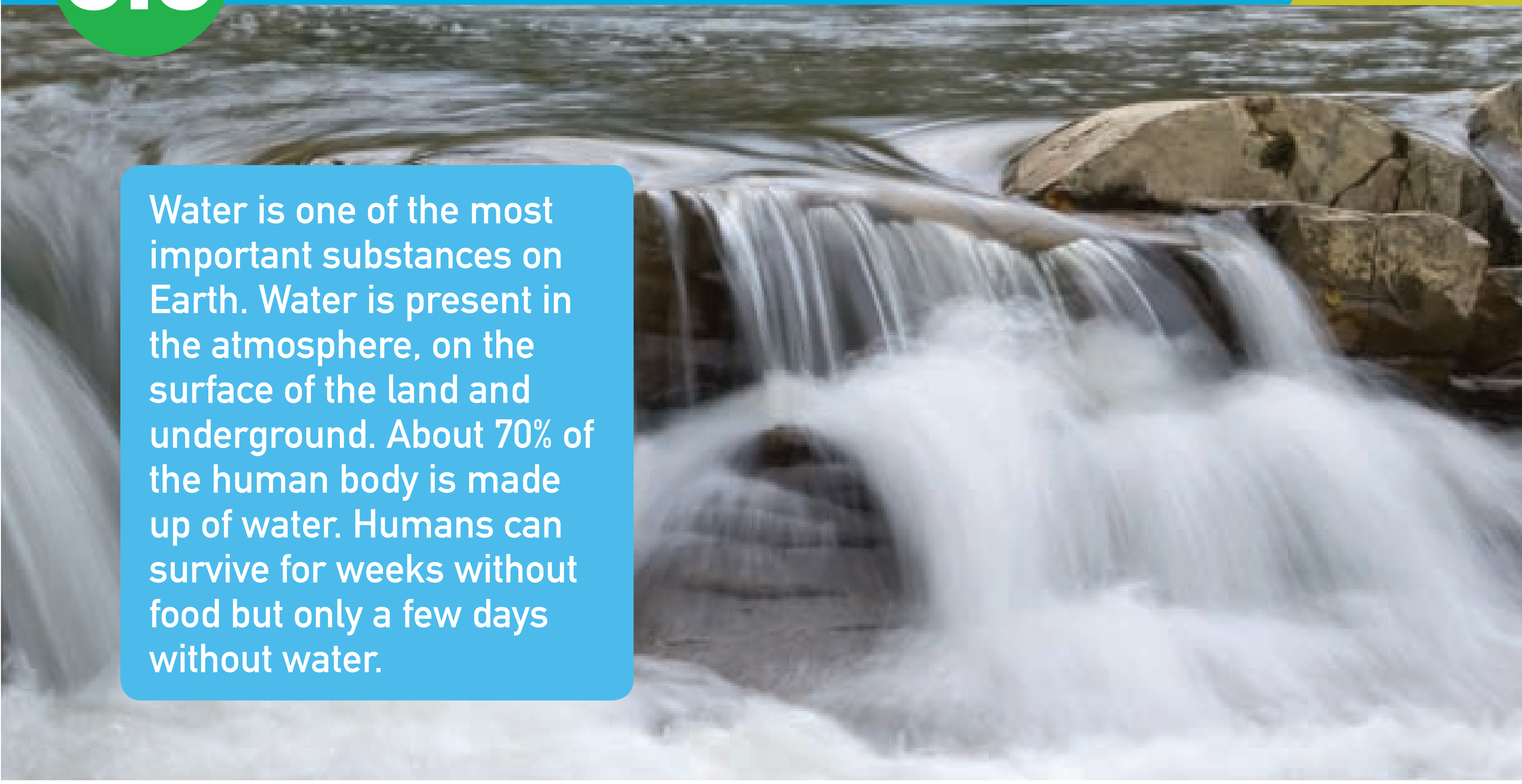
3.3 The water cycle



Water is one of the most important substances on Earth. Water is present in the atmosphere, on the surface of the land and underground. About 70% of the human body is made up of water. Humans can survive for weeks without food but only a few days without water.

Water on Earth

Look at the map of the Earth in Figure 3.3.1. It shows that there is far more water than land. About 70% of the Earth's surface is covered by water.

Figure 3.3.1 Seventy per cent of the Earth's surface is covered by water.

However, almost all of the water that covers the Earth's surface (97.5%) is in the oceans and salt water lakes. This makes it unsuitable for drinking and most other uses. The other 2.5% is fresh water, but almost all of that cannot be used because it is either trapped under ground or frozen in glaciers and in the ice caps of the north and south poles. Only about 0.01% of all water on Earth is renewable fresh water and is available for use. The tiny dark blue square in Figure 3.3.2 shows the very small proportion of water on Earth that is available for use by humans and other living things.

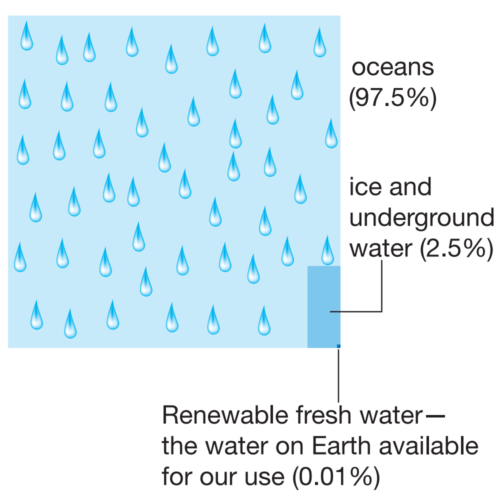


Figure 3.3.2 Comparison of the total amount of water on Earth and the amount we can use

INQUIRY science 4 fun

Dripping glass

Where did the water on the outside of the glass come from?

Yes

Collect this …

- glass
- cold water from the fridge
- sticky tape or marker pen (optional)
- paper towel

Do this …

1. Half fill the glass with cold water.
2. Dry the outside of the glass with the paper towel.
3. Mark the level of the water with the sticky tape or marker pen.
4. Place the glass on a piece of paper towel on a bench and leave for 5 to 10 minutes.

Record this …

Describe what happened.

Explain why you think this happened.

The water cycle

The amount of water on Earth is **finite**. This means that new water cannot be made. The water on Earth has been recycled over and over again since the Earth was formed.

The natural process of recycling water is known as the **water cycle**. As water moves through the cycle it changes **state**. Figure 3.3.3 shows that energy from the Sun causes water to evaporate from bodies of water such as the ocean, rivers and lakes. Liquid water in the ocean becomes water vapour in the atmosphere.

As the water vapour rises, it cools. At a certain point the air cannot hold any more water vapour and the air is said to be **saturated**. Any further cooling causes water vapour in the air to condense, changing into tiny drops of liquid water. These tiny droplets form clouds, like the one in Figure 3.3.4.

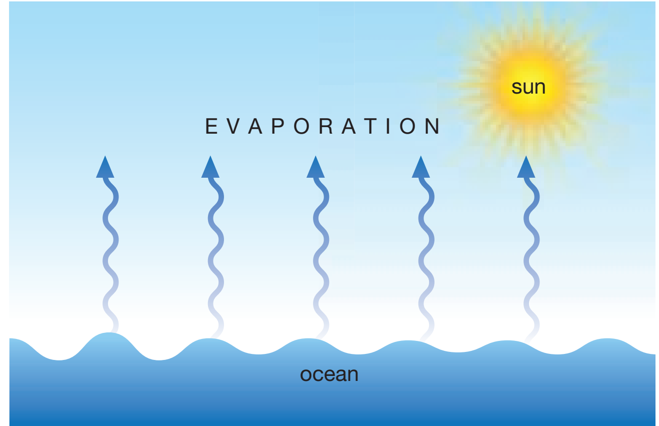


Figure 3.3.3 Evaporation moves water from oceans, rivers and lakes into the atmosphere. About 86% of the evaporation in the water cycle is from the oceans because they are the largest bodies of water.

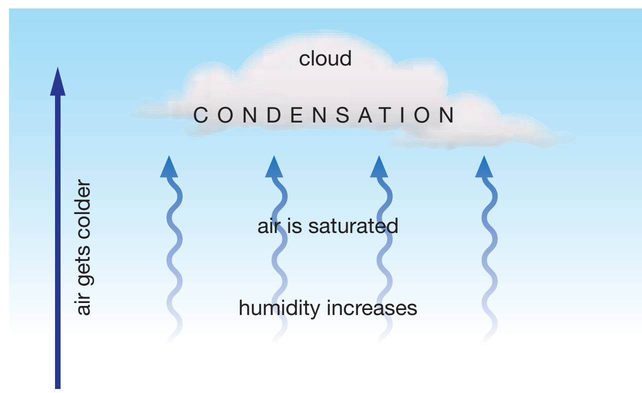


Figure 3.3.4 Cool air holds less water vapour than warm air. In cool air, water vapour condenses and forms clouds.

When the air cools further, the droplets of water combine to become larger and heavier droplets, which then fall back to Earth as **precipitation**. The precipitation may be in the form of liquid rain or it may be frozen, falling to Earth as snow or hail.

Figure 3.3.5 When the temperature in the atmosphere is very low, the water droplets in the clouds freeze. Precipitation then happens as snow or hail.

Two things may happen to the precipitation that falls on land. These are shown in Figure 3.3.6.

- It may flow over the surface as **run-off** moving back into rivers, lakes and streams and eventually flow back to the oceans.
- It may soak down into the soil in a process called **percolation**.

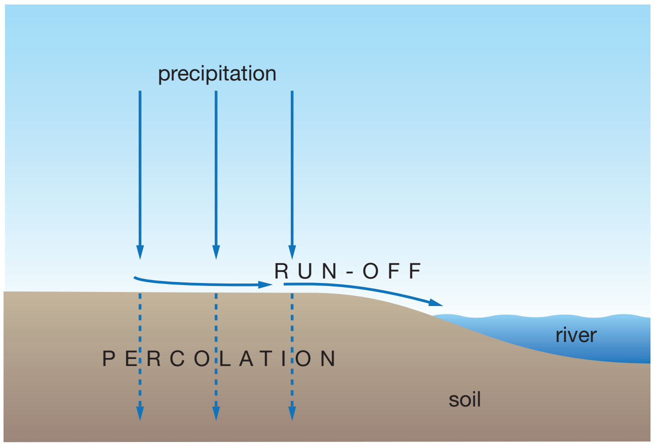


Figure 3.3.6 Once precipitation has landed on Earth it may flow over the surface or percolate into the soil and rocks beneath.

Some of the water that percolates through the soil is taken up by the roots of plants. This water then moves up through the plant. The heat of the Sun causes some of this water to evaporate from the stems, flowers and leaves of plants. The process of the evaporation of water from plants is called **transpiration**. It is shown in Figure 3.3.7. About 10% of the water vapour entering the Earth's atmosphere comes from transpiration.

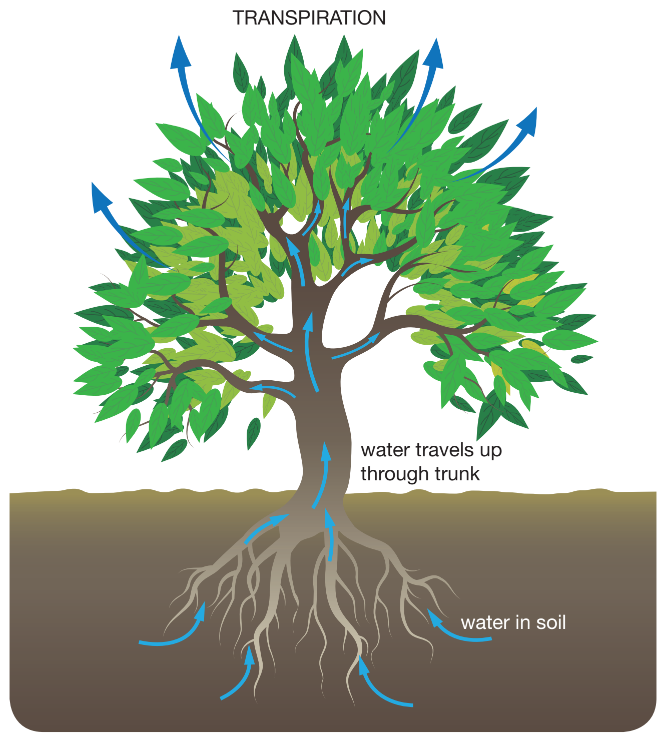


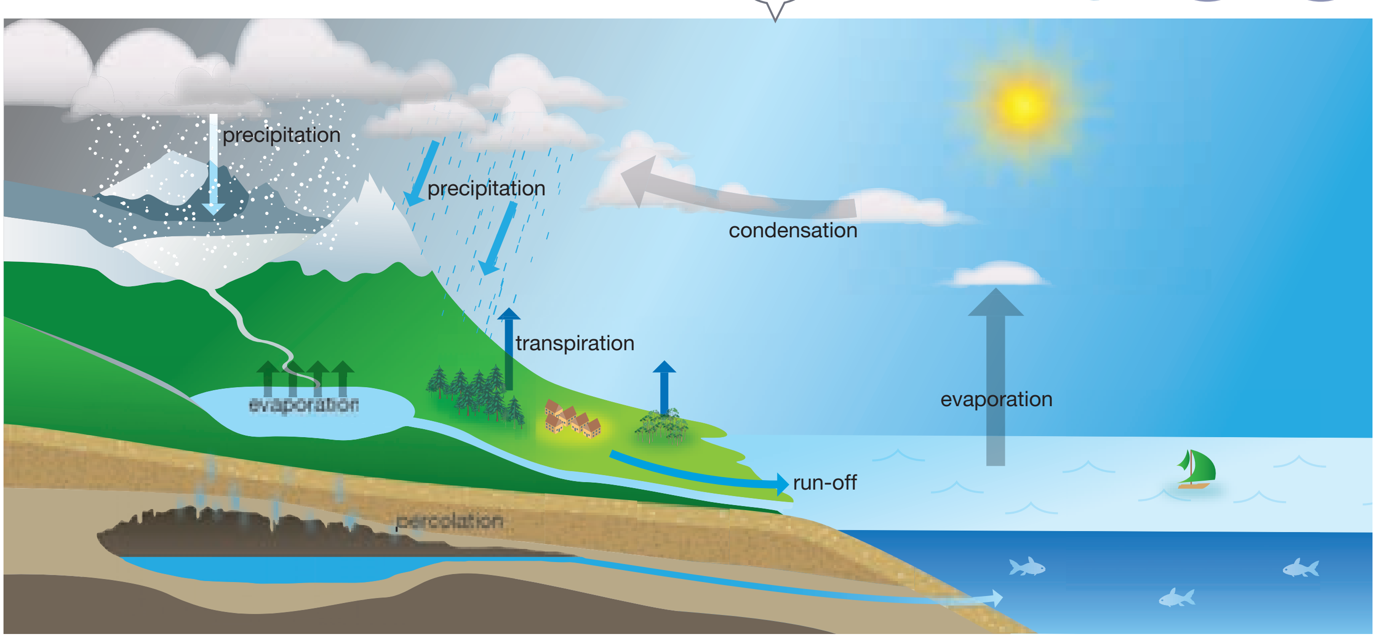
Figure 3.3.7 Transpiration is the evaporation of water from leaves and other parts of a plant. Through transpiration, water is carried from the soil and returned to the atmosphere.

Animals drink fresh water from rivers and lakes. This water is returned to the atmosphere as it evaporates from their bodies, or returned to the ground when it is excreted as urine.

Putting all these processes together creates the water cycle, as shown in Figure 3.3.8.

Figure 3.3.8 The water cycle

1 p100 3.5 3.6



Groundwater

Rainwater, rivers and dams are major sources of water for Australia. However, groundwater provides more than 20% of the water used in Australia each year. **Groundwater** is water that exists underground. Most groundwater is not in underground lakes or rivers. Instead this water is trapped in the tiny spaces between grains of sand or within pervious rocks. **Pervious rocks** are rocks that allow water to soak into them. Figure 3.3.9 shows how this works.

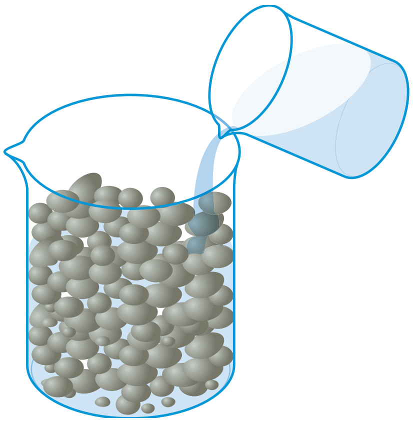


Figure 3.3.9 The effect of pervious rocks is like pouring water into a jar of pebbles or sand. The water does not sit on top. Instead, the water moves down, filling up the spaces between the sand or pebbles.

When the water within the pervious rocks can be extracted using a bore or well, then the layer of rock is known as an **aquifer**. Perth in Western Australia gets about 60% of its water from an aquifer.

The Great Artesian Basin

The Great Artesian Basin is one of the largest groundwater basins in the world. About one-fifth of Australia is sitting on top of it. Many millions of years ago there was an inland sea in Australia. Under this sea, rocks formed in alternating layers of pervious rock and impervious rock. **Impervious rock** does not allow water to soak into it. Movement of the land has exposed areas of the pervious rock. Water can soak into the pervious rock and flow underground. The impervious rock prevents the water from escaping. The result is a very large store of groundwater—the Great Artesian Basin.

It takes a very long time for the water to soak through the rock and into the aquifers. Some of the water in the Great Artesian Basin has been there for millions of years. The structure is shown in Figure 3.3.10.

Factors affecting the water cycle

Many natural factors influence the rate at which water moves through the water cycle. It can take an individual particle of water from a few days to thousands of years to complete the water cycle from ocean to atmosphere to land and back to ocean again. In that time the water slowly seeped through the rocks and was then trapped underground. It is still part of the cycle but will not move onto a different stage until the water is carried up to the surface through a bore or well.

States of water

The water that is trapped as ice at the north and south poles, in glaciers and on the top of high mountains is also part of the water cycle. The water in the ice shown in Figure 3.3.11 on page 96 cannot move on to the next stage until the ice melts.

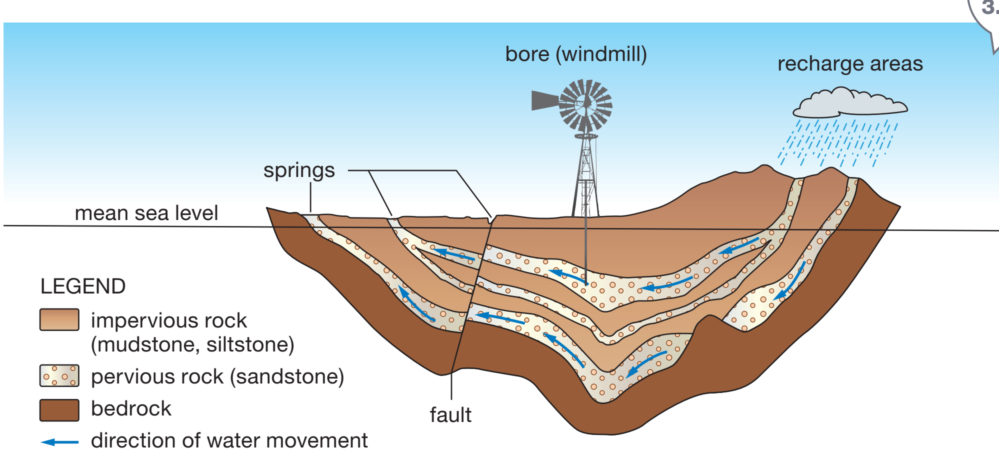


Figure 3.3.10 The Great Artesian Basin is made up of alternating layers of pervious and impervious rocks. Water is extracted from the pervious rocks using aquifers. These aquifers supply water to large areas of inland Australia.

Figure 3.3.11 The water in ice is still part of the water cycle. However, it may be hundreds or thousands of years before the water is able to move onto the next stage of the cycle.

Ice cannot be taken up by plants. Many trees living in areas where water in the soil is frozen for part of the year are deciduous. Deciduous trees lose all their leaves in winter. When they do not have leaves there is very little transpiration.

Martian water

Ice is found at the polar ice caps of the planet Mars. Some scientists think there may be liquid water on Mars. In 2005 NASA photographs revealed new soil deposits suggesting that water had carried sediment through two small valleys sometime during the past seven years.

SciFile

Air temperature

Changes in air temperature affect the rate of evaporation from bodies of water and soil. Changes in temperature also affect the rate of transpiration. As the air temperature increases, the rate of evaporation and transpiration both increase. Plants can slow transpiration down if they are losing water more quickly than they can take it in through their roots. Plants have special openings through which the water evaporates. Plants are able to close these openings if they are losing too much water. In this way plants are able to reduce the rate of transpiration and slow down the movement of water through the water cycle.

Humidity

Humidity is the amount of water vapour in the air. Water vapour can be added to the air until the air becomes **saturated**. When this happens, the air cannot hold any more water vapour. As the air above a surface reaches saturation point the rate of evaporation (and transpiration) slows down and stops. This can be seen in Figure 3.3.12.

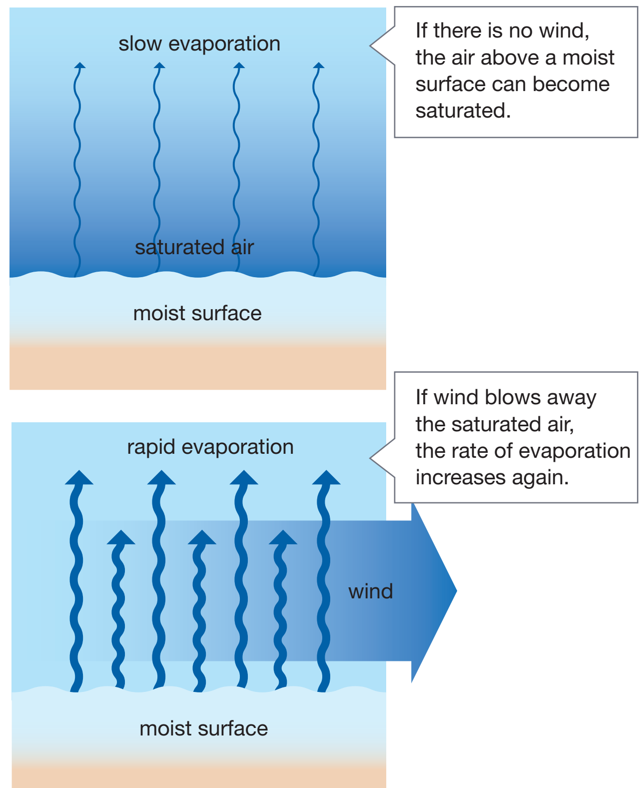


Figure 3.3.12 If there is no wind (top picture), the air above a moist surface becomes saturated and evaporation is slow. Wind blows away the moist air (bottom picture) and evaporation increases.

You may have experienced the effect of saturated air. When you sweat on a hot day with low humidity, the sweat dries (evaporates) off your skin quickly. However, if the air is very humid (as it often is in northern Australia during the summer months) then the sweat remains on your skin and you feel hot and sticky. Turning on a fan may help you feel more comfortable because it starts your sweat evaporating again.

Air movement

Air moving across a wet surface increases the rate of evaporation. Moving air carries away the layer of saturated air that is found on the wet surface. Evaporation and transpiration can then continue to take place.

2 p101

Landscape

The landscape affects run-off and percolation. Rain falling on smooth rock and steep slopes (such as the one in Figure 3.3.13) will quickly run over the surface and into streams and rivers. These streams and rivers will move the water quickly back into the ocean.

Figure 3.3.13 Water moves very quickly downhill when there is no vegetation to slow it down.

Where there are broken rock surfaces and areas of dense vegetation, run-off will be slower. Slower run-off allows more time for percolation to take place. Some soils like sand have many large spaces between the particles. Water can easily percolate into these soils and there is very little run-off. Other soils have small particles that are closely packed together. It takes a long time for water to percolate through these soils and more of the water will flow over the surface as run-off.

Hills and mountains experience more precipitation than low-lying areas. As air moves towards hills and mountains it rises to get over them. The rising air cools and the water vapour it holds condenses, resulting in precipitation. Often clouds are seen over mountains when there are otherwise few clouds around. The clouds in Figure 3.3.14 are evidence of the cooling effect on humid air.

Figure 3.3.14 The clouds on high mountains spoil the view of the top. However, they are evidence of the water cycle at work.

3.7

SciFile

Boiling water

At sea level water boils at 100°C. At the top of Mt Everest there is less pressure and water boils at just 68°C. Deep in the ocean pressure increases. Water near deep geothermal vents remains liquid at temperatures much higher than 100°C.

Vegetation

The type of environment a plant is growing in will affect the rate of transpiration. Some plants such as cacti and many Australian native plants have characteristics that help them conserve water so that they can survive in dry climates. They transpire less than plants without these characteristics.

Amount of sunshine

In nature the energy needed to evaporate water comes from the Sun. In parts of the world where there is a lot of sunshine there is more evaporation than in areas with little sunshine and heavy cloud.

3.3 Unit review

Remembering

1 **State** how much of the Earth's surface is covered in water.

2 **State** how much of Earth's water:
- **a** is salt water
- **b** is fresh.

3 **State** the word that describes rain, hail and snow.

4 **List** three natural factors that influence the water cycle.

Understanding

5 **Explain** why it is important that water is recycled in nature.

6 **Explain** why water is considered to be a resource that is in short supply when there is so much of it on Earth.

7 **Describe** what could happen to the rain that falls onto a field of grass.

8 **Describe** the role that animals such as cows or kangaroos play in the water cycle.

9 **Explain** what is meant by the phrase: *the air is saturated.*

Applying

10 **Identify** the process that moves water from:
- **a** rivers to the atmosphere
- **b** oceans to the ice cap at the south pole
- **c** the atmosphere to freshwater lakes
- **d** surface water to aquifers
- **e** surface water to rivers.

11 **Use** diagrams to **demonstrate** how water droplets in a cloud develop into rain.

12 Sketch a simple version of Figure 3.3.15 and **use** it to **demonstrate** what would happen to water that fell on the piece of ground represented by the diagram.

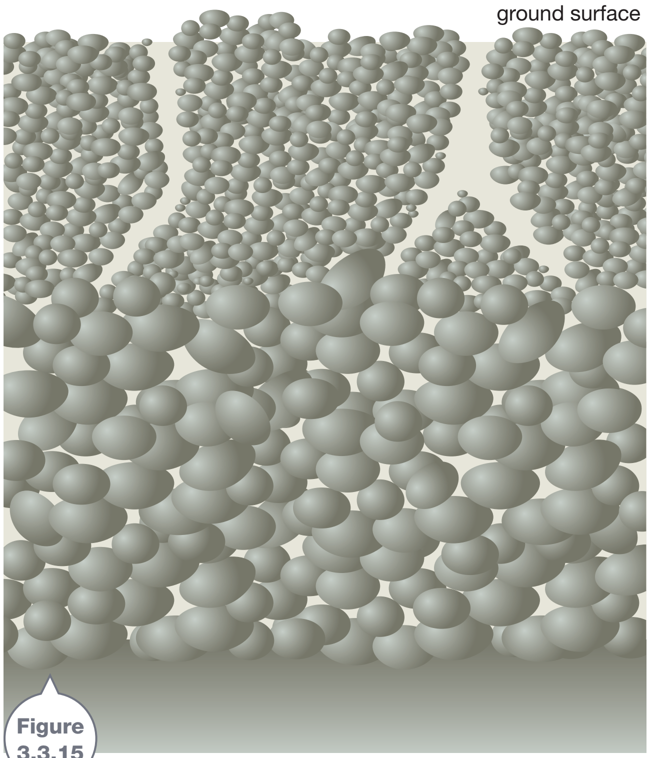


Figure 3.3.15

Analysing

13 **Compare**:
- **a** evaporation and transpiration
- **b** pervious and impervious rocks
- **c** percolation and run-off.

14 **Use** the table below to answer the questions that follow.

Water source	Percentage of total water
Oceans	97.24
Rivers and freshwater lakes	0.01
Inland seas	0.008
Ice caps and glaciers	2.14
Soil moisture	0.005
Ground water	0.61
Atmosphere	0.001

- a Oceans are the largest source of water on Earth. **Identify** the next largest source of water.
- b **Identify** which holds more water, the soil or the atmosphere.
- c **Compare** the amount of water in inland seas, and in freshwater lakes and rivers.

15 **Compare** the amount and rate of percolation of water through the two soil samples shown in Figure 3.3.16.

Evaluating

16 a **Deduce** which of the soils in Figure 3.3.16 would have the greatest amount of run-off in a heavy rainstorm.
b **Justify** your answer.

17 a **Propose** how you would respond to someone who says that all the water you use is recycled water.
b **Explain** your response.

Creating

18 **Construct** a diagram that demonstrates how the cloud on top of the mountain in Figure 3.3.14 on page 97 could have formed.

19 **Construct** a bar or column graph to accurately show the information in the table in question 14.

Inquiring

1 Humans cannot drink sea water. Research and find out why.

2 Research what happens to fish and other living things when the water in ponds and lakes freezes.

3 Find out how hailstones form.

Figure 3.3.16

3.3 Practical activities

1 Water cycle

Purpose

To construct a model of the water cycle.

Materials

- 500 mL beaker
- clear plastic film
- crushed ice
- small plastic bag
- tape (optional)
- water at room temperature

Procedure

1 Set up the equipment as shown in Figure 3.3.17.

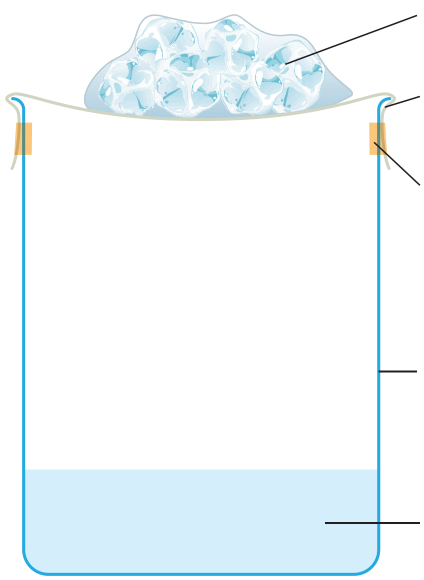


Figure 3.3.17 Model of the water cycle

2 Observe your model of the water cycle for about 20 minutes.

Results

1 Look at the underside of the plastic film (where the air in the beaker is in contact with the plastic). Describe the changes you observed:
  - a in the first minute of your investigation
  - b after about 5 minutes
  - c after about 10 minutes.

2 Use diagrams and written description to record changes you observe.

Discussion

1 **Identify** the part of the water cycle represented by the water in the beaker.

2 a **Explain** what was happening to the water in the beaker.
  b **Identify** the process in the water cycle that this represents.

3 a **Explain** what was happening to the air in the beaker when it was in contact with the plastic film.
  b **Identify** the process in the water cycle that this represents.

4 **Explain** how precipitation was represented in the model.

2 Measuring evaporation

Purpose

To test the effect of sunshine on the rate of evaporation.

Materials

- 2 shallow containers of the same size, material and depth, such as rectangular takeaway food containers
- ruler
- electronic balance (or kitchen scales that measure in 1 g intervals)
- marker pen
- water

Procedure

1. Label one container *sun* and the other container *shade*.
2. Place the sun container on the electronic balance.
3. Add water to the container until it is about 2 cm below the top of the container.
4. Find the mass of the water and the container.
5. Record the mass of the water and the container in a table similar to the one shown above.
6. Repeat steps 2 to 5 using the shade container.
7. Place the sun container where it will be in full sun all day and will be protected from wind.
8. Place the shade container in a shaded area also protected from the wind.
9. Leave the containers undisturbed for at least 24 hours. You can leave them for longer.
10. Carefully find the masses of the containers again. Record the new masses in your table.

	Mass (g)			Amount of water lost (mL)
	Start	Finish	Difference	
Sun container				
Shade container				

Results

Calculate the amount of water lost. Each gram that is lost represents the loss of one millilitre (mL) of water.

Discussion

1. **Compare** the amount of water lost from the different containers.
2. **Compare** your results with the results from other groups.
3. **Identify** any factors that you were not able to control that might have affected your results.
4. **Draw** conclusions about the effect of sun and shade on the rate of evaporation.

3.4 Water management

In nature plants and animals get water from rain, rivers and natural stores such as lakes. Indigenous Australians are able to find underground stores of water by using their observations of plants, birds and other animals. In modern society, water is needed for cities, industry and agriculture. To meet the needs of modern society, water resources have to be managed differently. This management changes the movement of water through the water cycle.

INQUIRY science 4 fun

Ants and water

Can ants help locate a water source?

Yes

Collect this ...

shallow container for water

Do this ...

1 Fill the container with water.
2 Place it on a path or on the grass in a partially shaded part of the garden.
3 Leave the container undisturbed for about an hour.

Record this ...

Describe any change in the behaviour of ants in the area.

Explain why this happened.

Traditional water use

Indigenous Australians are able to live in some of the driest parts of Australia because they can find and manage water resources. One technique to find water is to observe the vegetation. In the middle of a dry area, Ghost Gum trees (such as the one in Figure 3.4.1) indicate where there is underground water. Ant trails also lead to underground water and dingo tracks lead to rock pools and waterholes.

Figure 3.4.1 A mature Ghost Gum has a thick trunk that is covered in very white bark, giving it its name. It grows to about 20 m in height.

Traditional methods used by Indigenous Australians to obtain water include creating shallow wells and digging tunnels to reach water deeper underground. The mouth of the well or tunnel is covered to reduce evaporation and to prevent animals from drinking the water and polluting it.

In the past, the location of water sources determined the routes Indigenous Australians used to travel around the country. In this way they were sure to have reliable sources of water.

There are many **springs** where water from the Great Artesian Basin comes to the surface. One is shown in Figure 3.4.2. These springs are a major source of water for Indigenous Australians and for native plants and animals. Some European explorers and early settlers learned how to find water from the Indigenous people and so they too could get their water from springs.

Figure 3.4.2 Springs from the aquifers of the Great Artesian Basin were used by native animals and later as watering points for cattle.

1 p111

Storing water in dams

Australia is the driest permanently inhabited continent. The rain that does fall is not distributed evenly over the country. Dams are built to capture and store the rain.

Most farms in Australia have dams. The water collected is used for cattle to drink and may be used to irrigate crops. There are also many much larger dams such as Wivenhoe Dam near Brisbane. You can see this in Figure 3.4.3. These large dams collect and store water to be used by industry and households in the cities.

Figure 3.4.3 Large dams like the Wivenhoe Dam are needed to collect enough water for the needs of cities.

SciFile

All ice, no water!

Australia might be dry but the continent of Antarctica is even drier! This is because all of its water exists as ice. The constant freezing temperatures never allow the ice to melt.

All dams interrupt the water cycle because water stored in them does not flow down the river and into the ocean. Water from the surface of the dam evaporates and is returned to the water cycle. However, in a very deep dam some water may not be available for evaporation for a very long time.

SciFile

That's big!

The tallest dam in the world is the Nurek in Tajikistan in the Himalayan Mountains. The dam wall is 300 metres high. In 2014 when the Jinping-I Dam in China is completed it will be taller at 305 metres. Compare this with Wivenhoe Dam on the Brisbane River (Figure 3.4.3). It is just 50 metres high!

Irrigation

Most of the farm crops grown in Australia have been introduced here from other parts of the world. This means that they do not have characteristics that allow them to grow with only small amounts of water. These crops need continuous supplies of water and farmers provide this water through irrigation. **Irrigation** is a practice used in agriculture that provides water to crops using pipes and ditches.

There are two ways farmers irrigate their land:

- spray irrigation
- flood irrigation.

Spray irrigation

You can see spray irrigation in Figure 3.4.4. In **spray irrigation** a pump forces small droplets of water into the air. The water falls on the soil and percolates down to the roots of plants. The water then moves up through the plant and is eventually lost back to the atmosphere through transpiration.

Figure 3.4.4 Spray irrigation is like having rain fall on the crop whenever it is needed.

There are some differences between spray irrigation and rain. When it rains there are usually clouds in the sky and the air is very humid. These factors reduce the rate of evaporation. Spray irrigators may be used on hot days when there is bright sunshine. The tiny droplets of water produced by the spraying equipment evaporate quickly in hot, dry air. Water landing on the leaves also evaporates more quickly than in a natural rain storm. Therefore a significant amount of water that would normally percolate into the soil evaporates into the atmosphere.

Flood irrigation

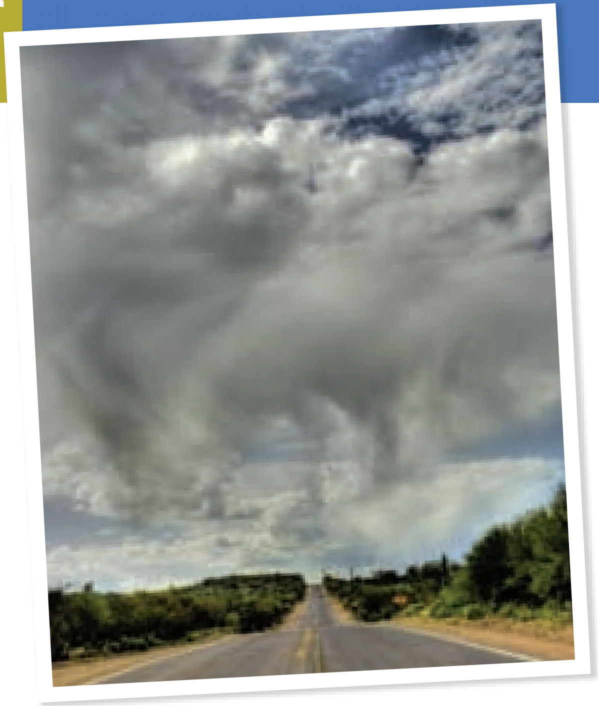
In **flood irrigation**, water is released into channels between the crop plants. This is shown in Figure 3.4.5. The water percolates into the soil to the plant roots. However, the water will evaporate quickly if the soil and irrigation channels are not shaded.

Figure 3.4.5 With flood irrigation the water reaches the roots. However, if there is not a good cover of vegetation much of the water will evaporate.

SciFile

Raining or not?

Not all precipitation reaches the ground. Virga is rain or snow that evaporates somewhere between the clouds and the Earth. It appears as a torn curtain hanging half way to the ground under the clouds.



Moving water around

Dams and pipes can be used to move water from an area where there is plenty of water to areas where there is not enough. The Snowy Mountain Scheme was a very ambitious project that began in 1949 and was completed in 1974. Figure 3.4.6 shows part of the scheme's dam and pipelines. Most of the scheme is underground. The Snowy River in New South Wales is fed from melting snow and rain in the Snowy Mountains. Its position can be seen in Figure 3.4.7. The dams and pipes divert the water from the Snowy River. Only 1% of the water that once flowed in the Snowy River now flows down it and out to sea.

Figure 3.4.6 The Snowy Mountain scheme is one of the largest irrigation projects in the world, with about 225 km of tunnels and pipelines.

Now a large proportion of the water from the Snowy River is diverted through tunnels and dams. It is used to irrigate large farming areas in the Murrumbidgee Irrigation Area, shown in Figure 3.4.8. Irrigation has enabled this area to become one of the main wine and food producing parts of Australia. Water that once flowed very quickly into the ocean is spread across land that is naturally dry.

Figure 3.4.7 Map showing the positions of the Snowy Mountain Scheme and the Murrumbidgee Irrigation Area.

Figure 3.4.8 The main use of the water from the Snowy Mountain Scheme is to generate electricity. It is also a major source of water for the Murrumbidgee Irrigation Area.

The water used for irrigation is returned to the atmosphere through transpiration and evaporation from soil. Irrigation water also percolates through the soil into the ground water. Eventually the excess water flows via the Murray River into the ocean on Australia's southern coast.

Cities

Building cities replaces pervious soil with impervious concrete and bitumen surfaces. Water that lands on soil percolates about 15 mm into the ground before there is any run-off. Water that falls on roofs, roads and footpaths runs off immediately. The water flows into stormwater drains (like the one in Figure 3.4.9) and out to the ocean.

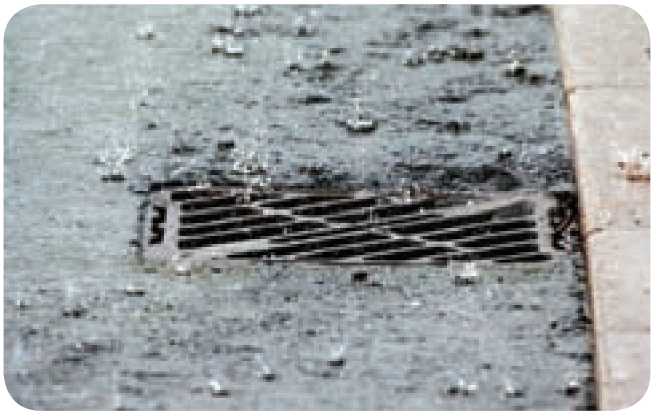


Figure 3.4.9 Water flowing off roofs, streets and other impervious city surfaces goes straight into stormwater drains. From there it goes directly to rivers and the ocean.

In many parts of Australia, attempts are being made to use stormwater. In some Sydney suburbs, stormwater is being collected in tanks and pits. Harmful substances are removed from the water and then it is used to irrigate parkland and sports fields and to water trees in the city.

In the city of Orange in New South Wales some of the water that flows into Blackman's Swamp Creek during storms is captured and then transferred to a nearby dam. Figure 3.4.10 shows how much water flows out during such a storm. All this stormwater is now collected, increasing the water supply for the city.

2 p112

Figure 3.4.10 A large amount of water flows along Blackman's Swamp Creek during a storm.

Changing vegetation

When trees are cut down and replaced with grass or bare soil, the movement of water over the land surface is changed. Trees, shrubs and long grass slow the rate at which water can flow over the ground. This means that there is more time for the water to soak into the soil.

In the absence of vegetation, water moves quickly over bare ground and often carries large amounts of soil with it as it flows into streams and rivers. Figure 3.4.11 shows the effect of this fast-moving water.

Figure 3.4.11 These channels in the soil (known as **rills**) have been created by fast-flowing water.

SCIENCE AS A HUMAN ENDEAVOUR

Use and influence of science

Using stormwater

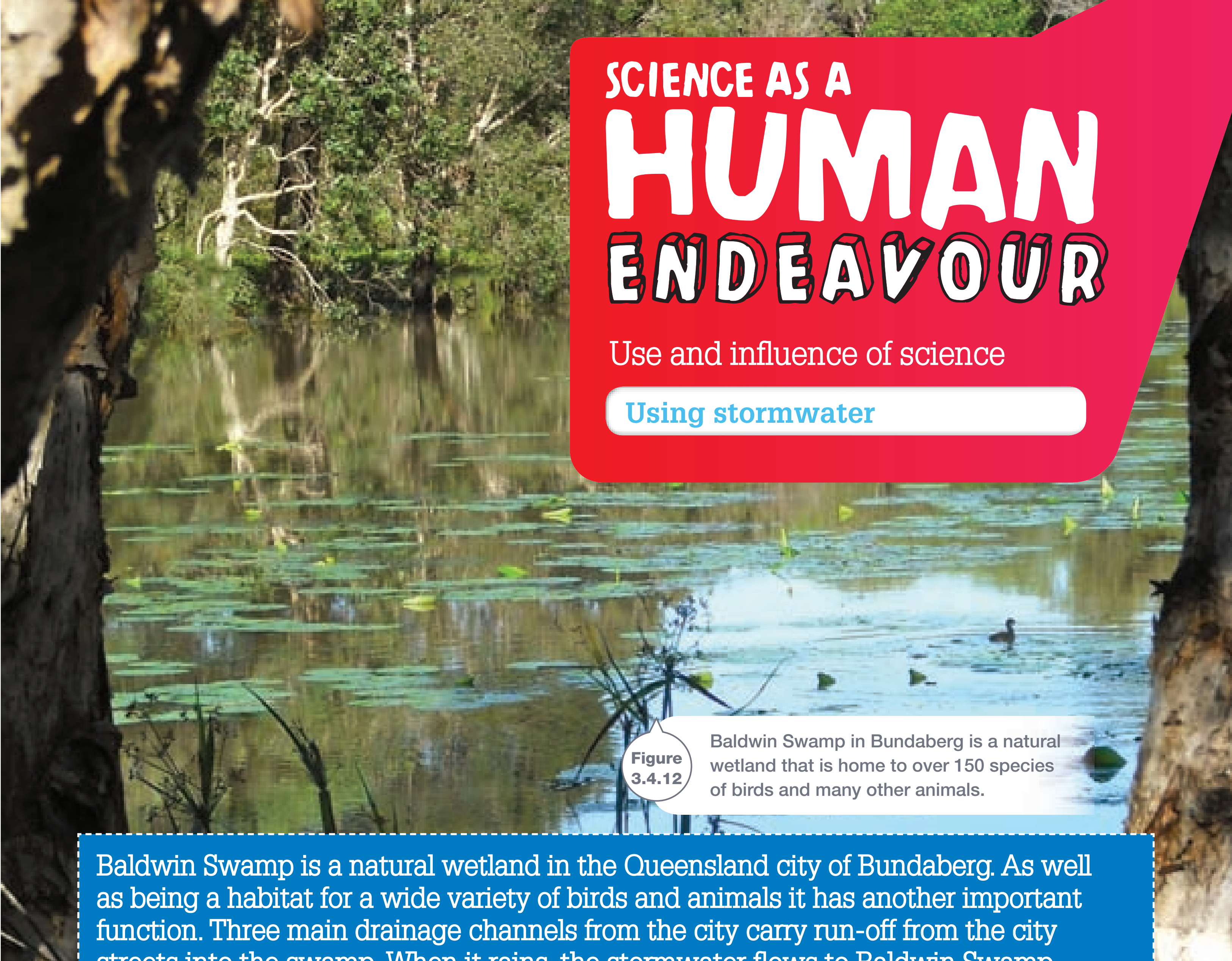


Figure 3.4.12 Baldwin Swamp in Bundaberg is a natural wetland that is home to over 150 species of birds and many other animals.

Baldwin Swamp is a natural wetland in the Queensland city of Bundaberg. As well as being a habitat for a wide variety of birds and animals it has another important function. Three main drainage channels from the city carry run-off from the city streets into the swamp. When it rains, the stormwater flows to Baldwin Swamp, carrying with it rubbish and pollutants. The rubbish has to be collected by City Council workers. Natural processes in the wetland absorb pollutants from water and improve the quality of the water before it flows out into the river and ocean.

The ability of wetlands to clean water has been used by city councils and land developers in a variety of ways.

On a big scale

Albert Park Lake in Melbourne (shown in Figure 3.4.13 on page 108) is visited by over 6 million people each year and is popular for sailing and rowing. In dry periods water levels in the lake decrease and people cannot sail or row on it. Up until 2005 water from the City of Melbourne's drinking water supplies was used to top up the level of the lake. This used up to 200 million litres of drinking water each year.

In 2005 the Victorian Government established a system that used stormwater to replenish the lake. Because stormwater is a major source of pollution for rivers and lakes, pollution control ponds had to be built as part of the system. This system has allowed the lake to continue to be used for sailing, and for model yacht and rowing clubs.

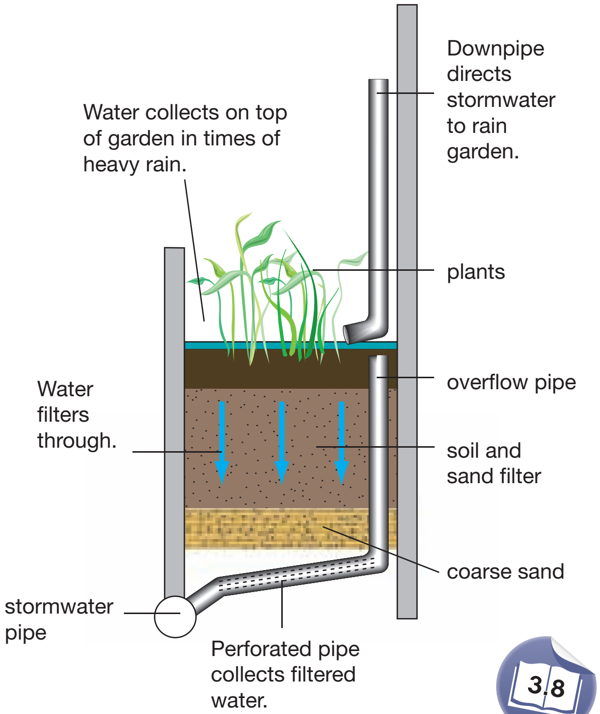
Rain gardens

Rain gardens are a much smaller scale way of dealing with stormwater. Figure 3.4.14 on page 108 shows how rain gardens slow down the rate of flow and clean pollution from the stormwater before it enters creeks and rivers.

Figure 3.4.13 Albert Park Lake is a popular place to go sailing and rowing.

Stormwater is channelled into the rain garden bed. In the garden bed is a layer of sand that filters the water. The filtered water is similar in quality to the water in undisturbed streams. It is not drinking quality but it is suitable for irrigation.

Rain gardens can be landscaped into suburban gardens as well as city parks, school yards and large nature strips that divide freeways. Figure 3.4.15 shows a rain garden in action.



3.8

Figure 3.4.14 A rain garden cleans stormwater before it enters creeks and rivers.

Figure 3.4.15 Rain gardens are attractive to look at and they also serve a very useful function.

Rain gardens are currently being built at a new housing estate near Caloundra on Queensland's Sunshine Coast. Here the rain gardens are called biopods. The stormwater in this estate is channelled towards a network of biopods, in which the water is collected. Small trees and other smaller plants growing in the biopods filter the water. The water does not flow out of the biopods to a river or creek but is stored and used later to water gardens. In the newest parts of the housing estate there is a biopod on each street corner.

3.4 Unit review

Remembering

1 **Recall** two observations Indigenous Australians use to help them find water sources.

2 **List** three ways that human actions change the water cycle.

3 **Name** two types of irrigation.

Understanding

4 **Explain** why dams are built near large cities.

5 **Explain** how a dam interrupts the water cycle.

6 At the end of winter the snow in the Snowy Mountains melts and the water flows into streams and rivers.
   a **Describe** what would have happened to that water before the Snowy River Scheme was built.
   b **Describe** what happens to the water from the Snowy Mountains now.
   c **Describe** the benefits that have resulted from the Snowy River Scheme.
   d **Describe** any disadvantages the scheme may have brought to the environment.

7 **Describe** two ways that run-off from cities is being reduced.

Applying

8 Figure 3.4.16 represents an area where part of a forest has been cut down. **Apply** your understanding of the water cycle to **explain**:
   a how and why the humidity of the air at points A and B would be different
   b how and why the rate of flow of water over the surface at points C and D would be different.

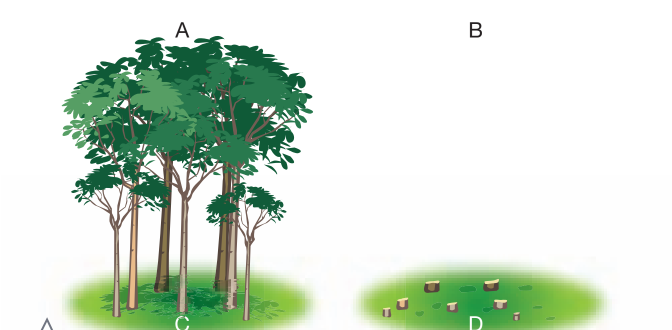


Figure 3.4.16

Analysing

9 **Compare** spray irrigation and flood irrigation by focusing on the effect they have on the water cycle.

10 **Compare** spray irrigation and a natural shower of rain.

Evaluating

11 A severe storm passes over Darwin.
   a **Explain** what happens to the rain that falls on the city.
   b **Deduce** what would have happened to the rain before the city was built.

12 Figure 3.4.17 shows a valley that has been flooded by the construction of a dam. **Deduce** the major change that the presence of the dam will have on the water cycle in that area.

Figure 3.4.17

Creating

13 Imagine a city block in the middle of a large city such as Sydney or Melbourne. **Construct** a diagram of the water cycle for that city block.

14 **Design** a project that would reduce the run-off from your school grounds and would make better use of stormwater.

Inquiring

1 Research the Aboriginal Dreamtime story of the Rainbow Serpent and find out how it relates to the current scientific understanding of the Great Artesian Basin.

2 Research any projects in your area that are designed to reduce the amount of stormwater flowing directly to rivers and oceans.

3 The construction of the Snowy River Scheme reduced the flow of water in the Snowy River by 99%. Research the effects the loss of water had on the environment of the river. Find out if there are any plans to address these effects.

4 The Aswan High Dam (shown in Figure 3.4.18) was built on the river Nile in Egypt between 1960 and 1970. Research the dam and answer the following questions.
   a Identify the reasons for the dam being built.
   b Compare the flow of the river before and after the dam was built.
   c Describe the effect that any changes have had on the environment downstream of the dam.

Figure 3.4.18 Aswan High Dam, Egypt

3.4 Practical activities

1 Water from leaves

Purpose

To investigate water loss from leaves.

Materials

- plastic bag approximately the size of an A4 piece of paper
- string
- access to trees with low branches
- marker pen
- 100 mL measuring cylinder

Procedure

1. Write your name on the plastic bag.
2. Select a twig on your tree that has healthy-looking leaves.
3. Carefully place your bag over the twig so that a number of leaves are enclosed as in Figure 3.4.19. The twig should still be attached to the tree.

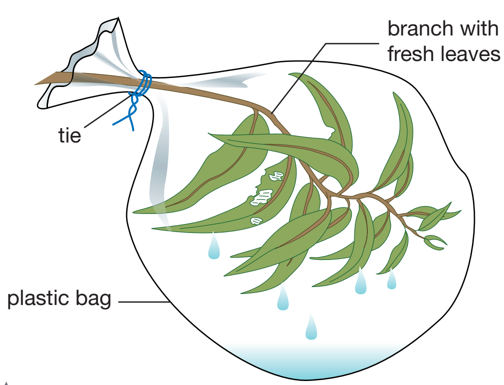


Figure 3.4.19

4. Use the string to tie the bag on tightly.
5. Leave the bag in place for 24 hours.

Results

1. After 24 hours remove the bag from the twig. Be careful not to lose any of the water.
2. Carefully pour the water into the measuring cylinder.
3. Record the amount of water collected.

Discussion

1. **Explain** how the water got into the bag.
2. **Deduce** how the humidity inside the bag would have changed during the 24 hours of the experiment.
3. **Propose** how this change in humidity could have affected the amount of water collected.
4. **Demonstrate** how the information you have collected relates to the water cycle.

3.4 Practical activities

2 Run off or soak in?

Purpose

To observe the percolation of water through different surfaces.

Materials

- 3×250 mL beakers or other transparent containers
- quantity of very fine gravel to half fill the beaker
- quantity of sand to half fill the beaker
- quantity of clay soil to half fill the beaker
- 100 mL measuring cylinder
- water
- marker pen

Procedure

1. Label the three beakers: *gravel*, *sand* and *clay*.
2. Fill the gravel beaker with gravel until it is half full. Gently tap the side of the beaker to settle the contents. Add more gravel if necessary.
3. Fill the sand beaker with sand in the same way.
4. Add some clay soil to the clay beaker and push it down firmly. Add more clay soil and push it down again. Repeat this process until the beaker is half full.
5. Measure 100 mL of water and pour it onto the top of the gravel beaker. Pour it over the whole surface, not just in one place. Observe what happens for five minutes.
6. Repeat Step 5 for the other two beakers.

Results

1. Record your observations of the way the water percolates through the three different materials.
2. Record whether any of the materials had water lying on the top after five minutes.

Discussion

1. **Propose** why it was necessary to push the clay soil down firmly instead of just tapping the side of the beaker.
2. **Identify** the material through which percolation occurred most quickly.
3. **Identify** the material through which percolation occurred most slowly.
4. **Explain** why the different rates of percolation occurred.
5. a **Identify** the material from which run-off was most likely to occur.
   b **Justify** your response.

3 Chapter review

Remembering

1 **Name** the following:
  a the term for water, wind and ice that transports sediments away from the site of weathering
  b the process of breaking rocks down into smaller pieces.

2 **List** four devices that may be found in your home that use energy but did not exist 50 years ago.

3 **List** the three changes of state that water passes through in the water cycle.

Understanding

4 **Modify** the following definitions to make them correct.
  a A natural resource is a substance supplied by the Earth for humans to make products they need.
  b A renewable natural resource is one that is replaced by natural processes that occur on Earth on a timescale much longer than a human life.
  c Deposition is the process where sediments are carried away by a moving stream of water, air or ice.

5 Renewable energy researchers are working to develop better ways to store energy. **Explain** why this technology is important.

6 **Describe** the effect that the ice sheets at the north and south poles have on the movement of water through the water cycle.

7 a **Describe** how the rate of evaporation changes on a windy day compared with a calm day.
  b **Explain** why this change happens.

8 Figure 3.5.1 is a simplified diagram of the water cycle.
  a Copy the diagram into your workbook.
  b **Modify** the diagram by adding the names of the changes of state that are taking place.
  c **Predict** places where water could stay for a long time before moving on.
  d **Predict** places where the movement to the next part of the cycle could be fast.

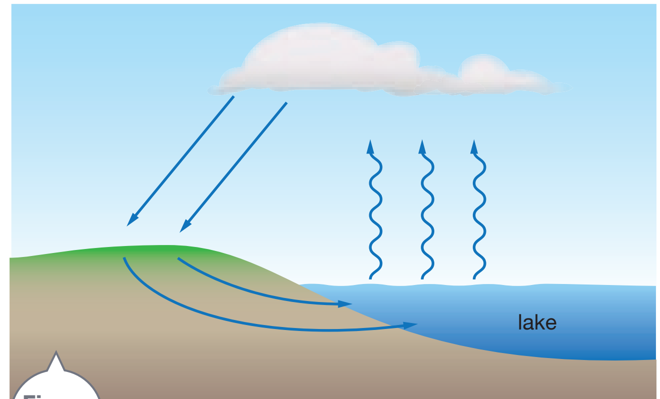


Figure 3.5.1

9 When settlers first brought cattle to the Australian inland, their cattle drank from the natural springs in the area. **Propose** the effect this would have on the water sources used by Indigenous Australians.

Applying

10 **Demonstrate** your understanding of erosion using observations at the beach, in your garden or travelling by car.

11 **Identify** the original source of the energy in fossil fuels.

12 **Identify** the source of heat in water springing from a geyser.

13 **Identify** the part of the water cycle that is represented in Figure 3.5.2.

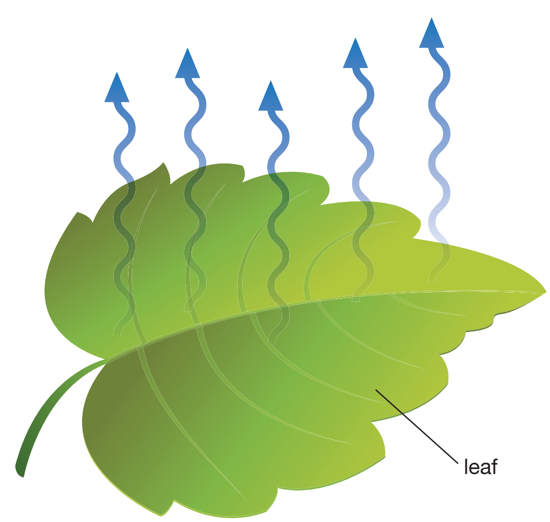


Figure 3.5.2

3 Chapter review

Analysing

14 **Compare** how long it takes to renew soils with how long it takes to replace water in the soil.

15 **Compare** how long it takes to replace rocks with how long it takes to renew gases such as oxygen in the air.

16 **Classify** these energy sources as either renewable or non-renewable:

- solar energy
- oil
- coal
- wind energy
- wave energy
- tidal energy
- LPG gas
- geothermal energy
- wood
- paper
- uranium.

17 **Compare** the amount of water lost from a field of bean plants when it is irrigated using spray irrigation and when it is not irrigated at all.

Evaluating

18 Tides are local temporary currents caused by the gravity of the Moon. **Propose** how a tide may affect soil erosion.

19 Considering the impact of greenhouse gases on global warming, it could be argued that the world should immediately stop using non-renewable forms of energy such as oil, coal and gas. **Evaluate** this argument.

20 Algae can grow in poor-quality soil and do not require the fresh water needed for many other biodiesel crops. **Propose** why algae could potentially offer a good source of biofuel.

21 **Deduce** why some clouds pass overhead without producing any rain.

22 Flexible solar cells are currently being developed. **Propose** three ways that flexible solar cells may be used in the future.

23 **a** **List** the major sources of energy used in Australia to power appliances and for transportation.

b **Propose** what Australia's major energy sources might be in 50 years time.

Creating

24 When storing water is it more efficient to have one large dam or a number of smaller dams? **Design** an experiment that could be used to answer this question.

25 **Use** the following key terms to **construct** a visual summary of the information presented in this chapter:

renewable resource, non-renewable resource, renewable energy source, solar energy, fossil fuels, water cycle, change of state, transpiration, precipitation, human impacts

3.9

Thinking scientifically

Q1 A renewable natural resource is one that is replaced by natural processes that occur in a timescale less than an average human lifetime. Some students were asked to classify some of Earth's resources into renewable resources and non-renewable resources. Their answer is shown in the following table.

Renewable resources	Non-renewable resources
1 rocks	7 wind
2 water	8 air
3 sunlight	9 coal
4 soil	10 petroleum
5 waves	11 natural gas
6 hydro-electric	12 nuclear

Which resources (using the number) did the students classify incorrectly?

A 1, 4, 7, 8
B 2, 3, 9, 10
C 5, 6, 11, 12
D 9, 10, 11, 12

Q2 A non-renewable energy source cannot be replaced. Identify which list below contains only non-renewable energy resources.

A coal, oil, sunlight, wind
B natural gas, sunlight, wind, tidal energy
C oil, uranium, sunlight, tidal energy
D natural gas, coal, oil, uranium

Q3 The change of state from GAS → LIQUID represents:

A the changes taking place in a cloud leading to rain
B the change that takes place in saturated air as it cools
C the change that takes place in leaves of trees with the Sun shining on them
D the change of state necessary for water to be able to percolate through soil

Q4 If the air temperature increased throughout the world, the rate at which water moves through the water cycle would:

A stay the same
B decrease
C increase
D increase in some areas and decrease in others

Q5 As water goes through the water cycle again and again, the amount of water on Earth:

A increases
B decreases
C stays the same
D varies from time to time

Glossary

Unit 3.1

Agents of erosion: water, wind and ice. All three of these agents transport sediments away from the site of weathering

Atmosphere: layer of gases above the Earth's surface

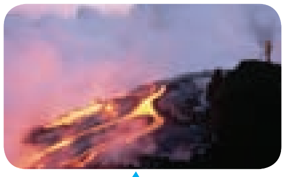
Deposition: the process where sediments drop out of a moving stream of water, air or ice

Erosion: the removal of sediments away from the place of their formation or deposition

Erosion

Humus: decaying plants and animals and their wastes

Igneous rock: rock formed by the cooling of molten rock, for example basalt



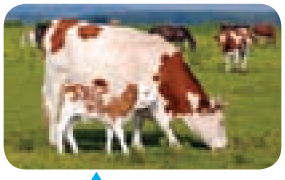
Igneous rock

Minerals: substances found in rocks

Non-renewable resource: a resource that takes longer than the average human lifespan to be replaced

Photosynthesis: the process by which plants use carbon dioxide, water and sunlight to make food

Renewable resource: a resource that is always being replaced naturally



Renewable resource

Resource: something that satisfies a particular purpose or need

Sediment: material such as silt and sand that is transported and deposited by water, ice and wind and forms layers on the Earth's surface. In time it can become compacted to form sedimentary rock

Sedimentary rock: rock formed by compacting and sticking together of sediments, for example sandstone

Weathering: the process of breaking rocks down into smaller pieces

Unit 3.2

Biogas: a gas produced from the fermentation of organic waste, such as waste from sugarcane, and used as fuel

Biomass: all plant and animal matter found on Earth

Fossil fuels: fuels such as coal, oil and natural gas, formed from the remains of living things buried millions of years ago

Geothermal energy: energy sources from heat below the Earth's crust

Hydroelectricity: the process of using water falling from a height to turn turbines and generate electricity

Non-renewable energy source

Non-renewable energy source: a source of energy that cannot be replaced after it is used, such as oil or coal

Nuclear fuel: using uranium or plutonium

Oscillating wave column: a chamber containing a turbine that is fixed in the ocean. As water flows into and out of the chamber, air pushes the turbine back and forth. This rotation is used to generate electricity

Renewable energy source

Renewable energy source: a source of energy that can be replaced after it is used, such as solar or wind energy

Solar cell: a device that absorbs solar energy and converts it directly into electrical energy

Solar cell

Tidal barrage: a construction in which water fills a basin as a tide comes in, rotating a turbine as it flows. The water is stored until low tide, when it is released and again turns the turbine. This rotation is used to generate electricity

Wind energy: harnessing energy from the movement of air using wind turbines

Unit 3.3

Aquifer: a layer of pervious rock from which water can be extracted using a bore or well

Finite: non-renewable or has limited availability, i.e. will run out

Groundwater: water that exists underground

Humidity: the amount of water vapour in the air

Impervious rock: rock that does not allow water to soak into it

Percolation: the process of water soaking into the soil

Pervious rock: rock that allows water to soak into it

Precipitation: any water falling from the sky

Run-off: rainwater not absorbed by the soil

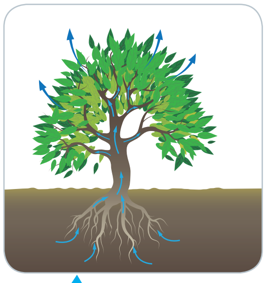
Saturated: not able to hold any more water vapour

States: solid, liquid and gas (another state called plasma exists at temperatures over 60 000°C)

Transpiration: the evaporation of water from plants

Water cycle: the natural process of recycling water

Precipitation



Transpiration

Unit 3.4

Flood irrigation: a type of irrigation where water is released in between crops in channels

Irrigation: a practice used in agriculture that provides water to crops using pipes and ditches

Rills: channels in bare soil created by fast-flowing water

Spray irrigation: a type of irrigation where a pump sprays water droplets into the air, which fall onto crops like rain

Springs: places where underground water comes to the surface

Flood irrigation

Rills