

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 underground 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.

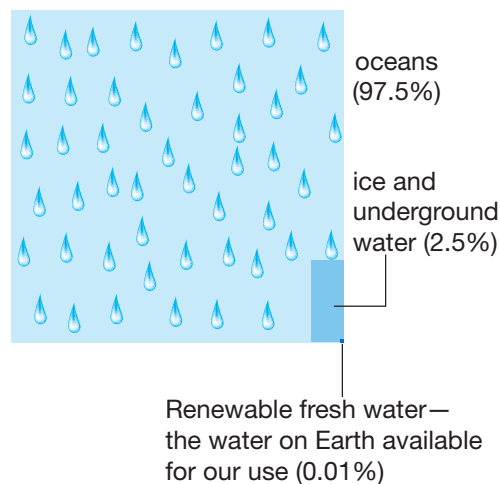


Figure 3.3.2 Comparison of the total amount of water on Earth and the amount we can use

Dripping glass

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



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.

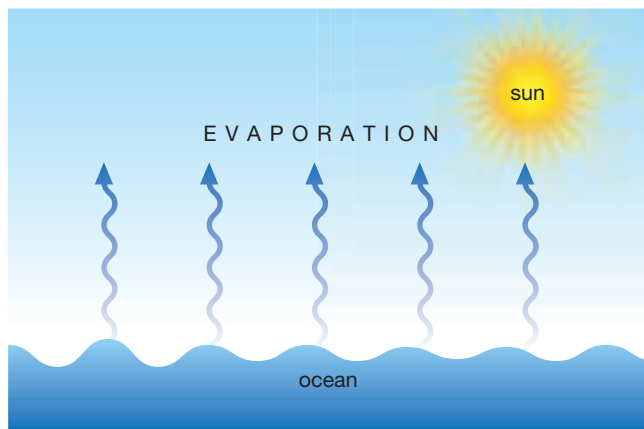


Figure 3.3.3

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.

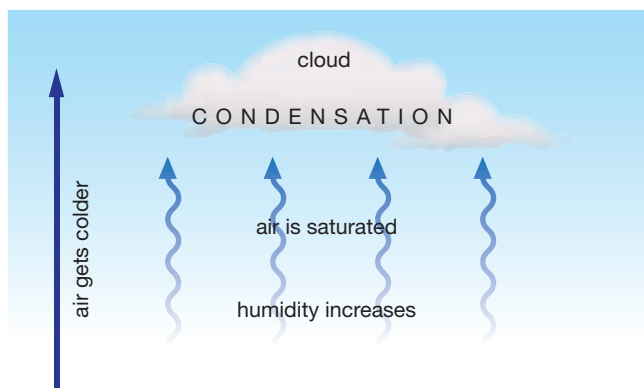


Figure 3.3.4

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**.

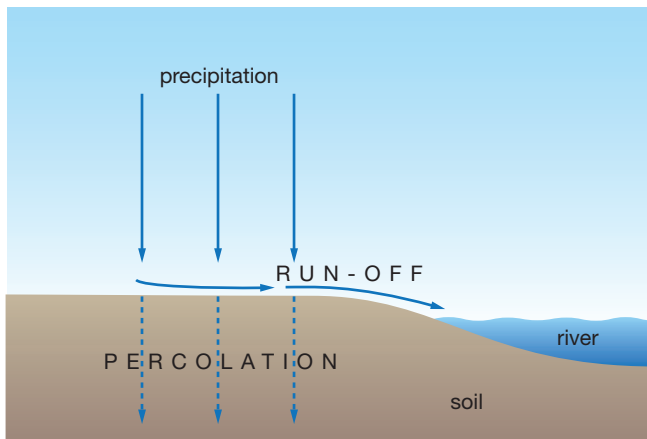


Figure 3.3.6

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.

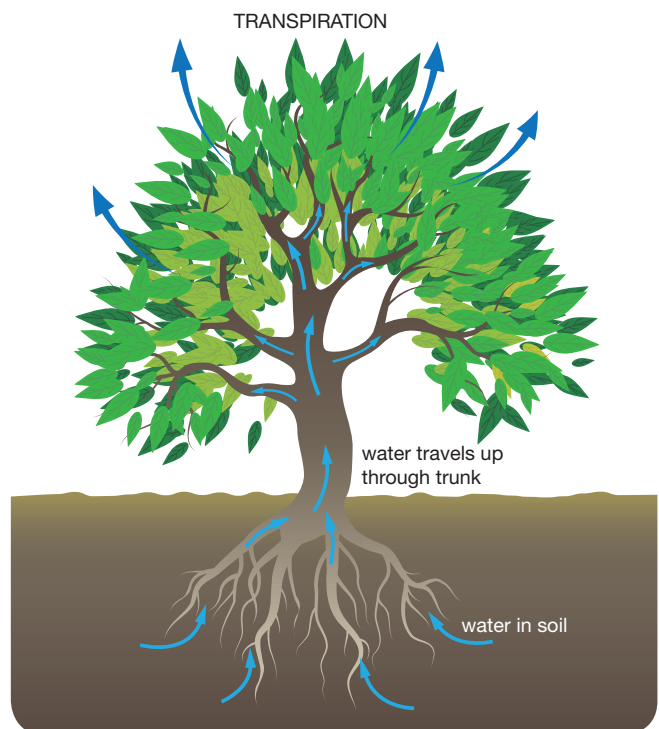


Figure 3.3.7

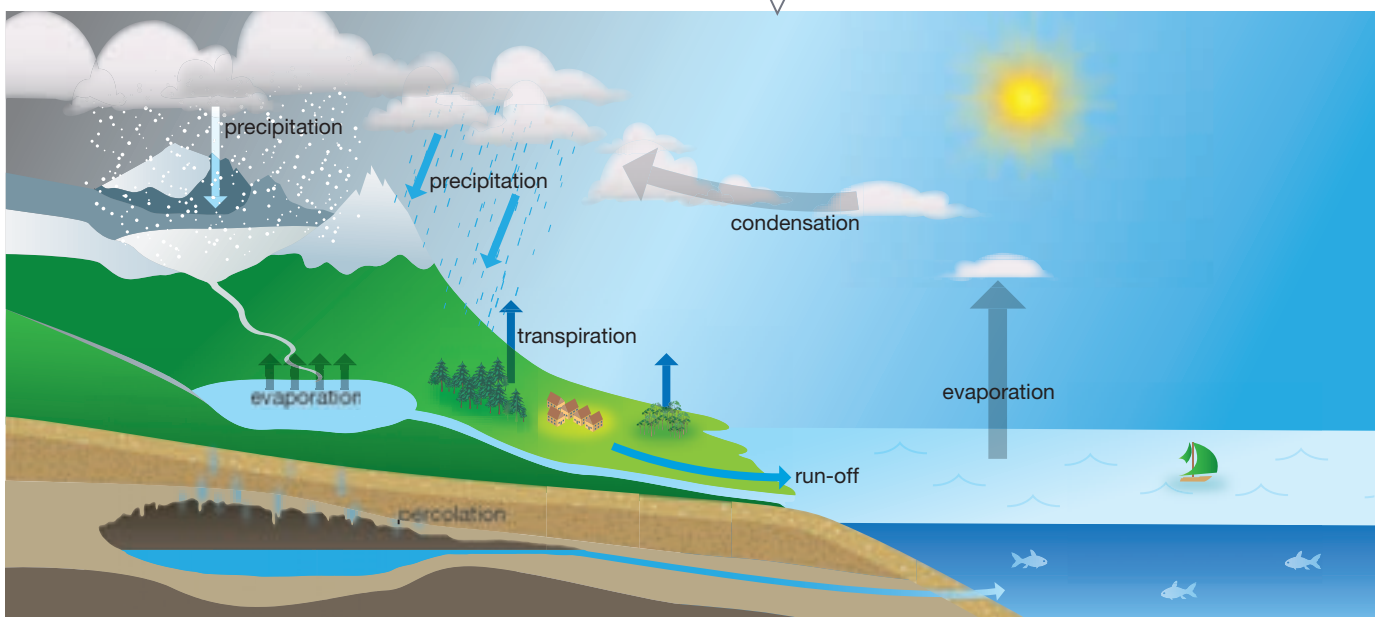
Transpiration is the evaporation of water from leaves and other parts of a plant. Through transpiration, water is carried from the soil and returned to the atmosphere.

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



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.

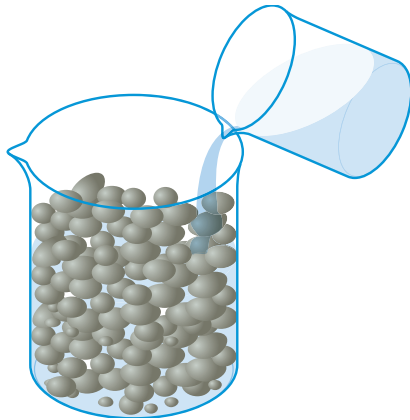


Figure 3.3.9

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,

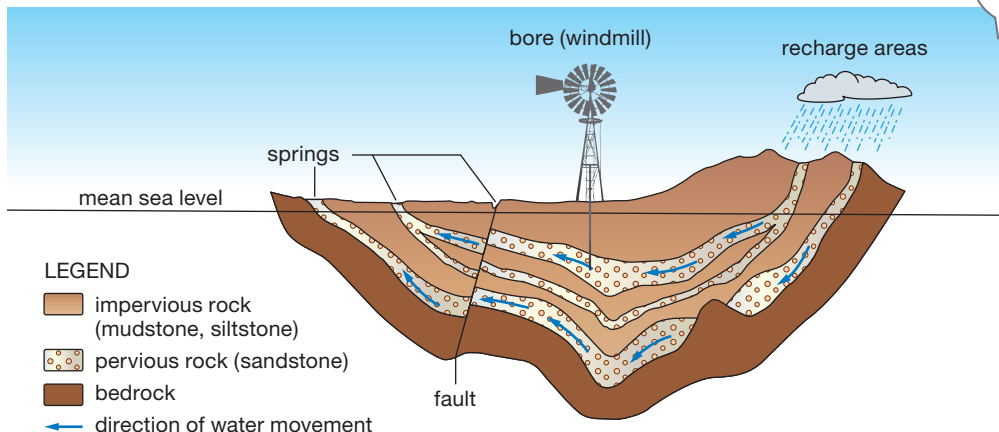


Figure 3.3.10

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.

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 3.3.11

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.

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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.

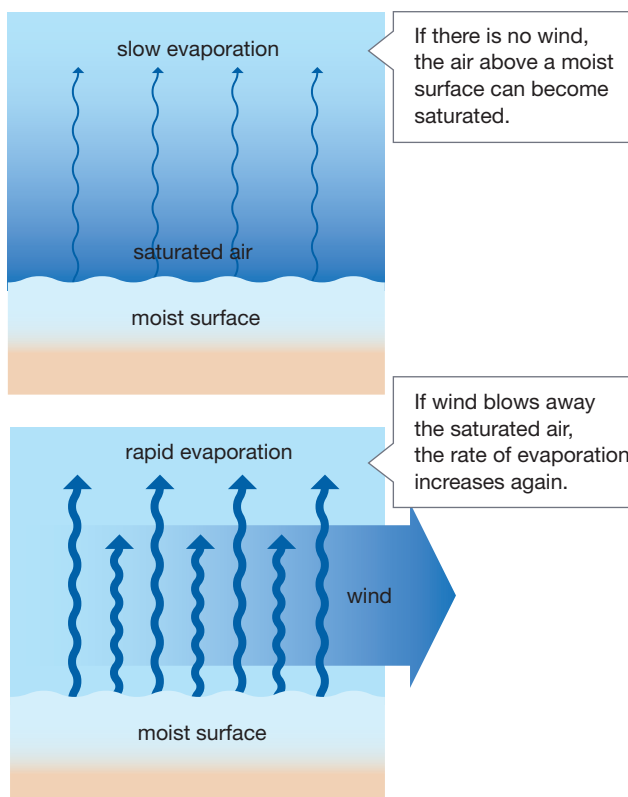


Figure 3.3.12

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.



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.

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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.

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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.

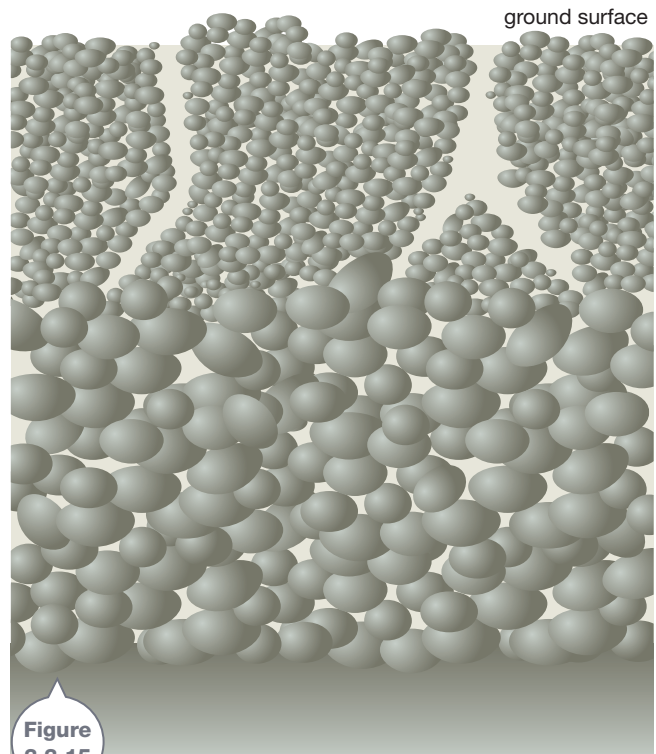


Figure 3.3.15

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.



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.

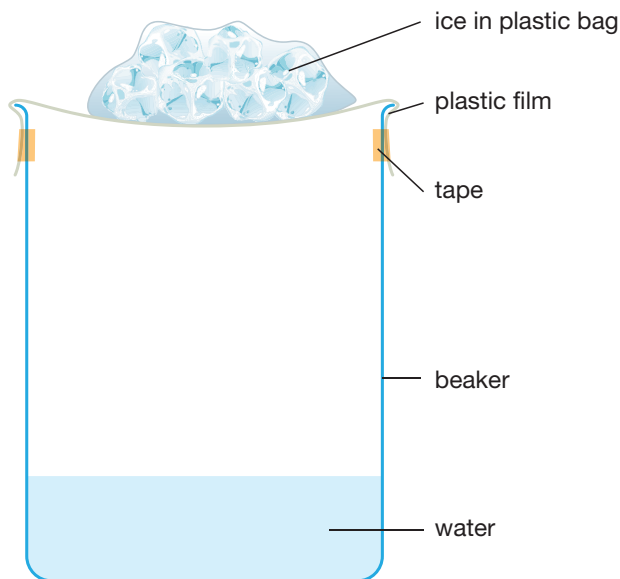


Figure 3.3.17

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.