:
- the question you are going to investigate
- the equipment and materials you will need and where you can get them
- a list of possible information sources.

Show this to your teacher who will give you helpful suggestions and then give you the okay to go ahead. *Do not attempt the project without your teacher's approval.*

3 Plan your time carefully by dividing the project into stages. An example of a plan for a 5-week project is shown below.

Selecting a topic and preparing plans	1 week
Doing project	2–3 weeks
Evaluating results and preparing report	1–2 weeks
Presenting report	1 day

4 Keep a journal just for your project. This will be very useful when you come to prepare your report. It could include notes you have taken from books, photographs or drawings of your experiments, tables of data, drawings or plans of a model at various stages of construction etc.

5 When doing experiments, you should follow these steps:
- Write down the aim of the experiment. This may be a hypothesis you are testing; for example. *Substances dissolve faster in warm water than in cold water.*
- Make sure any tests you do are fair. To do this you need to test one variable and control all the others.
- Do the experiment, and collect and record data. Computer spreadsheets are useful here.
- Try to duplicate your tests for more accurate results. For example, if you are germinating seeds, set up three or four pots for each test, not just one.

Remember, there are no incorrect answers when doing an experiment—only unexpected ones.

For more information on designing your own experiment see pages 13–14.

6 You will need to make a list of the sources of your information as part of your report, so keep careful notes of any books, magazines and websites you use.

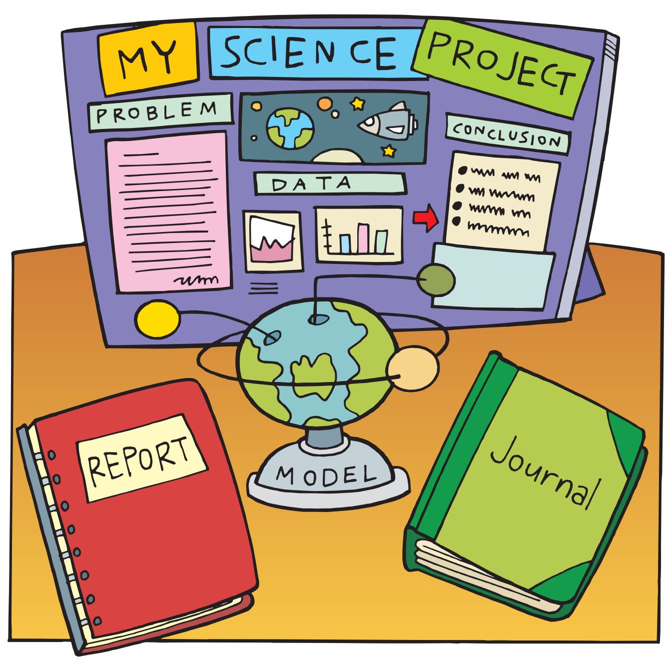
Hints on preparing a report

1 Your report should have the same headings as for an investigation. It should also have a Discussion where you discuss any difficulties, errors and results you cannot explain. Don't forget your Conclusion. Doing the project may be the most important thing for you, but most people will want to know how successful you were in achieving your aim.

2 As well as your written report, you will need to display any device or model you have made. You could also make a display for the library, a short talk using overhead transparencies or a PowerPoint presentation.

You can display a report made of many different parts on large sheets of white card taped together to create a display board as shown below.

3 Ask your teacher about entering your project in a science contest.



THINKING SKILLS ?

1 A neon street light converts 300 J of electrical energy into 200 J of heat energy and 90 J of light energy.

a Some energy is missing. Suggest what has happened to it and what it is.

b What is the efficiency of the light?

2 Peter burnt his finger on a frypan. He immediately put his burnt finger on a piece of ice. Explain how energy was transferred when

a he burnt his finger

b he put his finger on the ice.

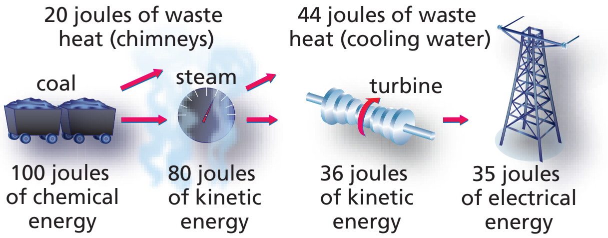
3 The diagram below shows the energy changes in a coal-burning power station.

a Draw an energy chain to describe what happens in the power station.

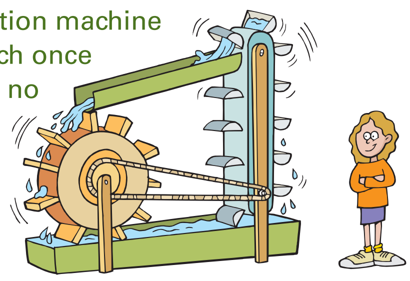
b A small amount of energy is lost when the kinetic energy of the turbine is converted to electrical energy. Infer how this energy is lost.

c How many joules of heat are released into the environment for each 100 joules of chemical energy stored in the coal?

d What is the overall efficiency of the power station?



4 The diagram shows someone's idea of a perpetual motion machine (a device which once started needs no more energy to keep it going). Do you think it will work? Explain your answer.



5 How could you demonstrate that sound is a form of kinetic energy?

6 Two cars collide head-on and come to a stop. What has happened to the kinetic energy that the cars had before the crash?

7 Draw a cartoon of an archer about to fire an arrow. Discuss with another student how potential energy is involved, and how this energy will change when the arrow is fired. Write a caption to describe your cartoon in energy terms.

8 In an experiment similar to the one you did in Investigation 1, five different foods were burnt and the increases in water temperature measured. The results are shown below.

Food	Mass of food (g)	Mass of water heated (mL)	Increase in water temperature (°C)
Beans	1.0	20	6
Bread	1.0	20	35
Cashews	0.5	20	47
Oil	0.5	20	73
Pasta	0.5	20	10

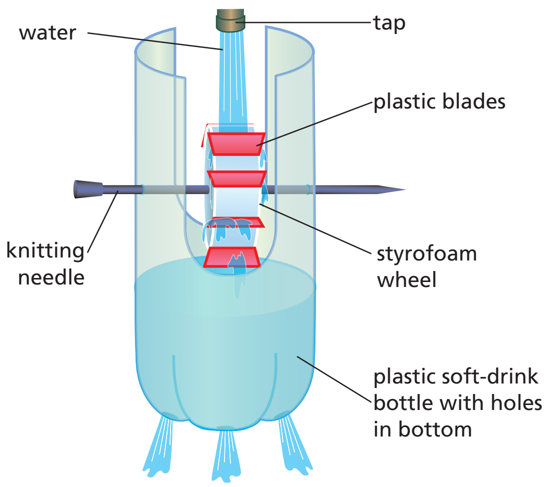
a Calculate the energy released from each food.

b Calculate the energy *per gram* released from each food. Which has the highest energy value?

9 Make a working model of a waterwheel. One way to do this is shown below.

a Describe the energy changes that occur in a waterwheel.

b How could you use your waterwheel to light a LED as in Inquiry 7?



Knowing and Understanding

Copy and complete these statements using the words on the right to make a summary of this chapter.

1 ______ makes thing go. It makes things happen, or causes ______. It is measured in joules or ______ (kJ).

2 There are many different ______ of energy; for example, light, heat, sound and ______.

3 ______ energy is the energy an object has because of its movement. Energy that is stored is called ______ energy.

4 Energy can be ______ from one object to another, and it can be ______ from one form to another. A series of energy changes is called an energy ______.

5 When an energy change occurs some energy is always wasted as ______. The law of conservation of energy says that energy cannot be ______ or destroyed.

6 Most forms of energy (including fossil fuels) can be traced back to the ______.

7 ______ energy sources such as solar energy can be replaced as they are used. ______ are non-renewable sources and cannot be replaced when they are used.

chain
changes
converted
electricity
energy
forms
fossil fuels
heat
kilojoules
kinetic
made
potential
renewable
sun
transferred

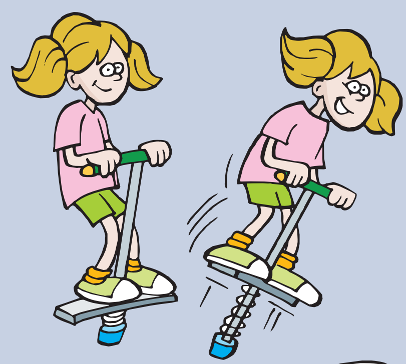
Self-management

A good way to explain scientific ideas is to draw pictures.

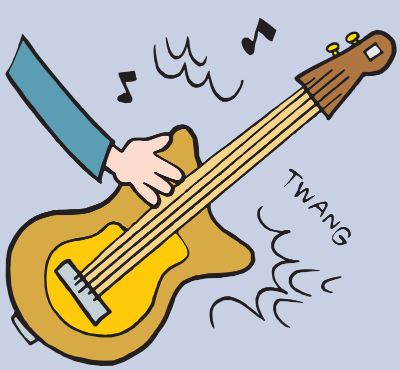
1 Apply what you have learnt in this chapter by explaining each of the four situations pictured in terms of energy. Try to talk about:
- forms of energy
- energy conversions
- transfer of energy.

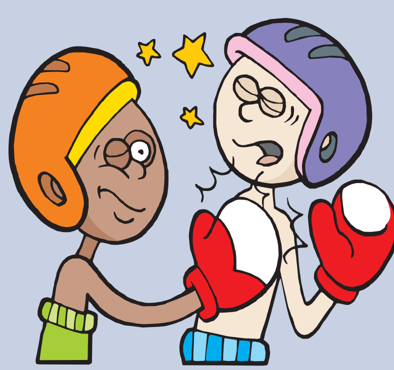
2 Draw your own picture to illustrate energy being
  a transformed from one form to another
  b transferred from one object to another.

3 Think of an energy chain and draw it.


A

B

C



D

Checkpoint

Remember to look at www.OneStopScience.com.au for extra resources

1 In any energy change some energy is always wasted as

A potential energy

B heat energy

C sound energy

D kinetic energy.

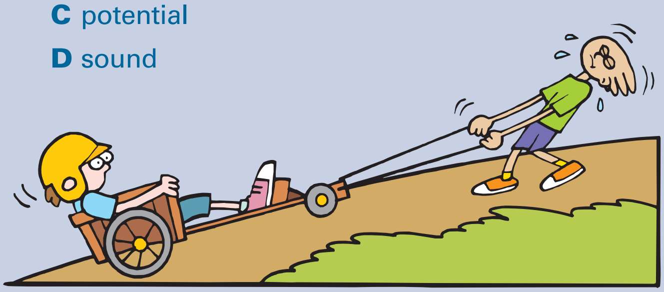
2 As a go-cart is pulled up a hill, which form of energy is gradually increasing?

A chemical

B kinetic

C potential

D sound



3 Which of these requires the most energy?

A riding a bicycle on level ground

B riding a bicycle up a hill

C walking

D doing your homework

4 The same energy conversion occurs in a person running, a car engine and a coal-burning power station. Which is it?

A kinetic → electrical

B heat → chemical

C heat → kinetic

D chemical → kinetic

5 Which of the following is incorrect?

A Energy can be made.

B Energy can be changed from one form to another.

C Energy can exist in more than one form.

D The energy in food came initially from the sun.

6 Which of the following involves a transfer of energy from one object to another, rather than an energy conversion?

A Hot coffee poured into a cup makes the cup hot.

B A hydro-electric power station uses running water to generate electricity.

C The tyres of a moving car become hot.

D Gas is burnt to cook a meal.

7 Classify the following energy sources as renewable or non-renewable: coal, diesel fuel, LPG gas, ocean waves, the sun, uranium fuel, wind, wood.

8 For every 100 joules of energy used by an electric light bulb, you get only about 5 joules of light energy.

a What happens to the other 95 joules of energy?

b How efficient is the light bulb?

9 Sam said that electrical energy is made in a hydro-electric power station (page 173 bottom right). In terms of the law of conservation of energy, is Sam correct? Explain.

10 The cartoon below shows a way of generating electricity. Write an energy chain to describe how it works.