7 Precious resources

When people describe Australia as being rich in resources, they are talking about coal, natural gas, oil, iron, copper, uranium and a host of precious minerals. But when it comes to the most precious resource of all — water — Australia is sadly lacking. Apart from Antarctica, Australia is the driest continent on Earth. All of our resources, whether they are fuels, precious minerals or water, must be used wisely to ensure that our future is sustainable — that is, a future in which we and generations to come can live in a healthy environment.

Think about resources

- How do geologists know where to mine for precious minerals?
- From a damp green swamp to a lump of coal — how does that happen?
- What makes underground coal mining so dangerous?
- How many homes can be powered by a single wind turbine?
- What causes warm and cold ocean currents?
- Where is most of the world's fresh water?
- How does global warming affect the water cycle?
- What makes soil such a precious resource?

In this chapter:

YOUR QUEST

Renewable and non-renewable resources

Renewable resources are those that replace themselves in a short time. For example, solar energy is a renewable resource that can be used for heating water or generating electricity. It is never 'used up' and is constantly being replaced by the sun. Oil is a **non-renewable resource** that takes millions of years to be replaced.

THINK, DISCUSS AND COLLABORATE

1 Working in a group, decide whether each of the following natural resources is renewable or non-renewable.

- Coal
- Diamonds
- Hydro-electricity
- Natural gas
- Water
- Wind energy
- Wood

After making your decisions, copy and complete the table below.

Natural resource	Renewable or non-renewable?	Reason for your decision
Coal		
Diamonds		
Hydro-electricity		
Natural gas		
Water		
Wind energy		
Wood		

2 Working in a group, discuss the materials listed in the table below. All of the materials in the table are made from natural resources. Copy and complete the table as your discussion proceeds. Fill any gaps by using the internet or books in the library.

Material	Natural resource from which it is made	Renewable or non-renewable resource?	Why it is useful?
Plastic			
Steel			
Aluminium			
Nylon			
Wool			
Paper			
Glass			

The riches below

The Earth provides a vast range of resources that allow us to live healthily and to make things that we take for granted every day. Buildings, furniture, cars, plastics (including nylon and polyester) are all made from natural resources. Most fuels are provided by or made from natural resources such as coal, oil and natural gas.

Metals in the Earth's crust

The outer layer or **crust** of the Earth, which includes all landforms, rocks and soil, is made mostly of solid rock. A bit like a shell, it covers the whole planet. It varies in thickness from about 8 kilometres below the oceans to about 40 kilometres below the continents.

The metals used in buildings, road vehicles, trams and trains, all electronic devices and countless other products are obtained from **minerals** found in the Earth's crust. Minerals are the natural substances that make up rocks, which are mixtures of two or more minerals. A substance that contains minerals of value is called a **mineral ore**.

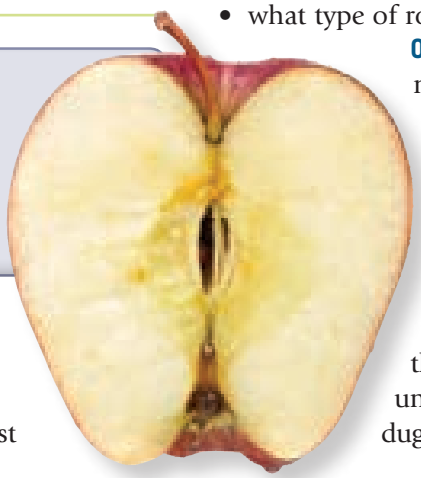
Minerals are non-renewable resources, because when they are mined and used they don't replace themselves quickly — in fact, it can take millions of years.

Some mineral ores commonly mined in Australia

Mineral ore	Metal
Bauxite	Aluminium
Galena	Lead
Sphalerite	Zinc
Haematite	Iron
Pentlandite	Nickel
Chalcopyrite	Copper

HOW ABOUT THAT!

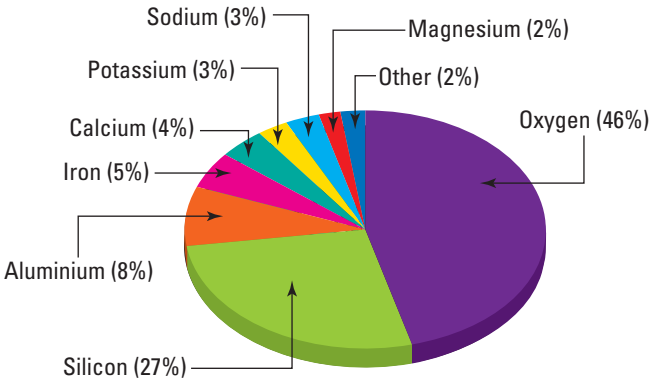
To get an idea of how thin the Earth's crust is, take a medium-sized apple and cut it half. Now imagine that the apple is the Earth — the crust by comparison is as thin as the apple skin!



Needle in a haystack

Locating mineral ores is a bit like finding a needle in a haystack. The amount of any mineral in the Earth's crust varies immensely from place to place. There is no point disturbing the environment and spending huge amounts of money by digging or drilling without knowing where a resource is.

The task of locating mineral sources usually begins with satellites high above the Earth. The satellites are equipped with cameras, radar and other sensors to look for features on the surface that provide clues about what lies below. Geologists on board planes and helicopters look for further clues about the minerals below before exploration begins on the ground. Some minerals, such as those that contain iron, nickel and cobalt, can be detected because of their magnetic properties.



The pie chart above shows that, out of the 92 naturally occurring elements, 98 per cent of the Earth's crust is made up of only 8 of them.

Mining the mineral ore

The process of removing the mineral ore from the ground is called **mining**. The method used for mining depends on several factors, including:

- how close the mineral ore is to the surface
- how much rock lies above the mineral ore
- what type of rock lies above the mineral ore.

Open-cut mining is a method of mining mineral ores that are close to the surface. A large hole is made to expose the rocks containing the mineral ores. Explosives are used to break up the rock and huge trucks are used to transport the soil and rocks out of the mine.

If the mineral ores are deep below the surface, **underground mining** is undertaken. Shafts and tunnels are dug deep into the ground to reach the

An open-cut gold mine at Kalgoorlie, Western Australia

mineral ore. Underground mining is more dangerous and expensive than open-cut mining. Shafts can be as deep as 4 kilometres. Temperatures in underground mines are high and there may be some danger from flooding, gas leaks or tunnels caving in.

Extracting the metal

After the rock containing a mineral ore is removed from the ground, the valuable part of it, the metal, is extracted. The method of extraction (or separation) varies from metal to metal. Most methods involve three separate stages.

1. **Concentration** *of the mineral ore*. The useful rock taken from the ground is a mixture of the useful mineral ore and unwanted sand, soil and other minerals. The unwanted substances are called **gangue**. The separation of copper rock from gangue is described in section 5.7.
2. **Reduction** *of the mineral ore to the metal*. This involves a number of chemical reactions because the mineral ore is a pure substance, not a mixture. The reduction process often involves **smelting**, in which the mineral ore is melted. The reduction of aluminium ore requires additional and expensive processes, which is one of the reasons why recycling aluminium cans is so important.
3. **Purification** *of the metal*. Most metals obtained from the reduction process still contain impurities. These are removed using various chemical processes to produce the pure metal.

Hot liquid iron being poured from a melting pot

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Mining and Australia's environment

Learn how the cost of digging up the Earth's riches must be balanced against the effect mining has on the environment.

eles-0128

UNDERSTANDING AND INQUIRING

REMEMBER

1 Why are minerals in the Earth's crust classified as non-renewable resources?

2 Which minerals can be detected because of their magnetic properties?

3 What is a mineral ore?

4 Explain why underground mining is more dangerous than open-cut mining.

5 Construct a two-column table.
(a) In the first column, list the three stages involved in extracting a metal from its mineral ore.
(b) In the second column, describe the purpose of each stage.

THINK

6 Why is exploration for mining sites for extracting mineral resources like 'finding a needle in a haystack'?

7 List the advantages and disadvantages of open-cut mining.

8 Suggest how open-cut mining got its name.

9 Suggest why the temperature in underground mining tunnels would be greater than the temperature on the ground surface.

INVESTIGATE

10 Find out where in Australia the minerals in the table on the previous page are mined.

11 Long before the big mining companies began exploring for and extracting minerals, Aboriginal and Torres Strait Islander peoples were extracting a type of mineral called ochre from the ground. Investigate and report on:
(a) which chemical substance is found in all ochre
(b) how ochre was used by Aboriginal and Torres Strait Islander peoples
(c) how ochre was mined.

Fossil fuels

Among the natural resources below the Earth's surface is a reserve of energy in the form of **fossil fuels**. The energy stored in fossil fuels comes from the remains of ancient plants and animals, buried under layers of the Earth's crust that have built up over tens or hundreds of millions of years. When we burn fossil fuels — coal, oil and natural gas — the stored energy is converted to other forms of energy, including heat, movement and light.

Dead and buried

Coal is formed from the remains of ancient plants. Millions of years ago, much of the land on Earth was covered with warm, humid forests and swamps. When trees and plants died, they were buried by layers of other dead plants before they could rot. As the layers of rotting material built up in the forests and swamps, they were compressed under the weight of other plants and water. Over millions of years, the weight and high temperatures drove moisture out of the plant remains. The plant matter left behind is known as **peat**.

Brown and black

As areas were flooded by swollen rivers or changes in sea level, **sediments** of gravel, sand, mud or silt covered the rotting vegetation. Over time, as they were buried under other layers, these sediments changed into rocks known as **sedimentary rocks**. If the swampy conditions returned, more layers of rotting plants and peat formed and were covered. Over millions of years, the peat was compressed by the weight of the layers above and became warmer. Much of the remaining moisture was driven out, forming **brown coal** (lignite). As the compression continued and more moisture was driven out, the harder and drier **black coal** (anthracite) was formed.

HOW ABOUT THAT!

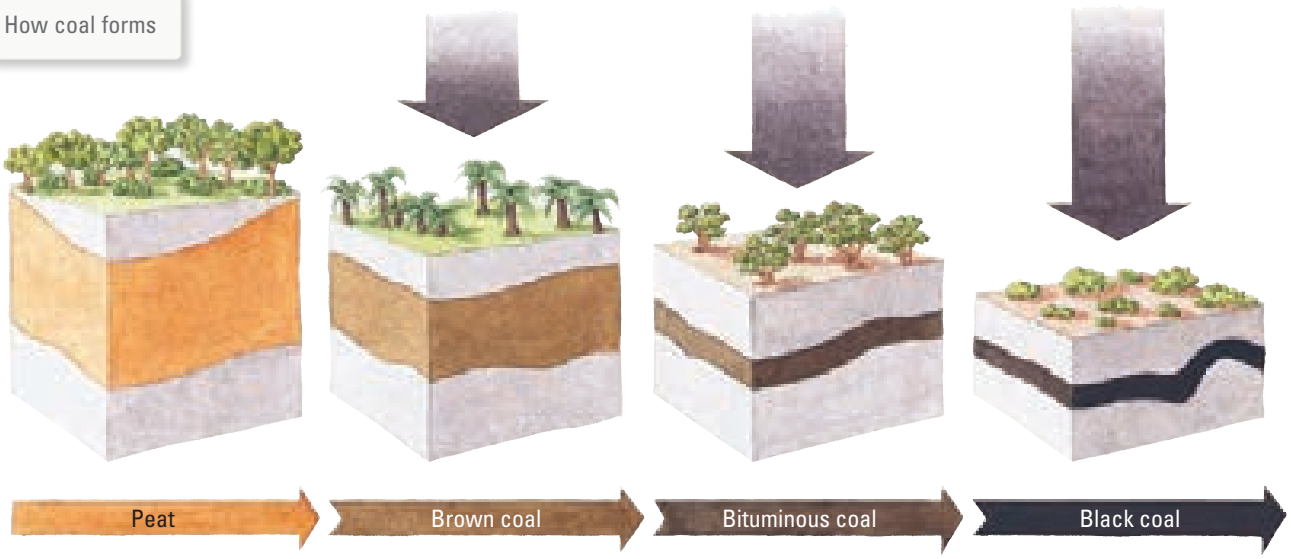
Almost one-quarter of the crust that makes up the Australian continent contains coal of one type or another. Australia has approximately 5 per cent of the world's known reserves of black coal and approximately 23 per cent of the world's recoverable reserves of brown coal.

Coal as a fuel

More than three-quarters of the black coal mined in Australia is exported. Most of the remainder is used to generate electricity in power stations. Some of the black coal is used in the production of steel and as briquettes for heating. The majority of Australia's brown coal mines are in Victoria, where most of the coal is used to generate electricity.

Black coal provides more energy than the same amount of brown coal, mainly because it contains less water. In some countries peat is used as a fuel. However, it has to be dried first. In Ireland, where there is very little coal or oil, peat is used to generate electricity.

How coal forms



At the coal face

In Victoria, the major reserves of brown coal are found in the Latrobe Valley, where more than 75 per cent of Victoria's electricity is generated. Because the coal is close to the surface, the open-cut method is used to mine it. Rock, soil and vegetation (the **overburden**) are first removed by bucket wheel excavators to expose the coal. Bucket-shaped excavators load the coal onto conveyors, which transport it to the power-station boilers.

When the coal is deeper, it must be mined underground. Underground mining is more costly than open-cut mining. Underground mining is also quite dangerous. As well as the threat of cave-ins and flooding, layers of coal contain poisonous methane gas. Another poisonous gas, carbon monoxide, is also often produced when explosives are used underground. The dust produced by the coal not only damages miners' lungs, but also forms an explosive mixture with methane gas. Proper ventilation systems in underground mines are needed to minimise these dangers.

Location of Australian brown and black coal mines

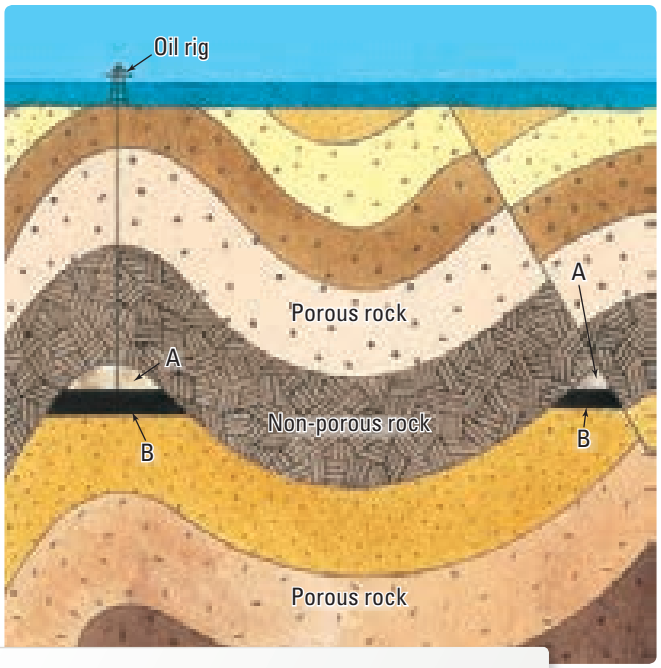
A bucket-wheel excavator at Yallourn in Victoria can remove 2300 tonnes of brown coal in one hour.

The good oil

Oil and **natural gas** are believed to have formed from the remains of tiny sea animals and plants. These organisms were buried in sediments at the bottom of the oceans millions of years ago. As these plant and animal remains slowly decomposed, they were compressed by water and the layers of sediment that formed above them. Chemical reactions gradually changed them into oil and natural gas, which then seeped upwards through some layers of sedimentary rocks. Such rocks are described as **porous**. The oil and gas were eventually trapped by rock layers that would not allow them to seep through (non-porous rock).

The oil taken from beneath the Earth's surface is converted in oil refineries into a number of different fuels, including diesel fuel, petrol and kerosene products. Natural gas is mainly used for heating and for cooking. Australia's biggest oil and natural gas reserves lie under the seabed in Bass Strait off the coast of Victoria and on the North West Shelf off Western Australia.

The layers are folded by rocks beneath the surface pushing against each other. Sometimes the forces are great enough to crack rocks so that layers slide up or down.

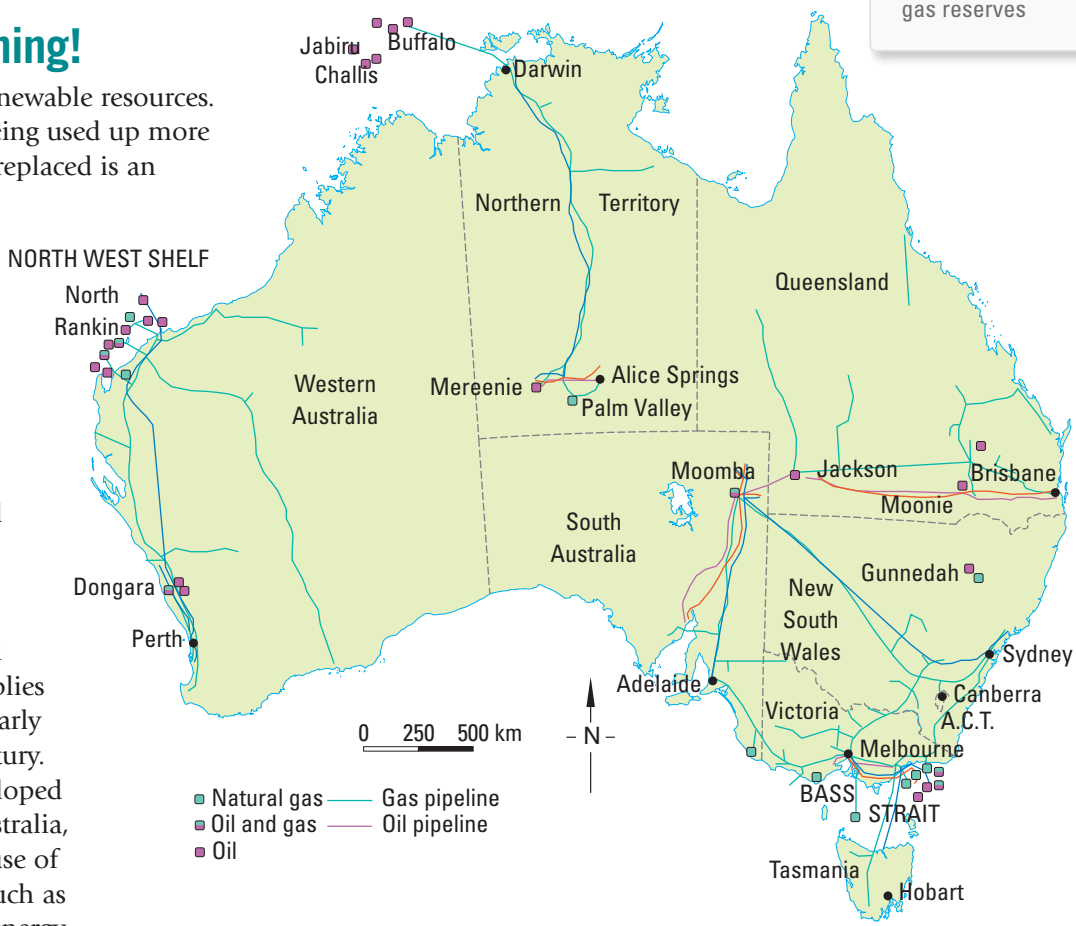


The trapping of oil and natural gas by layers of non-porous rock usually occurs as a result of the bending, cracking and movement of rocks beneath the surface.

Warning, warning!

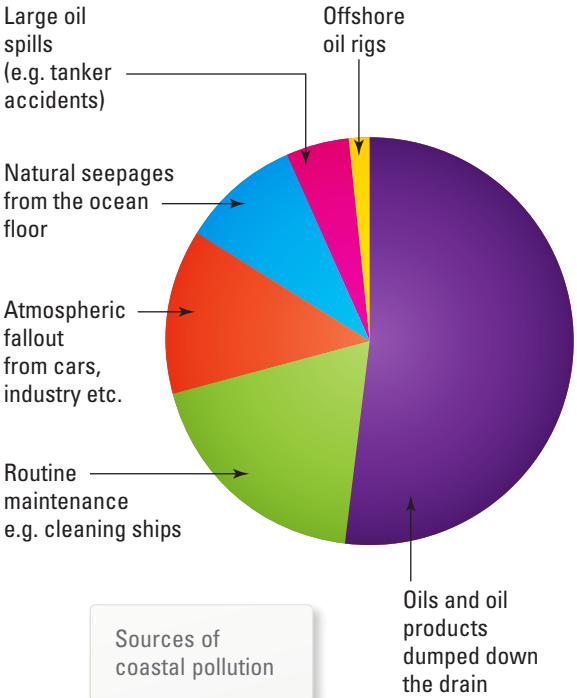
Fossil fuels are non-renewable resources. To say that they are being used up more quickly than they are replaced is an understatement. Until the Industrial Revolution began a little more than 200 years ago, the use of fossil fuels was rare; since then, it has increased steadily. It wasn't until the 1970s that the prediction was made that, if this rate of increase continued, all known fossil fuel supplies could be used up by early in the twenty-first century. Since then, most developed nations, including Australia, have encouraged the use of renewable resources such as solar, wind and tidal energy.

Australia's oil and gas reserves

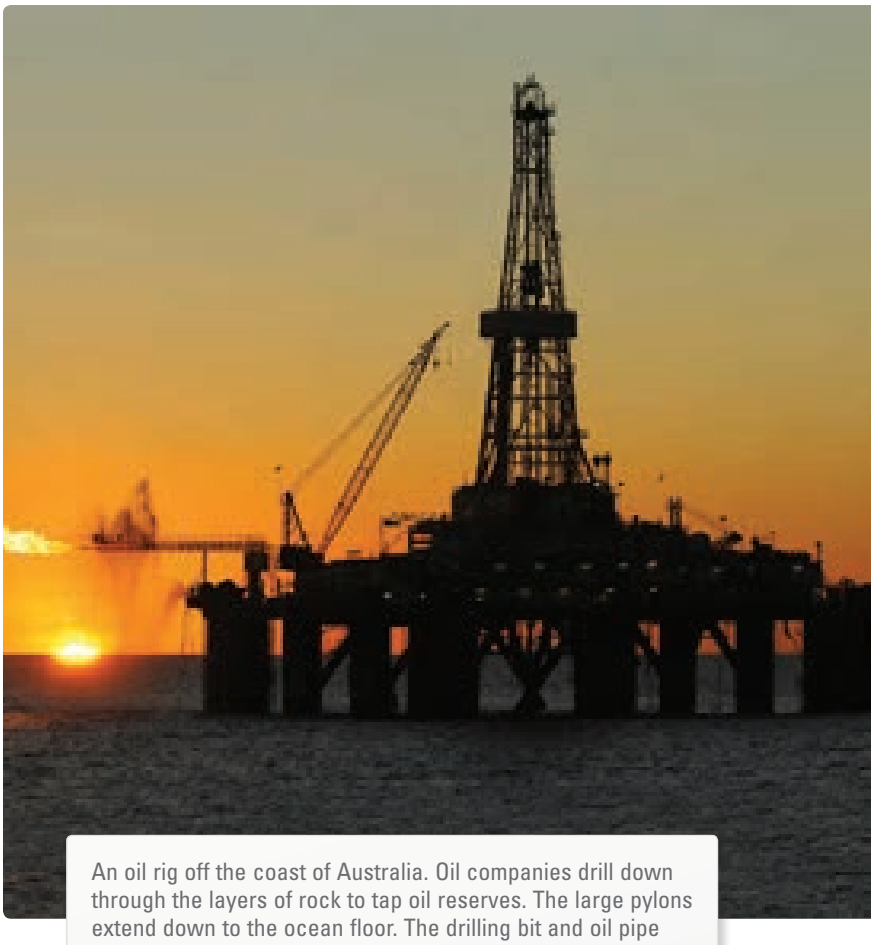


Coastal pollution

The pollution of the coastline is often blamed on oil from offshore oil rigs, oil spills and natural seepages. However, most pollution comes from the oil and oil products that are dumped down our drains.



Sources of coastal pollution



An oil rig off the coast of Australia. Oil companies drill down through the layers of rock to tap oil reserves. The large pylons extend down to the ocean floor. The drilling bit and oil pipe are fed down through the tall tower.

UNDERSTANDING AND INQUIRING

REMEMBER

1 From where does the energy stored in fossil fuels come?

2 What happens to the energy stored in fossil fuels when they are burned?

3 Apart from its colour, how is black coal different from brown coal?

4 Why is peat generally not used as a fuel in most countries of the world?

5 How does oil and natural gas get trapped underground?

6 Where are Australia's biggest oil and natural gas reserves?

THINK

7 When we burn fossil fuels — coal, oil and natural gas — the stored energy is converted to other forms of energy, including heat, movement and light. What else is produced?

8 Black coal is sometimes mined underground but brown coal is not, even though there are reserves that could be mined in that way. Suggest why that is the case.

9 Suggest why brown coal is used to generate electricity in Victoria rather than black coal, even though brown coal contains more moisture.

10 Explain why it is correct to describe fossil fuels as 'stored solar energy'.

11 Apart from the threat of the supply running out, describe two other major disadvantages of the use of fossil fuels.

INVESTIGATE

12 Find out what coal seam gas is and why it is controversial.

IMAGINE

Imagine a world with no heating in cold weather or cooling in hot weather, no television, no computers and no lighting at night. Make a list of the ten everyday 'necessities' and luxuries that you would miss the most if the world's supply of fossil fuels ran out and you had no renewable energy sources.

Make mine renewable

About 80 per cent of the world's energy needs are supplied by fossil fuels. In 2010, fossil fuels provided about 94 per cent of Australia's energy. Only 6 per cent is supplied by renewable energy sources. The federal government has set a target of 20 per cent renewable energy by the year 2020.

A question of responsibility

Most power stations on mainland Australia rely on coal to drive the **turbines** used to generate electricity. The problems caused by using a fossil fuel such as coal, including pollution and global warming, give us no choice but to look for alternative sources of energy. Governments, industry and power companies all have a responsibility to seek renewable alternatives. Even you, as a consumer, have a responsibility to make sensible choices about your energy use. The first step is to be aware of the problems caused by using coal and of other options for generating electricity.

WHAT DOES IT MEAN?

The prefix *photo* in 'photovoltaic cell' comes from the Greek word *photos*, meaning 'light'.

Renewable options

Solar energy

Photovoltaic cells can be used to power domestic hot water systems. Photovoltaic cells transform light energy from the sun into electrical energy that can be used immediately or stored in rechargeable batteries.

Solar thermal power stations use curved mirrors that reflect sunlight onto tubes filled with oil. The hot oil is used to heat water to form steam, which drives the turbines that generate electricity.

Wind energy

Wind 'farms' dotted with wind turbines can be found in many countries throughout the world, including Australia. A single wind turbine can provide enough energy to supply more than 700 average homes with the electricity they need. **Wind energy** is renewable because wind is caused by the uneven heating of the Earth and its oceans by energy from the sun.

Biomass

Biomass is a renewable fuel produced by the remains of living things. Dead and rotting plant and animal tissue produces gases such as methane, methanol and oils that can be used as fuels to drive small turbine electricity generators. Some small biomass electricity generators already exist in rubbish tips.

Ocean waves

The energy of ocean waves has been used to generate electricity on a wave 'farm' in Portugal since 2008. The up and down movement of the waves is used to drive motors that generate electricity. **Ocean wave energy** is renewable because the waves are produced by the effect of the wind on the ocean.

Tidal energy

The energy of rising and falling tides is used in several power stations worldwide. Reversible turbines are placed at the entrance to a bay in areas with extremely high and low tides. Water moving into and out of the bay drives the turbines as the tide changes. Tides are caused by the gravitational pull of the moon and the sun, so **tidal energy** is renewable.

Geothermal energy

In parts of New Zealand and Iceland, energy transferred from rocks just below the Earth's surface is used to turn water into steam and drive turbines in geothermal power stations. Other countries that use **geothermal energy** include the United States and Japan.

Hydro-electricity

About 15 per cent of Australia's electricity is generated by **hydro-electric** power plants. This is a renewable energy source because it depends on solar energy and water. Heat from the sun evaporates water from the oceans. Clouds are formed and it eventually rains. The turbines in hydro-electric power stations are turned by water falling through pipes from very high and large dams.

WHAT DOES IT MEAN?

The word *geothermal* comes from the Greek terms *geo*, meaning 'of the Earth', and *therme*, meaning 'heat'.

In a hydro-electric power station the turbines are driven by water falling through pipes from a high dam.

The nuclear energy option

Nuclear power stations use energy released from the radioactive metals uranium or plutonium to boil water to produce the steam that drives turbines to produce electricity. **Nuclear energy** is a non-renewable energy source. Most of the world's nuclear power stations can be found in the United States, Europe, Japan and Canada.

UNDERSTANDING AND INQUIRING

REMEMBER

1 How much of Australia's energy will be supplied by renewable energy sources in 2020, according to the target set by the federal government?

2 List two ways of ensuring that the Earth's supply of non-renewable energy resources doesn't run out.

3 Describe two ways in which solar energy can be used to generate electricity.

4 Identify a non-renewable fuel that is not a fossil fuel.

THINK

5 The turbines in coal-fired and hydro-electric power stations rotate in only one direction. Why are the turbines in tidal power stations reversible?

6 Which renewable energy options involve the use of heat from the sun? (*Hint:* There is more than one answer.)

7 Nuclear energy is a non-renewable energy source.
(a) Why is it classified as non-renewable?
(b) Is nuclear energy a fossil fuel? Give a reason for your answer.

8 Most of the methods of generating electricity involve the use of turbines. Into what form of energy do turbines convert the energy of steam, falling water and other energy resources?

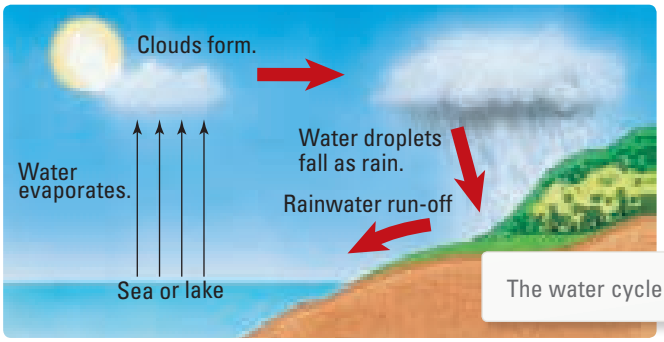
9 Each of the renewable energy options for generating electricity solves some of the problems caused by burning fossil fuels. However, each of them also has disadvantages. Describe the disadvantages of each of the renewable energy options.

INVESTIGATE

10 Choose one of the renewable energy options or nuclear energy and research it in more depth. Write a report, using diagrams where necessary, to show how this form of energy is used to generate electricity.

Stability and change: Water — the liquid of life

Water is essential for life on Earth. It is therefore our most precious resource. There is certainly plenty of water on the planet — almost 70 per cent of the Earth's surface is covered with water. But almost all of it is salt water in the oceans. The rest is in rivers, lakes, glaciers and ice in the polar regions.



The water cycle

The water cycle

Water is constantly moving and changing states. Heat from the sun makes water from the oceans evaporate slowly and form water vapour. The invisible water vapour rises with the warm air. When the water vapour becomes cold enough, it condenses to form **clouds** of tiny water droplets. The clouds are visible and are kept up by the air moving around them. If a cloud is close enough to the ground it is known as **fog**.

At high altitudes the air is very cold. When thick clouds reach this very cold area, the water droplets in them join together to form larger droplets, which are too heavy to be held up by moving air. The large droplets fall to the ground as rain. If the air is cold enough, the water is frozen and falls as snow or hail. Rainwater falls into the sea or runs over the ground into rivers and streams, eventually reaching the sea. This constant movement of water between the various states is called the **water cycle**.

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The water cycle

Did you ever wonder why it rains or where all the water comes from? This video lesson will show you the amazing cycle of water as it is transferred from the oceans to the sky.

eles-0062

Ocean currents

The sea water in the oceans of the world is constantly moving in currents. Ocean currents near the surface of the world's oceans move warm water and cooler water between the tropics and the North and South Poles. The main causes of the currents are the warming of water near the equator and the sinking of colder water near the poles. Other factors, including wind and rate of evaporation, also affect the currents.

INVESTIGATION 7.1

Forming clouds

AIM To model the formation of clouds

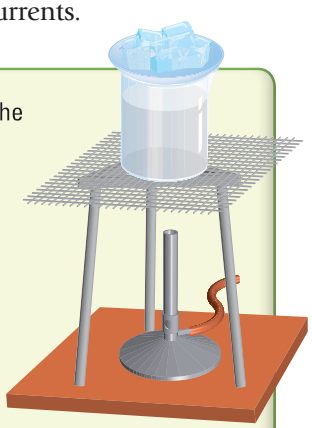
Materials:

250 mL beaker
ice cubes
watchglass
safety glasses
heatproof mat, Bunsen burner and matches
tripod and gauze mat

METHOD AND RESULTS

- Half-fill a beaker with water and heat it until the water is boiling.
- Stop heating and cover the beaker carefully with a watchglass. Observe the bottom of the watchglass.
- Remove the watchglass and heat the water again until it boils.
- Stop heating and turn off the gas supply. Quickly but carefully, cover the beaker with a watchglass containing ice cubes.
- Observe the area under the watchglass.

1. Describe what happened to the bottom of the watchglass when you first boiled the water.
2. Describe what happens in the beaker just below the watchglass.
3. What change of state has taken place?


Forming clouds in a beaker

INVESTIGATION 7.2

Observing clouds

AIM To investigate the links between clouds and rain, hail and snow

METHOD AND RESULTS

1. Before commencing your observations, design a table in which you can record them; but first read the observations to be made.
2. Record the fraction of the sky covered by cloud for five consecutive days. Make your observations at the same time each day.
3. Record whether there was any drizzle, rain, hail or snow during the hour after your observations were made.
4. If it did drizzle, rain, hail or snow, investigate and record the type of cloud that produced it.
5. Which types of cloud produced drizzle, rain, hail or snow?

DISCUSS AND EXPLAIN

6. Does the likelihood of drizzle, rain, hail or snow seem to depend more on the amount of cloud or the type of cloud?

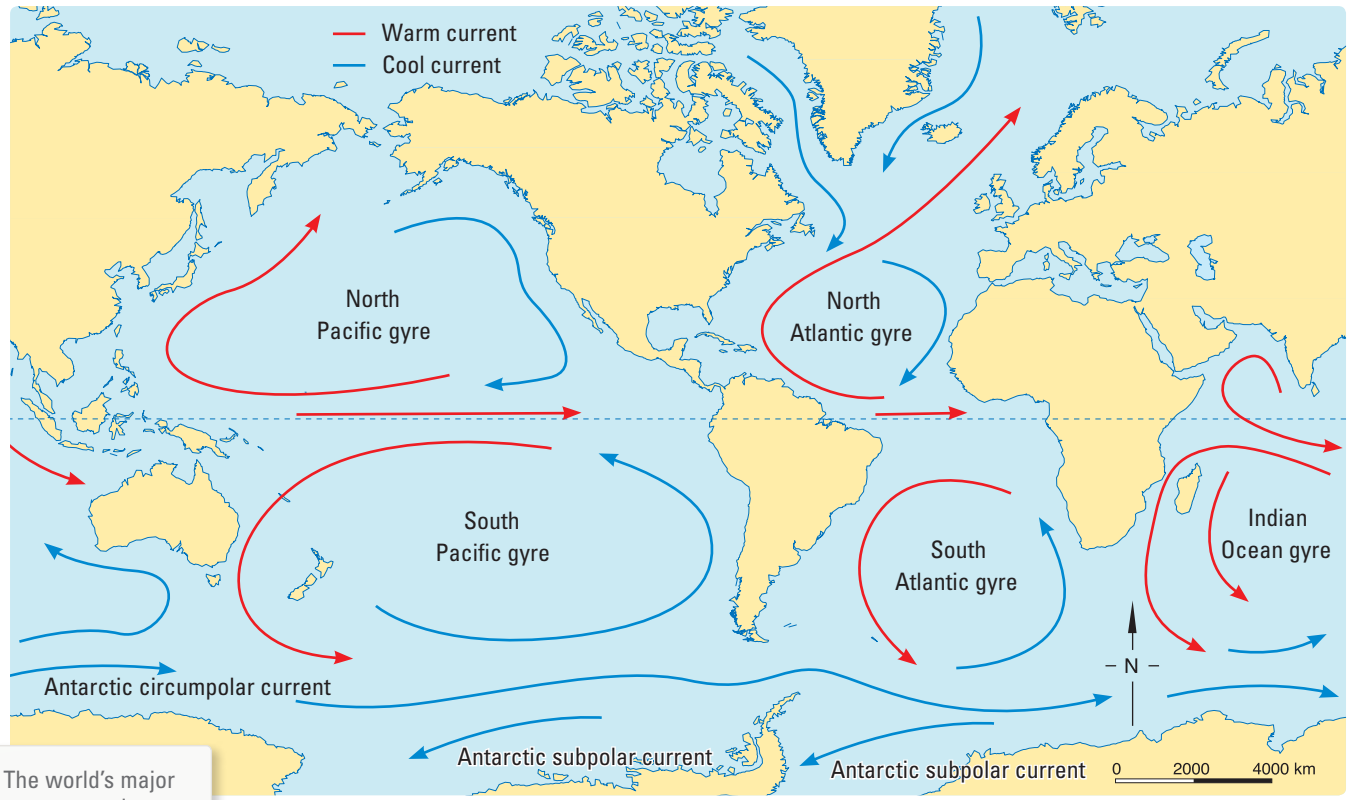
Ocean currents have a major influence on the water cycle and weather patterns. Changes in the ocean currents in the southern Pacific Ocean can cause periods of drought or unusually high rainfall in parts of Australia. Some ocean currents are permanent and form circular patterns called **gyres**. The diagram below shows the major ocean currents and gyres.

Global warming

During daylight hours, heat from the sun enters the atmosphere and warms up the Earth's surface. At night, heat from the surface escapes through the atmosphere. Some of the gases in the atmosphere, including carbon dioxide, trap some of the heat. This trapping of heat is called the **greenhouse effect**.

Without a natural greenhouse effect, the Earth would be too cold to sustain life as we know it. Together, plants and animals help to keep the gases in the atmosphere in balance. During the day, plants take in carbon dioxide to help them make their own food. In doing so, they produce and release oxygen. Animals do the reverse, breathing in oxygen and breathing out carbon dioxide. For a very long time the amount of carbon dioxide and oxygen in the atmosphere has been fairly constant.

However, over the past 200 years the amount of carbon dioxide and some other heat-trapping gases



The world's major currents and gyres

Cyclone Tracy, which devastated Darwin on Christmas Eve in 1974, killed 65 people (16 at sea) and injured 650. Nearly 70 per cent of homes were destroyed. Some 35 000 people had to be evacuated. Global warming could cause an increase in the number of cyclones like Cyclone Tracy.

has increased. As a result, the Earth's temperature is beginning to rise. The rising temperature is known as **global warming**. Two of the main reasons for global warming are:

- *the burning of fossil fuels*. Each year the world's population adds almost 30 billion tonnes of carbon dioxide to the atmosphere by burning fossil fuels — and the amount is growing year by year.
- *the clearing of forests*. Trees absorb carbon dioxide from the air and produce oxygen. As forests are cleared, this means of keeping the gases in the atmosphere in balance is removed. In Australia, two-thirds of all forests that existed 200 years ago have been cleared.

Global warming and the water cycle

The increase in the Earth's temperature is likely to have an impact on the water cycle and therefore the world's climate. There is already evidence that in Antarctica, where 70 per cent of the world's fresh water is stored as ice, the coastal ice shelf and glaciers are melting. The permanent cover of ice in the Arctic Circle is shrinking by an estimated 9 per cent every 10 years. As the polar icecaps shrink, rising sea levels could cause flooding of some islands and coastal cities.

Changes in climate due to global warming and changes in the water cycle may also cause:

- less rain and snow in high mountain regions
- more wild storms, including tropical cyclones
- more heat waves, droughts and bushfires.

The evidence for climate change is gathered by teams of scientists using technology including:

- satellites carrying sensors that collect data about moisture in the atmosphere and on the Earth's surface
- probes and other measuring instruments on and beneath the Earth's surface
- radar to collect data that reveal the properties of clouds.

The data are used in computer modelling to improve our understanding of the water cycle and climate. Computer modelling allows us to predict future changes in the water cycle and make better decisions about the sustainable management of water. It also has allowed us to predict day-to-day weather with more certainty than in the past.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Where is most of the water on Earth found?
2 What causes sea water to evaporate?
3 What are clouds and how do they form?
4 Describe the two main causes of the world's ocean currents.
5 What are gyres?
6 Describe the greenhouse effect and explain why it is important for life on Earth.
7 List two main reasons for global warming.
8 Explain how global warming is changing the water cycle.
9 Explain how evidence for changes in the water cycle is collected.

THINK

10 Explain why some clouds pass overhead without producing rain.
11 Why does the water vapour in clouds condense?
12 Explain why you can see clouds but not see water vapour in the air.
13 Could humans alter the water cycle? In what way might this happen?
14 Is water a renewable or non-renewable resource? Explain your answer.

INVESTIGATE

15 Research and report on what El Niño and La Niña are and how they affect Australia's weather patterns.

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work sheets
7.1 Clouds
7.2 The water cycle

Managing water wisely

Aside from Antarctica, Australia is the driest continent on Earth. Yet Australians are the third greatest users of water per person — only the USA and Canada use more. This makes fresh water a natural resource that we cannot afford to waste. Wise management of this precious resource is essential.

In Australia's major cities, 59 per cent of the available water is used by households. Most of the rest is used by industry or in other ways including maintaining parks and for firefighting. More than half the water used by households is used for watering gardens and flushing toilets. Until recently, people in major coastal cities have taken the supply of clean water suitable for drinking for granted. There was enough clean water available in dams to use for watering lawns and gardens, washing the car and filling swimming pools. However, in recent years, droughts have been responsible for severe water restrictions in most major cities and many smaller regional towns.

Dealing with drought

According to a clear majority of scientists, climate change will result in an increase in the number and length of droughts. However, droughts are not new to Australia. There have been twelve major droughts in different parts of Australia since the 1860s, when proper weather record keeping began. Australians have to live with droughts, and as the population grows the demand for water will increase.

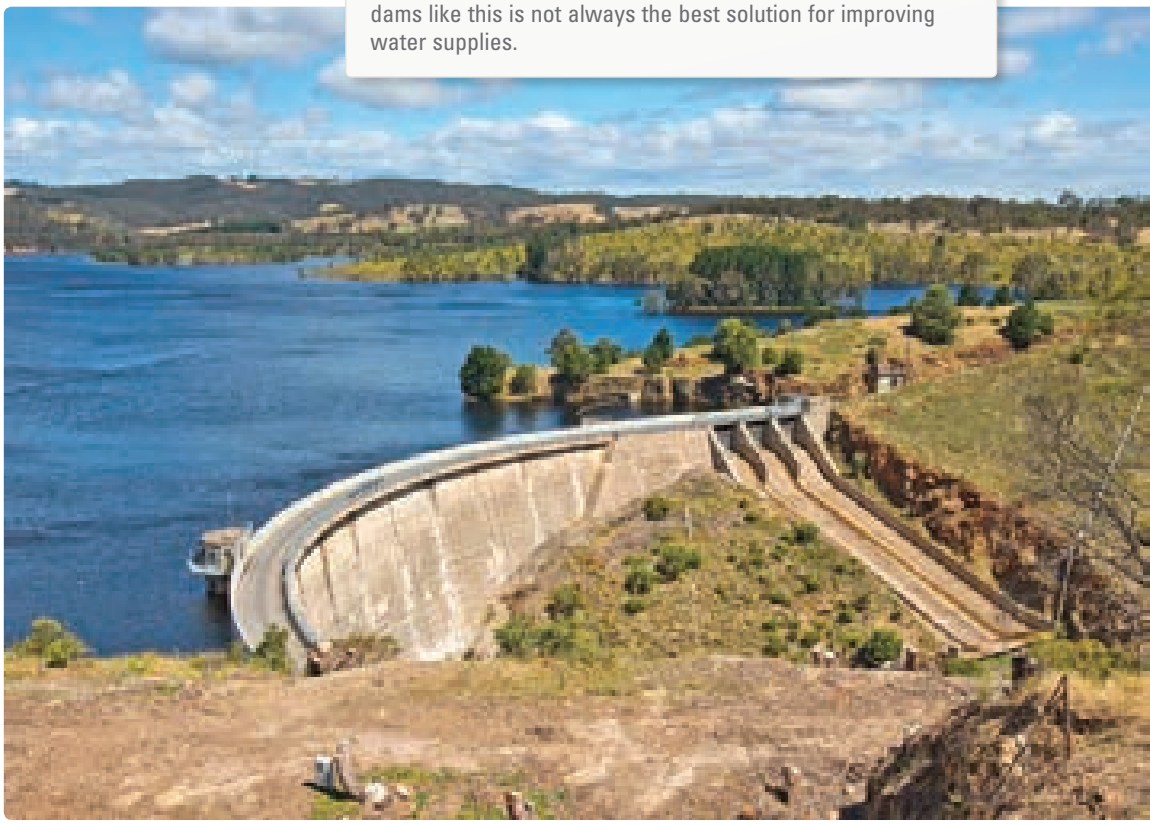
Apart from more severe water restrictions, the most obvious solution is to build more dams and reservoirs. However, building more dams and reservoirs is not always the best method of increasing water supplies.

Dams on major rivers interfere with the flow of water downstream, causing problems for the environment and for farmers.

Blackwater and greywater

About 20 per cent of the waste water from an average household comes from the toilet. This waste is known as **blackwater**. The waste water that comes from the kitchen, bathroom and laundry is known as **greywater**. It does not flow into the sewerage system or septic tanks.

Greywater from the laundry can be used on the garden and is commonly used during periods of water restrictions. However, greywater contains chemicals left over from detergents and other laundry products, which could cause damage to plants. The damage can be minimised by choosing detergents that are low in phosphorus and are **biodegradable**. Untreated water from the kitchen should never be used on gardens because it contains oil, grease and other chemicals that could damage plants.



Myponga Dam, near Adelaide, South Australia. Building more dams like this is not always the best solution for improving water supplies.

eBook*plus* **eLesson**

Water — a vital resource
Watch a video showing how water is essential to life.

eles-1615

The safest way to use greywater is to install a greywater treatment system, which removes chemicals that can damage plants. In some locations a council permit is required for the installation of a greywater treatment system, so it is important to check first. Untreated blackwater should never be used on a garden.

The tale of Toowoomba

Toowoomba is a city in southeast Queensland, well known for its beautiful parks and gardens. In 2006, a prolonged drought had left its dams with only 20 per cent of their full capacity. Toowoomba's economy relies on the influx of tourists visiting the city to see its lush parks and gardens. Desperate measures were required. The Toowoomba City Council proposed that a quarter of the recycled water from its sewage treatment plant be discharged into its three dams.

The proposal divided the city and, after a long and bitter debate, the voters of Toowoomba rejected it. The vote was 38 per cent in favour and 62 per cent against.

As a result of the rejection, Toowoomba was placed on level 5 water restrictions, the strictest in Australia at the time. The use of tap water outdoors was banned.

Toowoomba's economy relies on attracting visitors to its lush, well-watered parks and gardens.

Recycled water

In some countries, fresh water is so scarce that treated sewage is used as drinking water. This recycled water goes through a number of processes to ensure that it is safe to drink.

Several studies have shown that most Australians are happy to use recycled water for firefighting, watering lawns, flushing toilets and irrigation. However, there is little support for the idea of drinking recycled water.

Is desalination the answer?

In major cities close to the ocean, **desalination** can be used to 'top up' dwindling water supplies. This process of separating fresh water from salty sea water is described in chapter 5. However, like dams, desalination has some negative consequences for the environment.

Monitoring water quality

The quality of the drinking water can be maintained only with constant monitoring to ensure that dangerous levels of pollution are quickly identified and fixed. In Australia, water quality is monitored by state and territory government agencies, water authorities, local councils, landcare groups and community groups. Streams and reservoirs are checked for numerous properties including

temperature, flow rate, cloudiness, dissolved oxygen, pH, bacteria and the presence of pesticides and unwanted nutrients.

Lessons in sustainability

Over many thousands of years, Indigenous Australians have successfully located and conserved fresh water in some of the driest parts of the continent. Some of their techniques for locating and conserving water provide valuable lessons for today's scientists and engineers as they meet the challenge of supplying a growing population with this precious resource in a sustainable way. Many Indigenous techniques for locating and collecting water are used in survival training by the Australian Defence Force.

HOW ABOUT THAT!

NASA engineers have collaborated with other scientists and engineers to develop a system that recycles water from air breathed out, sweat and urine into safe drinking water. It was first used by astronauts on the International Space Station. The system is now used in developing countries where water is scarce or heavily contaminated. Volunteers in the northern Iraq village of Kendala help install and test a water purification system that has its origins in the space program.

UNDERSTANDING AND INQUIRING

REMEMBER

1 Explain why fresh water is such a precious resource in Australia.

2 How do Australian households use the majority of their fresh water?

3 Describe two ways in which greywater can be used on gardens without damaging plants.

4 Explain the difference between blackwater and greywater.

THINK

5 Describe the problems that could affect the environment and farmers downstream from a newly built dam on a major river.

6 Suggest why the majority of the voters of Toowoomba rejected the use of recycled water from a sewage treatment plant when more water was so desperately needed.

7 Would you be prepared to drink recycled water in the form of properly recycled sewage if it was declared safe by environmental authorities? Give reasons for your answer.

BRAINSTORM

8 In a small group, make a list of ways in which you can save water around your home.

INVESTIGATE

9 Research and report on the location of rivers, dams and reservoirs that supply drinking water to your home.

10 If you have access to recycled water, compare its appearance and odour with those of tap water. Do NOT drink the recycled water as it will not have been treated properly for safe drinking.

11 Use the library and the internet to research and report on the importance of the Aboriginal rain dance.

12 Use the **Water saver** weblink in your eBookPLUS and play the water saving game.

13 To find out more about saving water in your home use the **Investigator** weblink in your eBookPLUS and be a home water investigator.

14 To take part in the waterworks adventure, use the **Waterworks** weblink in your eBookPLUS.

15 Use the **Indigenous weather knowledge** weblink in your eBookPLUS to research and report on:
(a) how Aboriginals and Torres Strait Islanders used the story of the Rainbow Serpent to predict changes in the water cycle from season to season and locate sources of water in the desert
(b) what today's scientists can learn about the water cycle and water as a resource from the knowledge of Indigenous people.

16 Complete the **Water works** interactivity in your eBookPLUS to learn about the stages of the water cycle. **int-3077**

Soil — it's worth conserving

Good soil contains the nutrients needed for the growth of plants. It is therefore vital in feeding the Earth's growing population. But about 43 per cent of the Earth's dry land is desert or desert-like and useless for growing crops. In Australia the situation is much worse, with 96 per cent of Australian soil unsuitable for growing crops. That's what makes the rest of our soil such a valuable resource.

HOW ABOUT THAT!

About 43 per cent of the Earth's dry land is desert or desert-like. In Australia the situation is much worse. About 96 per cent of Australia's soil is not suitable for growing crops. That's what makes the soil that is left so valuable.

Weathering and erosion

Rocks on the surface of the Earth are slowly and continuously being changed by natural events. They are broken down into smaller rocks in a process called **weathering**.

The wind wears rock away, especially in dry conditions when it blasts the rock with sand and soil it has picked up.

Water on the ground can react with certain chemicals in rocks, soil and decaying plants, producing other chemicals that make the rocks crack and crumble more easily.

Carried away

Weathered rock is usually moved from one place to another by the wind, running water, the sea or glaciers.

This process is called **erosion**. The weathered rock moved by erosion is deposited, and settles on the land, riverbeds and floors of lakes, seas and oceans to form **sediments**.

Soil is formed by weathering, erosion and **deposition** of rock. Soil also contains **humus** — decaying plant and animal material that plants can grow in.

Fertile soil is a mixture of minerals, rock particles and humus. It also contains space between the particles where air, water, nutrients and microbes can be stored. The variation in soils from place to place largely depends on the rock and minerals from which it formed.

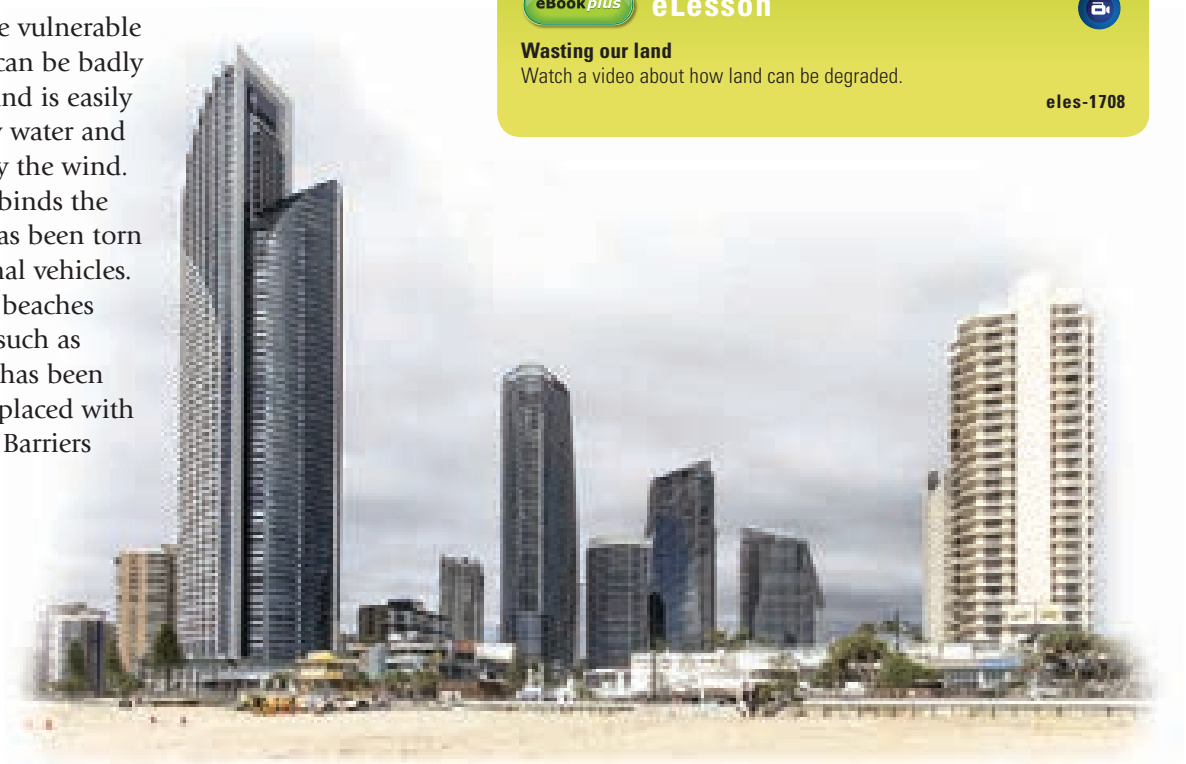
Holding it together

Fertile soil can be blown away by the wind or washed away by rain or streams. The roots of trees and other vegetation help protect fertile soil from erosion. When early European settlers arrived in Australia, they cut down numerous trees to create farmland. As the population grew, more trees were cleared to provide space for industrial areas and housing. Cities have grown larger and the forests have grown smaller. Trees are still being cleared on a large scale for wood and wood products such as paper (see photo at left). During the past 200 years, over two-thirds of Australia's natural forests have been cleared. The removal of trees on a large scale is known as **deforestation**.

Forests in Australia and elsewhere are still cleared to supply wood and wood products.

Coasts under threat

Coastal areas are vulnerable to erosion and can be badly affected. Bare sand is easily washed away by water and blown inland by the wind. Vegetation that binds the sand together has been torn up by recreational vehicles. Vegetation near beaches in tourist areas such as the Gold Coast has been removed and replaced with huge buildings. Barriers such as sea walls, mesh fences and **groynes** are built to hold sand on the beaches.



eBook*plus* **eLesson**

Wasting our land
Watch a video about how land can be degraded.

eles-1708

INVESTIGATION 7.3

Modelling soil erosion

AIM **To use a model to investigate the effect of vegetation on soil erosion**

Materials:
stream tray or other metal or wooden tray
sand
wooden block
rubber tubing to fit a water tap
small plastic lid (from an orange juice container)
twigs, matches or cotton buds to act as trees

METHOD AND RESULTS

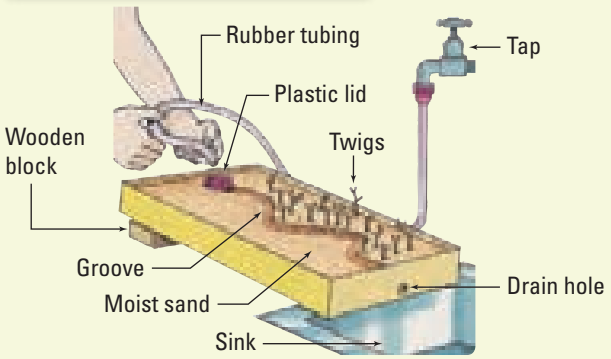
- Pack slightly damp sand into the tray so that it is fairly level.
- Use a small block of wood to raise one end of the tray slightly. Place the other end of the tray on the edge of a sink or over an empty bucket.
- With one finger, make a slightly winding groove in the sand as shown in the diagram at right.
- Plant 'trees' along one edge of your model river using twigs, matches or cotton buds.
- Place the plastic lid in the sand at the top of the groove and aim the rubber tubing from the tap over it.
- Turn on the tap so that water flows slowly but steadily into the plastic lid, overflowing into the groove.

1. Describe what happens as the water flows down your model river. Take particular notice of the difference between the two sides of the river.
2. Is there any particular part of the river where erosion is more apparent? Which part?
3. Where is the eroded sand deposited?

DISCUSS AND EXPLAIN

4. The main aim of this experiment is to examine the effect of plants on the amount of erosion. State your conclusion.

Using a stream tray to model the erosion of soil by a winding river



On the mend

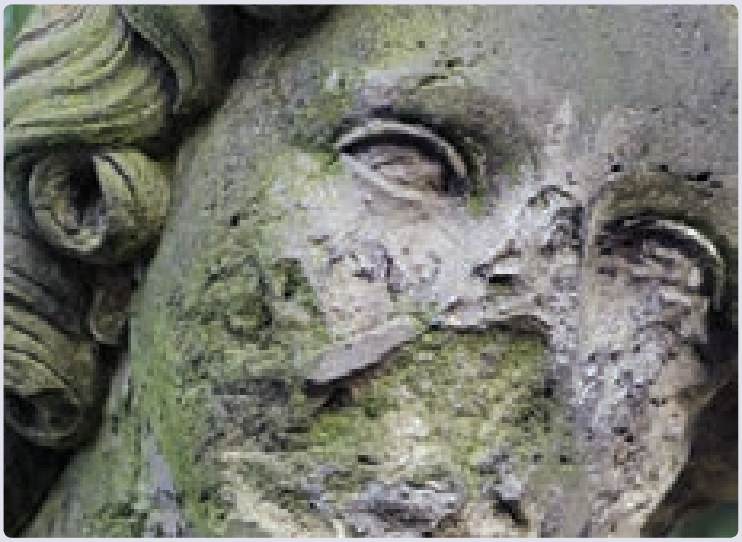
Scientists, conservation groups and government bodies play an important part in improving the environment. The aim is to reduce the impact of human activity and repair past damage. Some methods for reducing erosion and repairing the damage already caused by erosion include:

- farmers ploughing their fields around hills rather than up and down the slope. This reduces the amount of soil washed down hills by rain.
- sealing roads and gutters to direct water into proper drains
- controlling numbers of livestock to prevent overgrazing
- replacing trees that have been removed
- fencing off large sections of beaches and banning recreational vehicles in many coastal areas
- reducing the impact of introduced animals, such as rabbits, on native vegetation.

HOW ABOUT THAT!

Every day many harmful chemicals are pumped into the air. Some are naturally formed chemicals, but many are from cars, factories or from other human activity. The chemicals in the air can dissolve in water, much like salt in hot water. The dissolved chemicals return to the ground in rainwater, snow or fog, and the combination is called **acid rain**.

Acid rain can poison trees, soil and water supplies. It even eats away at rocks, including those used in buildings and statues.



UNDERSTANDING AND INQUIRING

REMEMBER

1 What is weathering?

2 What is erosion, and how does it differ from weathering?

3 Identify four natural agents of erosion.

4 When weathered rock is deposited by erosion it forms sediments. What is the difference between soil and sediments?

5 Explain how the cutting down of trees speeds up erosion.

6 Define the term 'deforestation'.

7 Describe at least three actions that farmers can take to reduce erosion.

8 Outline at least four ways in which governments can reduce erosion.

THINK

9 Acid rain is a serious problem in industrial areas where there is a lot of air pollution. However, rain reaching the ground after falling through clean air is also slightly acidic. Explain how this could be.

10 Explain how the overgrazing of livestock increases the rate of erosion.

11 Is soil a renewable or non-renewable resource? Explain your answer.

IMAGINE

12 How much weathering and erosion would take place on the moon? How long would you expect a footprint to remain on its surface? Justify your answers.

CREATE

13 Some people use coastal sand dunes as a playground. Four-wheel-drive recreational vehicles and sand slides can damage the fragile dune system. Design and produce a leaflet or poster to educate people about the care of coastal sand dunes. Your leaflet or poster should list reasons why they should not walk on or use recreational vehicles in those areas vulnerable to erosion.

14 Complete the **Break down** interactivity in your eBookPLUS to learn about some changes to rocks. **int-3101**

eBook*plus*

work sheet 7.3 Weathering and erosion

Rising salt

While saltiness may be a good thing when you are talking about salted peanuts or fish and chips, it is not a good thing at all when you are looking at salt in the soil.

One of the biggest problems facing Australia's farmers is soil **salinity**. Salinity is a measure of how salty a substance is, but it is commonly used to describe soil that simply contains too much salt for the healthy growth of plants. Soil salinity occurs when salt in the soil layers and rocks deep below the surface is brought up to the surface.

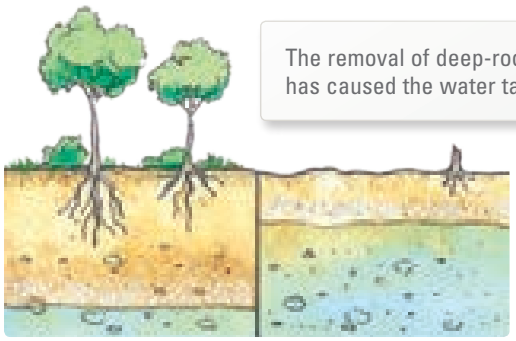
Slow and natural processes

The salt in the lower layers of soil has increased naturally over a very long period for two major reasons.

- Australia has at different times over millions of years either been covered by the ocean or contained a vast inland sea. The sediment that was deposited in these waters later became dry land, and the rocks that formed have retained a lot of salt from the water.
- Because Australia is a relatively flat and dry continent, there are few major rivers large enough to flush salt from the land out to sea. Instead, the salt soaks down deep into the soil. This water that saturates the soil below the surface is called **groundwater**. The top surface of the groundwater (called the **water table**) usually lies far below the roots of the native trees.

The human factor

Natural processes caused the water table to rise slowly over hundreds of thousands of years. However, things changed quickly after 1788 when European settlers started to use the same farming techniques that they had used in Europe. They cleared the native plants and trees from vast areas of land to graze cattle and sheep and to plant crops. Later, they set up irrigation systems to provide water to the crops they had planted.



The removal of deep-rooted trees has caused the water table to rise.

The new crops and pasture grasses have much shallower root systems than the native plants and do not cover anywhere near as much of the soil. So now, when rain falls, much more rainwater enters the groundwater, causing the water table to rise. This rising water table carries with it a lot of the salt that had been locked in the rocks and soil below. The water table rises even faster on irrigated land. After many years of this type of farming, the salt has reached the upper soil layers near the surface.

Salinity affects the land in a number of different ways.

- Where the soil is rich in salt, few plants can survive. This has meant that many crops and many grasses established for herds have died. The native species that originally inhabited the cleared regions cannot tolerate the salt either, so they can't be replanted.
- Where water runs off into waterways it has taken the salt with it, causing increased salinity of waterways. This means that they cannot be used for drinking, and the populations of animals that depend on these fresh water sources have decreased. The Murray River, one of the major sources of fresh water in this country for humans and animals, has been badly affected by salinity.
- The reduced supply of drinkable water has led to a decrease in biodiversity of plants and wildlife in saline regions.

The soil in cleared regions has also been damaged by heavy erosion. The deep roots of native plants and trees helped keep the soil on the surface in place. When these native plants are cleared, heavy rainfall washes the topsoil into waterways, leaving behind land on which little can grow.

The devastation of the rising water table and salinity threatens much of Australia's farmland.

At present, the problem of salinity is being treated with increased planting of salt-tolerant plants and trees and a massive decrease in land-clearing practices. However, it will be many years before this major problem is solved.

Salinity of water

Description of water	Salinity (g/L)
Distilled water	0.0
Murray River, Albury (NSW)	0.05
Desirable limit for drinking water	0.5
Murray River, Morgan (SA)	0.8
Upper limit for citrus trees	1.0
Upper limit for drinking water	1.5
Upper limit for dairy cows and ewes	6.0
Groundwater, Loddon Plain North (Victoria)	15.0
Pacific Ocean	35.0

The salinity of water is a measure of the amount of salt dissolved in it. It can be expressed as the number of grams of salt per litre (g/L) of water.

Australian research to reduce soil salinity

Evergraze

Scientists and farmers working on the Evergraze trial are studying a range of plants for grazing pastures at a number of experimental sites, including Wagga Wagga in NSW. They aim to reduce soil salinity by reducing the amount of groundwater by 50 per cent. The trial focuses on plants that can thrive over spring, summer and autumn, such as lucerne and chicory.

Dr Ralph Behrendt and farmer David Robertson are key researchers in Evergraze trials.

Lucerne plants have roots down to 3 metres below the soil surface. This means that the plants dry the soil to a greater depth so, when it rains, most of the water is used by the plant. This keeps the water table low and therefore helps to reduce soil salinity.

Saltbush

Scientists in Western Australia are studying the use of saltbush for sheep grazing. Many species of saltbush are found in arid regions in the world. However, none of these are common in grazing regions in Western Australia. Scientists, including research scientist Dr Hayley Norman, have discovered that saltbush could be a valuable plant in managing soil salinity. Unlike other plants, saltbush has a very high tolerance to salt and retains salt in its leaves. As an unexpected bonus, sheep grazed on saltbush have health benefits; their meat has a lower fat content.

Dr Hayley Norman, CSIRO research scientist, is showing that saltbush is a nutritional feed source.

UNDERSTANDING AND INQUIRING

REMEMBER

1. Define the term 'water table'.
2. Explain why the water table has risen throughout much of Australia during the past 200 years.
3. Explain why the rising water table is a threat to farm crops.

THINK

4. Describe how soil damage due to salinity could be reduced.

INVESTIGATE

5. Design and carry out an experiment to investigate the effect of the salinity of water on the growth of one type of plant.
6. Some plants are more tolerant to salty water than others. Design and carry out an experiment to identify some plants that might be more suited to areas affected by salinity.

STUDY CHECKLIST

THE EARTH'S RESOURCES

- ☐ distinguish between renewable and non-renewable resources
- ☐ compare the timescales for the extraction of minerals and fossil fuels with the timescales for their formation and regeneration
- ☐ explain how useful metals are produced from the mineral ores in rocks
- ☐ distinguish between open-cut mining and underground mining

ENERGY SOURCES

- ☐ identify coal, oil and natural gas as fossil fuels
- ☐ distinguish between black coal, brown coal and peat in terms of composition and usefulness as a source of energy
- ☐ compare renewable and non-renewable energy sources
- ☐ describe examples of the use of a range of renewable and non-renewable energy sources

THE WATER CYCLE

- ☐ recognise the importance of water as a natural resource
- ☐ describe the water cycle in terms of changes of state of water
- ☐ describe the formation of ocean currents and their influence on the water cycle and weather patterns
- ☐ explain the impact of global warming on the water cycle and weather patterns
- ☐ describe the causes of a rising water table

SOIL

- ☐ recognise the importance of soil as a natural resource
- ☐ describe the processes of weathering and erosion
- ☐ identify and describe some examples of reducing erosion and the damage done by erosion
- ☐ explain why soil salinity in Australia has increased naturally

SCIENCE AS A HUMAN ENDEAVOUR

- ☐ define sustainability and describe the importance of sustainability in the management of all of the Earth's natural resources
- ☐ consider the advantages and disadvantages of open-cut mining and underground mining
- ☐ describe and compare methods of maintaining and conserving water supplies
- ☐ explain how human management of land and water has contributed to erosion, a rising water table and rapidly increasing soil salinity
- ☐ consider how Aborigines and Torres Strait Islanders used and managed natural resources.

eBookplus DIGITAL RESOURCES

ANSWERS for this chapter can be found online in your eBookPLUS.

Online section

This section of the chapter can be found online in your eBookPLUS.

7.8 Thinking tools: Matrixes and plus, minus, interesting charts (eBookplus ONLINE ONLY)

Individual pathways

Activity 7.1	Activity 7.2	Activity 7.3
Investigating resources	Analysing resources	Investigating resources further
doc-6093	doc-6094	doc-6095

FOCUS activity
Access more details about focus activities for this chapter in your eBookPLUS. doc-10580

eLessons

Mining and Australia's environment
Mining is one of Australia's most important industries. In this eLesson, you will learn how the cost of digging up the Earth's riches must be balanced against the effect that mining has on the environment.
Searchlight ID: eles-0128

The water cycle
This video lesson will show you the amazing continuous cycle of water in the Earth's hydrosphere. Through the processes of evaporation, condensation, run-off and rain, water is moving constantly as it transfers between the oceans and the sky.
Searchlight ID: eles-0062

Water — a vital resource
Watch a video showing how water is essential to life.
Searchlight ID: eles-1615

Wasting our land
Watch a video about how land can be degraded.
Searchlight ID: eles-1708

Interactivities

Water works
Use this interactivity to learn more about the stages of the water cycle.
Searchlight ID: int-3077

Break down
Use this interactivity to learn about how rocks change.
Searchlight ID: int-3101

LOOKING BACK

Link to assessON for questions to test your readiness **FOR** learning, your progress **AS** you learn and your levels **OF** achievement. **www.assesson.com.au**

1 Are the precious minerals obtained from mines renewable or non-renewable resources? Explain your answer.

2 What are the solid wastes of metal extraction called?

3 Copy and complete the table below to match the metals with their mineral ores.

Mineral ore	Metal
Bauxite	
Galena	
Haematite	
Chalcopyrite	

4 List three factors (other than cost) that are used to decide whether a mineral ore is extracted by open-cut mining or underground mining.

5 Describe what happens to the rock taken from the ground during the first stage of extraction of its precious metal.

6 List the three most commonly used fossil fuels.

7 From what are all fossil fuels created?

8 What happens to most of Australia's coal after it is mined?

9 Apart from the colour, what are the differences between brown coal and black coal?

10 The diagram below shows rocks in the region below an oil rig.
(a) Identify the two substances labelled A and B.
(b) What property must the layer of rock directly above A and B have?

11 Draw a flowchart to show how oil and gas are believed to have formed.

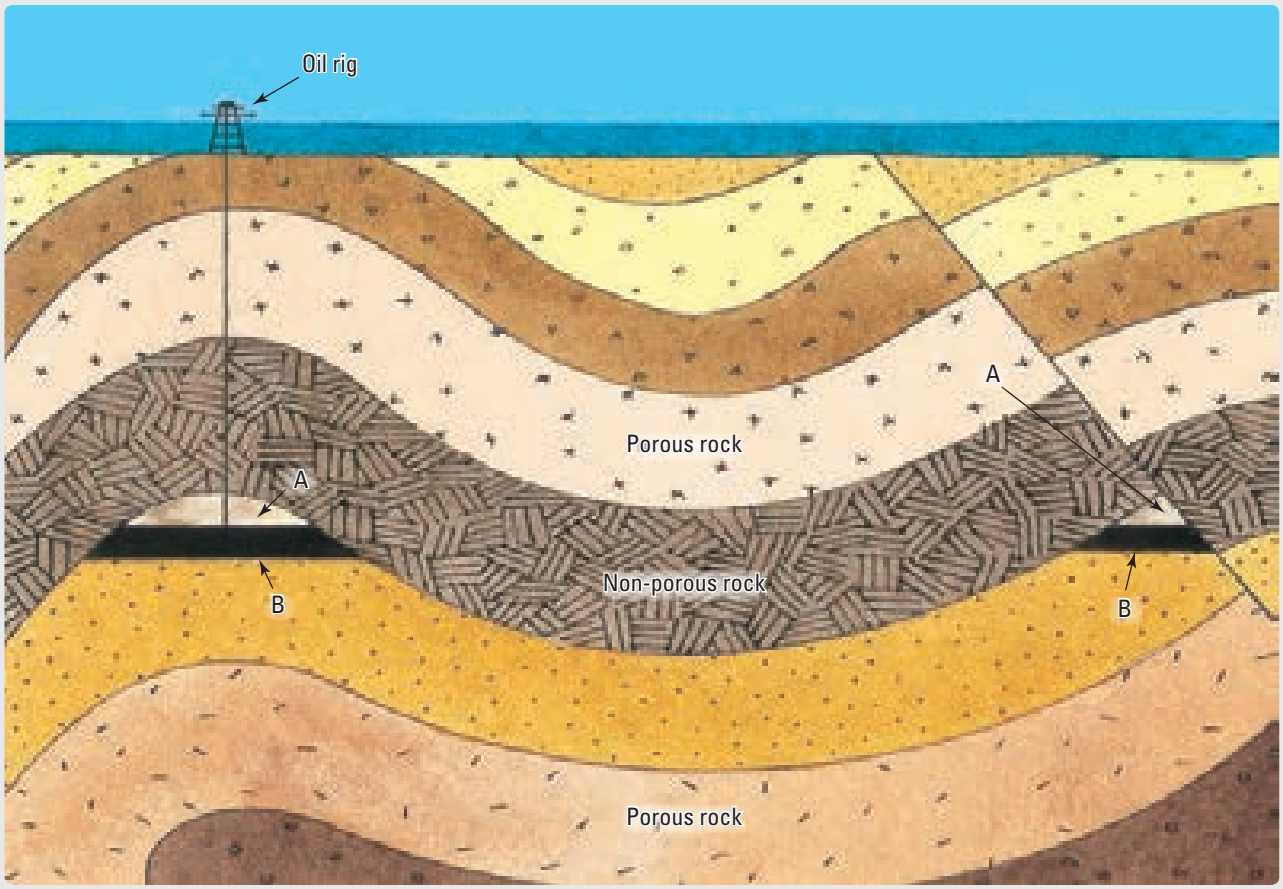
12 What is the difference between the way in which coal is formed and the way in which oil and natural gas are formed?

13 Which fossil fuel is the most commonly used in Australia to generate electricity in power stations?

14 Why is it so important for Australia to reduce its dependence on fossil fuels?

15 Our huge dependence on non-renewable energy sources is not sustainable. What is meant by the term 'sustainable'?

16 Explain why the petrol used to fuel cars and the coal used to generate most of Australia's electricity are known as non-renewable energy sources.



17 Solar energy and wind energy are two examples of renewable energy sources. What makes a renewable energy source different from a non-renewable source?

18 Why do you think uranium-fuelled nuclear energy is not used to generate electricity in Australia even though we have more uranium reserves than any other country in the world?

19 Create a circular flowchart to describe the water cycle.

20 Which two regions of the Earth interact in the water cycle?

21 What are the main causes of the world's ocean currents?

22 Write a description of how clouds are formed.

23 Explain how global warming is different from the natural greenhouse effect.

24 What role does carbon dioxide play in global warming?

25 Why does the use of fossil fuels make a difference to the Earth's atmosphere and surface?

26 How does cutting down trees in forests increase the amount of carbon dioxide in the air?

27 Explain how global warming has interfered with the natural water cycle.

28 List three effects of global warming on weather patterns.

29 Explain why building dams is not always the best solution for the problem of maintaining an adequate water supply for growing cities and towns.

30 Identify three alternatives to building more dams to maintain reliable water supplies.

31 Where does greywater come from?

32 How does a greywater treatment system make greywater safe for the watering of plants?

33 Where does blackwater come from?

34 Which groups are involved in monitoring the quality of drinking water in streams and reservoirs?

35 List at least five properties that are monitored to ensure that drinking water is healthy and of good quality.

36 State two reasons why soil is such a precious resource.

37 Explain the difference between:
(a) weathering and erosion
(b) erosion and deposition
(c) sediments and soil.

38 Explain how the planting of trees can reduce erosion.

39 In your opinion, is fertile soil a renewable or non-renewable resource? Explain your answer.

40 What is salinity and how does it affect the usefulness of soil?

41 Explain why the water table in Australia is rising more quickly that it did before European settlement.

42 Why is a rising water table a problem for farmers?