5 Separating mixtures

Why learn this?

Chocolate is a mixture of ingredients — cocoa, butter, sugar, milk and flavours — blended to give a great taste. The sugary coating is a mixture too. Even the colouring can be a combination of many different colours.

Chocolate isn't the only substance that can be made by combining different ingredients. Many substances are made this way. And, the individual ingredients in some substances can also be separated further into parts.

In this chapter, students will:

5.1 distinguish between pure substances and mixtures and identify some common mixtures
5.2 learn about solutions and compare soluble and insoluble substances
5.3 identify and classify different mixtures of insoluble substances that they encounter in everyday life
5.4 compare different methods, such as filtering, decanting, centrifuging and separating funnels, used to separate insoluble substances from suspensions
5.5 appreciate how a variety of separation methods are used to process blood donations
5.6 use processes such as distillation, evaporation, crystallisation and chromatography to separate the solutes from the solvent in a solution
5.7 apply knowledge of separation techniques to develop an understanding of how sewage is treated
5.8 examine how water supplies are treated before reaching a population so that water is safe for drinking.

Each of these sweets contains a mixture of ingredients including cocoa, butter, sugar, milk, flavours and colours.

Separating mixtures

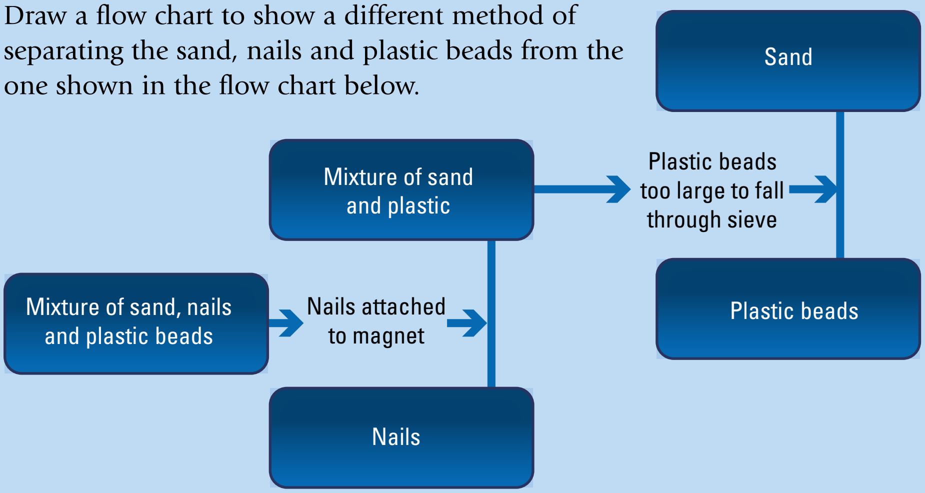
Imagine that a few small iron nails have been dropped into a child's sandpit and have sunk into the sand so that they can't be seen. One way of separating the nails from the sand is to use a magnet. This works because the nails and sand have different **properties**, or features. The nails are made from a substance that is attracted to magnets, but the sand is not attracted to magnets.

But what if plastic beads had been dropped into the sandpit instead of nails? They can't be separated from the sand with a magnet. The key to separating them is recognising the different properties of the plastic beads and the sand. An obvious difference is size. The plastic beads are much bigger than grains of sand. A child's sand sieve would do the trick. Sand grains pass through but the plastic beads don't.

The flow chart below shows one way of separating the parts of a mixture of sand, nails and plastic beads.

1. Suggest another method of separating the nails from the sand.
2. What difference in properties does your suggested method use to separate the substances?
3. Draw a flow chart to show a different method of separating the sand, nails and plastic beads from the one shown in the flow chart below.

Chocolate is a mixture of cocoa, butter, sugar, milk and flavours.



INVESTIGATION 5.1

Design and separate

AIM To investigate properties used to separate mixtures

Your task is to separate the parts of a mixture of matches, pebbles, steel paperclips and sand.

You will need:

sand (about 250 mL)
small pebbles
plastic container (about 500 mL)
other equipment and water as required
'dead' matches
steel paperclips
A3 paper

- Mix the matches, pebbles and paperclips evenly in a plastic container of sand.
- Devise and write a step-by-step plan of a method to separate the four parts. You will need to think about the properties of each part of the mixture that will make separation possible.
- Make a list of all of the equipment that you will need.
- Check your plan with your teacher, and then gather the equipment and perform the separation.
- On A3 paper, draw a flow chart like the one above to show how each part was separated from the mixture.

Pure substances and mixtures

eLesson
Lavoisier and hydrogen
Watch a video from *The story of science* about the discovery of the elements.

eles-1772

eBook*plus*

Is this a mixture or a pure substance?

Consider the water in this glass. It looks like it has come straight from a tap, but what can we tell about the composition of the liquid in this glass just by looking at it? Can we say for sure that it is pure water? And what exactly do we mean by pure anyway?

Pure substances and mixtures

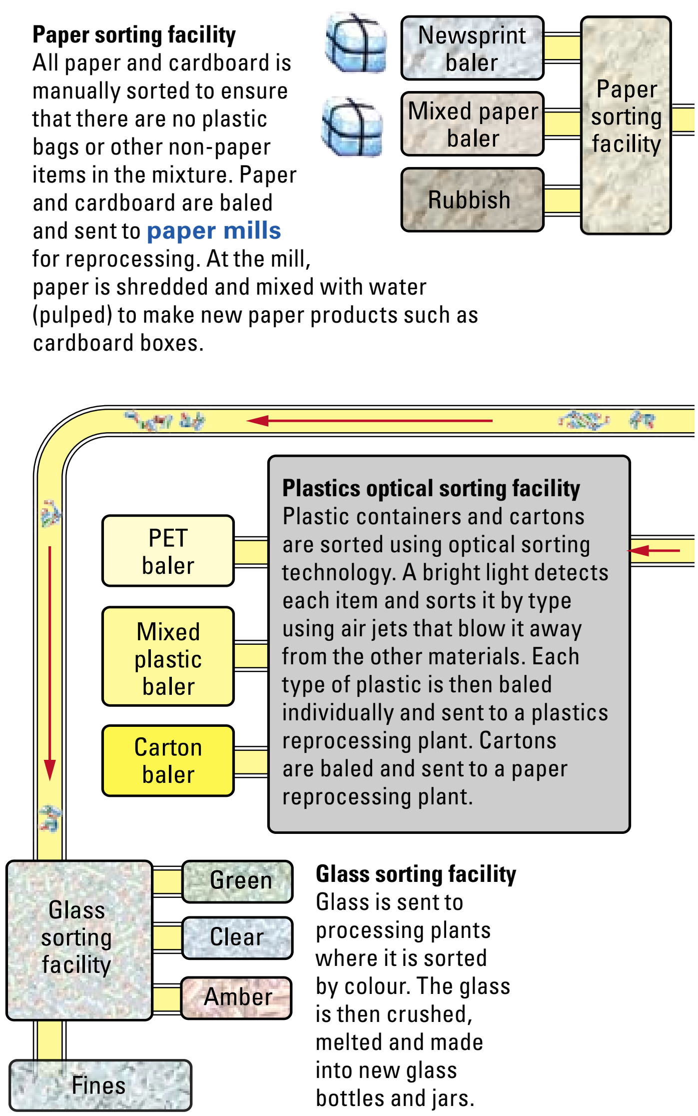
You will recall from chapter 3 that all matter is made up of particles and that there are many different types of particle. Substances in our world can generally be classified as being either **pure substances** or **mixtures** according to the kinds of particles they contain and how these are arranged.

A pure substance is made up of the same type of particle throughout. White table sugar that you put on your breakfast cereal, for example, is a pure substance and is made up of nothing except identical particles of sucrose. Oxygen gas, fine gold and distilled water (which has been processed so that it is free of pollutants and minerals) are also examples of pure substances. The particles in a pure substance all have the same physical and chemical properties.

A mixture, on the other hand, is made up of at least two substances that have different properties and so it contains several different kinds of particle. Sea water is an example of a mixture because it is made up of water particles and salt particles. Tap water in most cities is also a mixture of water and other substances, such as chlorine, sodium, calcium, magnesium and fluoride.

Chocolate milk is an example of a mixture because it is made up of particles of milk (which is itself a mixture), sugar and cocoa. Some other common mixtures are shown in the table at the top of the next page.

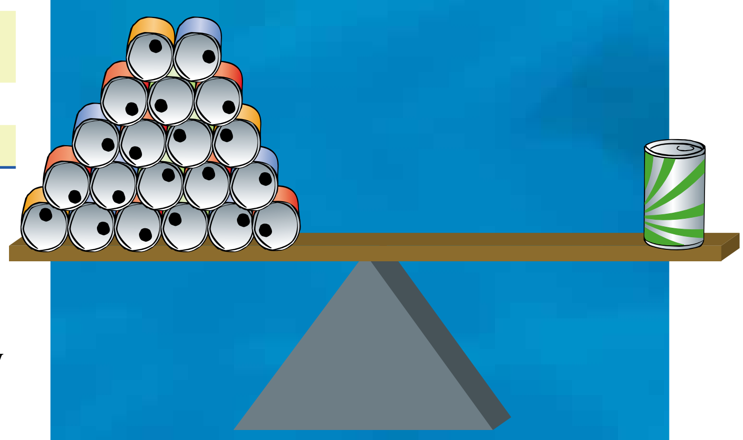
In most cases, it can be difficult to tell whether a substance is a pure substance or a mixture just by looking at it. This is because the individual particles in the substance are usually too small to see, so it is hard to tell if they all look the same or if there are different types of particle present.



Mixture	Made up of ...
Salt water	Water, salt
White coffee	Water, coffee, milk (may have sugar)
Chocolate	Cocoa, milk, sugar, cocoa butter
Cola drink	Water, carbon dioxide, sugar, caramel, colouring agents, flavouring agents
Soil	Silica, iron oxide, organic matter, nitrogen
Bread	Flour, yeast, water, egg, sugar

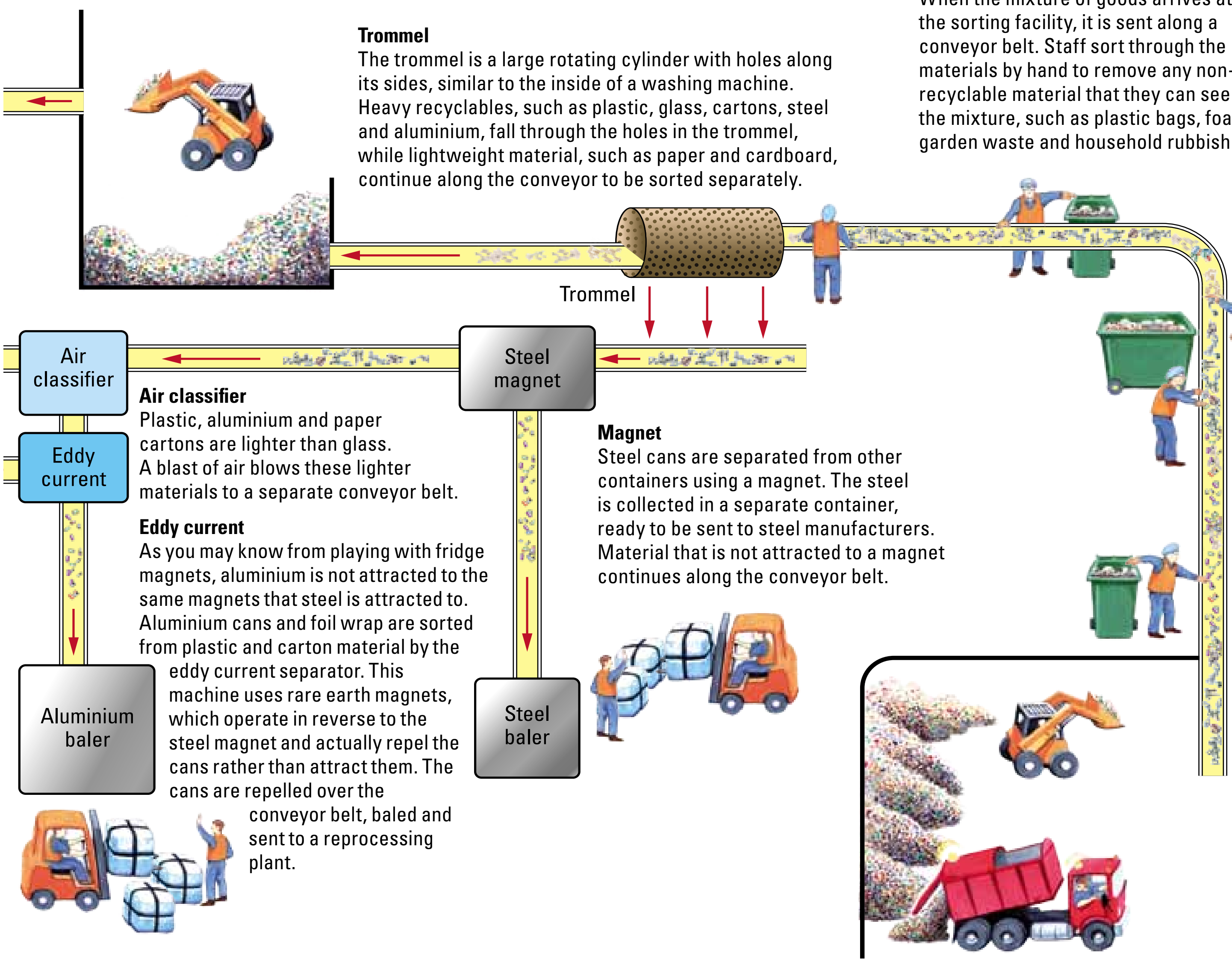
HOW ABOUT THAT!

It takes the same amount of energy to make 20 cans from recycled aluminium as it does to make just one new can from raw materials.



Recycling plants

Most local councils have a **recycling program**. Items such as paper, all plastic bottles and containers, glass, aluminium and steel can be recycled and made into new products. Recycling reduces the amount of waste that goes to **landfill** and saves precious resources such as trees and bushland. Many **manufacturing processes** pollute the environment. Recycling and reusing materials reduces the need to manufacture from raw materials.



Pre-sort
When the mixture of goods arrives at the sorting facility, it is sent along a conveyor belt. Staff sort through the materials by hand to remove any non-recyclable material that they can see in the mixture, such as plastic bags, foam, garden waste and household rubbish.

Trommel
The trommel is a large rotating cylinder with holes along its sides, similar to the inside of a washing machine. Heavy recyclables, such as plastic, glass, cartons, steel and aluminium, fall through the holes in the trommel, while lightweight material, such as paper and cardboard, continue along the conveyor to be sorted separately.

Magnet
Steel cans are separated from other containers using a magnet. The steel is collected in a separate container, ready to be sent to steel manufacturers. Material that is not attracted to a magnet continues along the conveyor belt.

Air classifier
Plastic, aluminium and paper cartons are lighter than glass. A blast of air blows these lighter materials to a separate conveyor belt.

Eddy current
As you may know from playing with fridge magnets, aluminium is not attracted to the same magnets that steel is attracted to. Aluminium cans and foil wrap are sorted from plastic and carton material by the eddy current separator. This machine uses rare earth magnets, which operate in reverse to the steel magnet and actually repel the cans rather than attract them. The cans are repelled over the conveyor belt, baled and sent to a reprocessing plant.

Separating by sight

Household rubbish is usually a mixture of food scraps, recyclable materials and other waste. The first step in recycling is to **separate** the recyclable items from other household rubbish. We can see the differences between the types of rubbish, and we know which items can be recycled. Big recycling plants use this knowledge to separate the tonnes of recycled goods they receive.

Separating mixtures

Many mixtures can be separated into the basic substances that they are made of. There are a number of different ways of doing this, but all of these methods rely on the fact that the individual substances that make up a mixture have different properties.

For example, after you've cooked pasta, you separate the cooked pasta (solid and in hollow cylinders) from the water (liquid) using a strainer. Water passes easily through the strainer, but the pasta is caught.

If you are doing woodwork and you drop some nails in the sawdust, there are several ways to separate them because their properties are so different.

ACTIVITIES

REMEMBER

1 **Define** the term 'mixture'.

2 **Explain** why some mixtures are easier to separate than others.

3 How can you **distinguish** pure substances from mixtures?

4 **Recall** two reasons why recycling is good for the environment.

5 **Explain** why recyclable materials need to be separated.

THINK

6 **Describe** all the properties you can think of for:
(a) salt
(b) sand
(c) water.

7 **Explain** how you would separate the parts of a mixture of salt, sand and water. Use the properties that you considered in question 6.

8 Imagine you dropped nails in the sawdust in woodwork class. **Propose** two reliable ways of separating the nails from the sawdust.

9 **Construct** a table with two columns with the headings 'Pure substance' and 'Mixture'. List the following substances under the appropriate heading: freshly made apple juice, tap water, soft drink, cake batter, sterling silver, distilled water, gold nugget, glass, cornflakes.
You may have to research some of these substances to find out which column they belong to.

10 **Construct** a table like the one below and complete it with information on separating recyclable rubbish.

Method	What is removed?	Properties

(a) Record the methods used to separate different types of material in a recycling plant.
(b) For each method, record which material is removed from the flow of rubbish.
(c) What properties of this material allow it to be separated from the mixture?

11 **Deduce** why the same magnets are not used for separating both aluminium and steel cans.

12 **Explain** why people, rather than machines, need to manually separate some of the recycling mixture.

INVESTIGATE

13 How would you separate the sand from a mixture of sand and sawdust? **Construct** a flow chart to show the steps you would use. Check your method with your teacher before trying out your experiment.

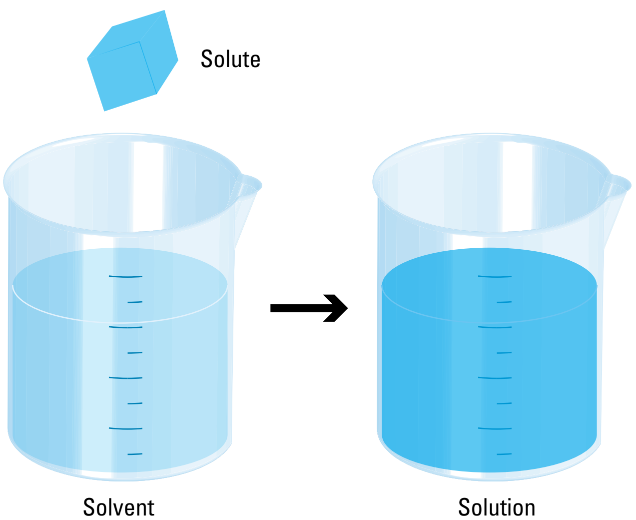
CREATE

14 Design and **construct** a poster or brochure that explains which items can be recycled. Check with your local council about how they prefer recycling materials to be separated ready for collection. Include this in your brochure or poster.

Looking for solutions

When you add a teaspoon of sugar to a cup of hot water and stir it, the sugar crystals seem to disappear. Where have they gone? Actually, the sugar is still there; the sugar particles have been separated away from each other and have spread out among the water particles. As the individual particles of sugar are so small, they are unable to be seen with the naked eye. We say that the sugar has **dissolved** in the hot water and has formed a sugar solution.

A **solution** is a mixture made up of one substance dissolved in another. The substance that is dissolved is called the **solute**, and this can be a solid, a liquid or even a gas. The substance that the solute is dissolved in is called the **solvent**; this is usually a liquid. In the case of our sugar and hot water, the sugar is the solute and the water is the solvent. Water is considered to be a very good solvent because many chemicals dissolve in it quite easily. Solutions in which water is the solvent are said to be **aqueous solutions**.



A solute dissolves in a solvent and creates a solution.

The solute in a solution can be any state of matter. When we dissolve things such as sugar or salt, the solute is a solid. When we add cordial to water, the cordial dissolves in the water; in this case, the solute is in a liquid form.

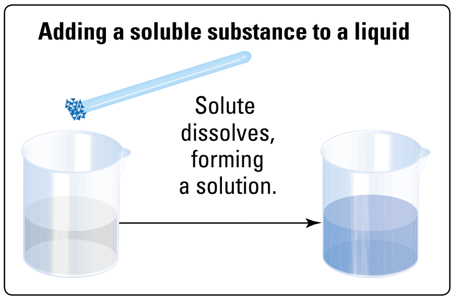
A solution does not have to have just one solute dissolved in it though — a substance such as a fizzy drink has many different substances dissolved in water, some of which are solid and some liquid, as well as the gas carbon dioxide that gives it the fizz.

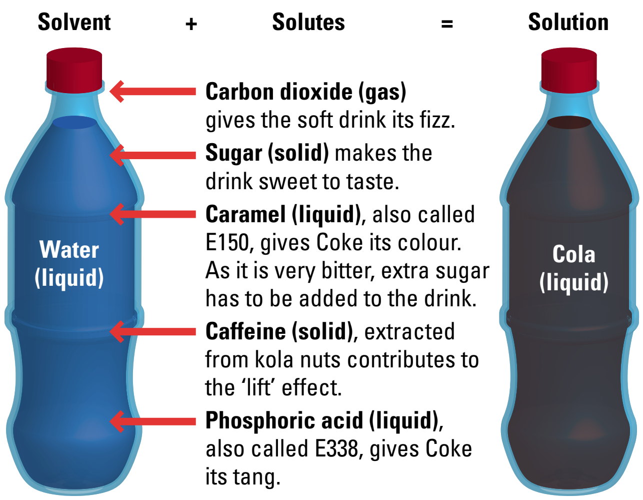
The carbon dioxide is pumped into the bottles or cans at high pressure. The bottles and cans are then sealed to keep the carbon dioxide dissolved in the solution. When you open the drink, the pressure is reduced and the carbon dioxide bubbles out of solution.


When the carbon dioxide is dissolved, you can't see that it's there. When you open the container, the pressure is reduced. The carbon dioxide is separated from the mixture and bubbles to the surface.

Soluble or insoluble?

Substances that dissolve in a particular solvent are said to be **soluble** in that solvent. Remember that, just because a substance is soluble in one solvent, doesn't mean that it is soluble in all solvents. For example, waterproof ink (which you will find in permanent markers) is soluble in alcohol but it is *not* soluble in water. We use the word **insoluble** when a substance does not dissolve in a particular solvent.





Time to concentrate!

When you are making up a cordial solution, you dissolve cordial syrup in water. If you add only a little bit of syrup to the water, you get a very pale cordial drink, which tastes only slightly of the cordial. However, the more syrup that you add, the darker the colour of your cordial drink and the stronger the taste will be. The relative amount of solute (in this case, the cordial syrup) compared with the amount of solvent (water) determines the **concentration** of the resulting solution.

The amount of solute dissolved in the solvent determines the concentration of the solution.

INVESTIGATION 5.2

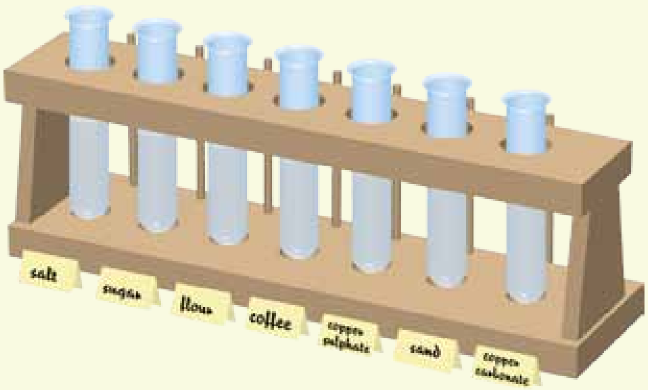
Soluble or insoluble?

AIM To investigate the solubility of some common substances in water

Substances that dissolve are said to be soluble. Those that do not are insoluble.

You will need:

safety glasses and laboratory coat
heatproof mat
7 test tubes
test-tube rack
spatula
samples of salt, sugar, flour, coffee, copper sulfate, sand and copper carbonate



- Half-fill each of the test tubes with cold water.
- Label the test tubes: salt, sugar, flour, coffee and so on.
- Use a spatula to add a very small amount of each substance to its labelled test tube. Do not use more than a quarter of a spatula full.
- Draw up a table of your results like this incomplete one:

Substance mixed with water	Clear or cloudy?	Solution? (yes/no)
Salt		
Sugar		
Flour		
Coffee		

- Hold each test tube up to the light. Decide whether the mixture is clear or cloudy. Record your results in the table.

DISCUSSION

1. **Which of the substances dissolved in water?**
2. **How can you tell if a substance has dissolved?**
3. **Read the information on *filtration* on pages 140–141. Which of the mixtures could be separated by filtration?**

The concentration of a solution is a measure of how much solute has been dissolved in a fixed amount of solvent. Solutions in which there is very little dissolved solute are said to be **dilute** solutions while those that have a great deal of solute dissolved in them are called **concentrated** solutions.

There is a limit to how concentrated you can make a solution. Eventually, as you add increasing amounts of solute to a solvent, you reach a point at which no more solute dissolves — this is referred to as **saturation**. Solute added to a saturated solution simply remains undissolved in the container.

The concentration of a solution is usually described in terms of the mass of solute dissolved in a fixed amount (usually 1 litre) of solvent. For example, a salt solution that is made up of 5 grams of salt and 100 mL of water would have the same concentration as a solution with 50 grams of salt in 1000 mL of water. Both solutions would have a concentration of 50 g/L.

HOW ABOUT THAT!

During World War II, scientists George de Hevesy and Niels Bohr had to hide two solid gold Nobel prize medals from the Germans who had just occupied their country, Denmark. They decided to place the medals in the only substance that is able to dissolve it — a mixture of hydrochloric and nitric acids called aqua regia. The resulting black mixture sat in plain sight for the rest of the war on a shelf in de Hevesy's laboratory. Afterwards, the gold was recovered from the solution and the medals recast and returned to their original winners.

ACTIVITIES

REMEMBER

1 **Explain** the difference between a solution, a solvent and a solute.

2 Name the solvent and the solute in each of the following solutions.
(a) Sea water
(b) Soft drink
(c) Coffee

3 **Identify** the solvent, solute and solution in this photo.

4 What leaves a fizzy drink to cause it to go flat?

5 What substance is added to cordial to make it more dilute?

6 **Describe** how an aqueous solution is different from other solutions.

7 What is the difference between a concentrated solution and a saturated solution?

THINK

8 What colour do you think Coca Cola would be if caramel was not added? **Explain** your answer.

9 Why would you not expect to find a solution with a solid solvent?

10 You had a marker pen with waterproof ink in your shirt pocket but it has leaked everywhere! Suggest how you might remove the ink stain.

11 What substance should you add to salt water to make it (a) more concentrated or (b) less concentrated?

INVESTIGATE

12 Some substances dissolve better in hot water than in cold water. Design an experiment to compare the amount of sugar that can be dissolved in tap water that is cold and tap water that is hot.

13 It is claimed by manufacturers that some washing powders work just as well in cold water as in hot water. **Investigate** washing powders to find out whether they dissolve as well in cold water as they do in hot water.

14 Conduct a survey of food and drink products. Use the list of ingredients to determine what is in them. What are the most common chemicals added to food and drink products?

15 Design your own experiment to test whether a fizzy drink goes flat faster when it is cold or when it is warm. Remember to use a 'fair test'. You must keep everything the same except the one thing that you want to test.

16 Place an unopened can of soft drink and an unopened can of diet soft drink of the same type in a sink of water.
(a) Which can floats?
(b) Which can sinks?
(c) What does this tell you about the sugar in soft drinks and diet soft drinks?

Mixing insoluble substances


Why have layers formed in this salad dressing?

Last week, you made a really nice salad dressing and it turned out just like the picture in the recipe book — a lovely, even, creamy, green-coloured liquid. Yum!

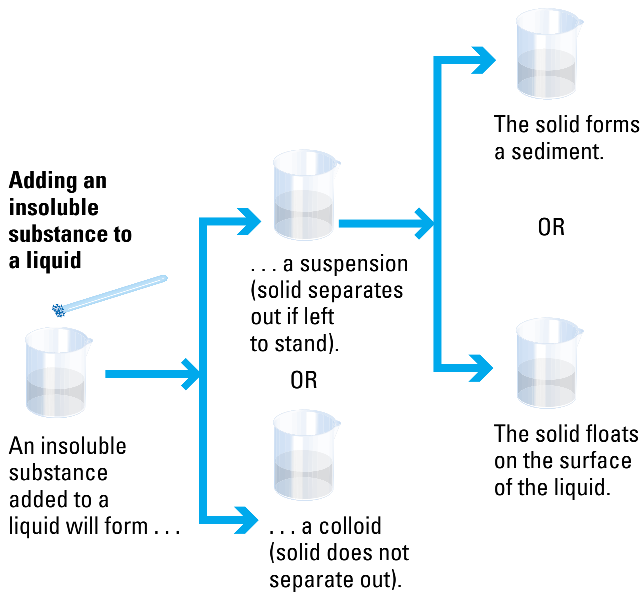
But now that you've gone to the fridge to get the salad dressing out to put on your lunch, it looks kind of odd. There seem to be two different layers of liquid in the bottle now — a dark browny-green layer on the bottom and a clear pale green layer on the top. What on Earth has happened to the dressing?

Sneaky suspensions

A solution is formed when a soluble substance (solute) dissolves in a solvent to form a **solution**. However, when insoluble substances are mixed, a different type of mixture is formed.

When an insoluble substance is added to a liquid and then stirred, particles of the undissolved substance are distributed throughout the liquid. What happens after that depends upon the size and density of the insoluble particles. If the solid separates from the liquid after a while, we say that the mixture is a **suspension**. If the solid particles have a very low density, they end up floating on the surface of the liquid. If the solid particles are large and dense, they sink to the bottom of the liquid to form a layer of **sediment**. For example, if you were to mix finely ground pepper and flour into water, you would find that the pepper, water and flour separate when left to stand; eventually, you would find that the pepper floats on the top of the clear water while the flour forms a thick white sediment on the bottom.

Olive oil is not soluble in vinegar. When brown vinegar and olive oil are mixed together vigorously, they form a creamy green salad dressing, which is a suspension. Over time, though, the two liquids will separate again, forming the layers you see in the photo above, with the less dense olive oil floating on top of the more dense vinegar.



Some insoluble substances neither settle at the bottom nor float on the top of the substance they've been mixed into; instead, their particles remain spread throughout the liquid. These mixtures are called **colloids**.

Special types of mixtures

A colloid forms when the particles of one substance spread throughout another but do not settle out to form a sediment. Instead, the particles remain spread out. The substances that make up a colloid can have just about any state of matter. For example, a marshmallow is a colloid of a gas spread through a soft solid, hairspray is a liquid that spreads through a gas, and pumpkin soup is formed from solid lumps of pumpkin spread through liquid water. Even morning mist is a colloid formed by fine water droplets suspended in air.

Colloids that are made from liquids that spread evenly throughout each other and do not settle out are referred to as **emulsions**.

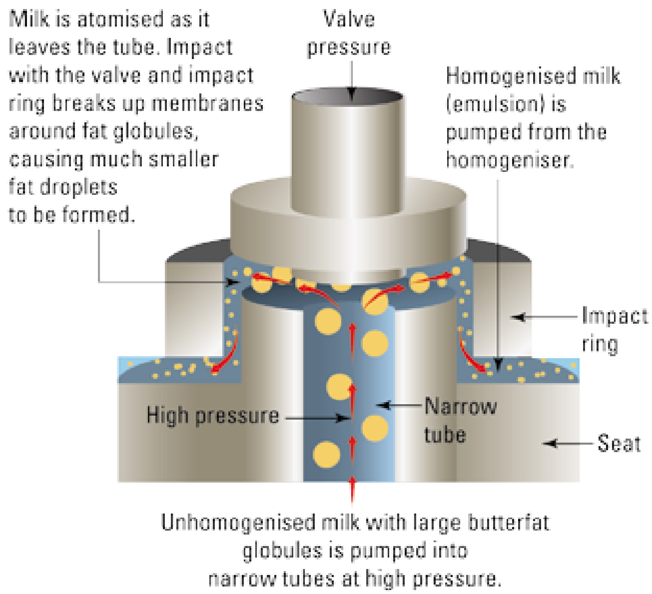
True emulsions are rare in nature. Many emulsions that we commonly see, such as homogenised milk and mayonnaise, are the result of industrial processes that bring together substances that, under normal circumstances, would separate out and look, feel or taste unappetising.

Homogenising milk

Milk straight from the cow is actually a suspension of large globs of creamy butterfat floating in the watery body of the milk. If left alone, the cream separates and floats to the top to form a cream layer. Dairy companies use a process called **homogenisation** to give the milk a smooth, creamy taste and a more even texture.

Unhomogenised milk has a layer of insoluble cream floating on the milk; homogenised milk is an emulsion.

During homogenisation, the milk is forced at high pressure through tiny tubes in an **atomiser**. This destroys the membranes that surround the large butterfat globules, allowing the globules to be broken up into much tinier butterfat droplets. These much smaller droplets spread evenly throughout the watery part of the milk and are unable to clump together and settle out in a layer. The homogenised milk is an emulsion.



The homogenisation process

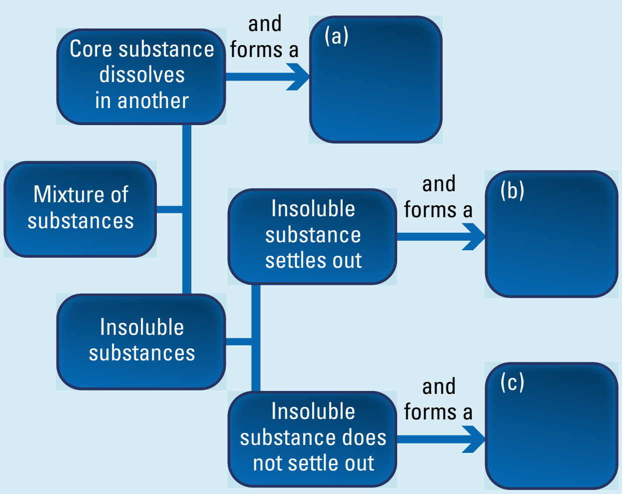
ACTIVITIES

REMEMBER

1 **Identify** a single word that can replace each of the following expressions.
   (a) Liquid in which a substance dissolves
   (b) Insoluble particles that settle to the bottom of a liquid
   (c) Substance that dissolves in a liquid
   (d) Mixture that is formed when a solute dissolves in a solvent
   (e) Mixture in which the insoluble particles stay mixed throughout another substance

2 **Explain** how a colloid differs from a suspension.

3 Copy and complete the following diagram by placing the correct term in the lettered boxes.



4 How is homogenised milk different from fresh milk?

THINK

5 Is smog a solution, suspension or colloid? **Explain** your answer.

6 Cream and butter are both made from milk. What types of mixture are cream and butter?

7 Many products contain chemicals called ‘emulsifiers’. What do you think these chemicals do?

INVESTIGATE

8 Find out how skim milk, low-fat milk, condensed milk and evaporated milk are made. Which of these also undergo homogenisation?

CLASSIFY

9 In groups of three or four, decide whether the following substances are suspensions, solutions, colloids or combinations of these. Write down a reason for each decision. Share your results with the class.
   (a) Muddy water
   (b) Cup of coffee
   (c) Mayonnaise
   (d) Whipped cream
   (e) Hot chocolate
   (f) Cup of tea with tea leaves in it

eBook*plus*

10 Use the **‘Time Out’ mixtures** interactivity in your eBookPLUS to identify liquid mixtures. **int-0224**

work sheet 5.1 Solutions and suspensions

Separate ways

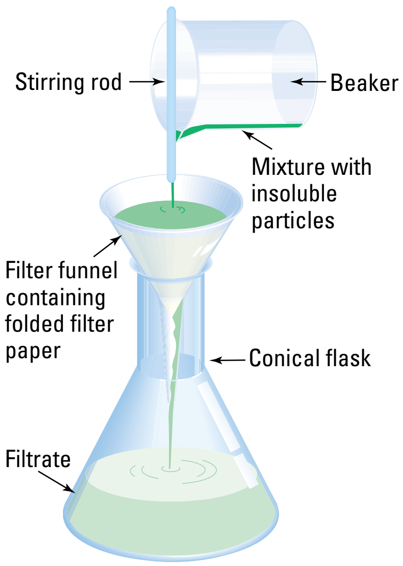
There are a number of ways to separate undissolved substances from a liquid; you use many of these every day.

The simplest method of separating a mixture of a liquid and a sediment is called **decanting**. In this process, the mixture is poured into a container and, once the sediment settles to the bottom, the liquid is carefully poured off the top. You use the decanting method whenever you pour the hot water off cooked vegies for dinner!

Filtering

What do a vacuum cleaner, tea strainer and protective face mask have in common? They are all devices for separating mixtures by filtration. In the laboratory, filtration is done using filter paper, but there are many other useful methods of filtration that are used in the home and in industry. During filtration, solutions or gases pass through the filter but particles that cannot fit through the filter are trapped by it. Insoluble particles can be separated from a solution using filter paper in a funnel as shown above right.

Indigenous Australians combine **sieving** (a type of filtration) and decanting to prepare native yams, which contain a poison. The yams are boiled and placed into a dilly bag. The bag is squashed and the softer parts of the yam are strained through the bag into a can of water. The bag acts as a sieve, allowing some substances to pass through but not others. The skins and harder parts of the yam that are left in the bag are thrown away. The water is decanted from the can, and repeated washing with water removes more poison. The yam is then placed into another dilly bag and hung up overnight before being ready to eat.



Equipment used to filter a mixture that contains insoluble particles

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eLesson

Centrifuging

Watch this video lesson to learn how to separate a solid from a liquid: in this case, lead oxide from water.

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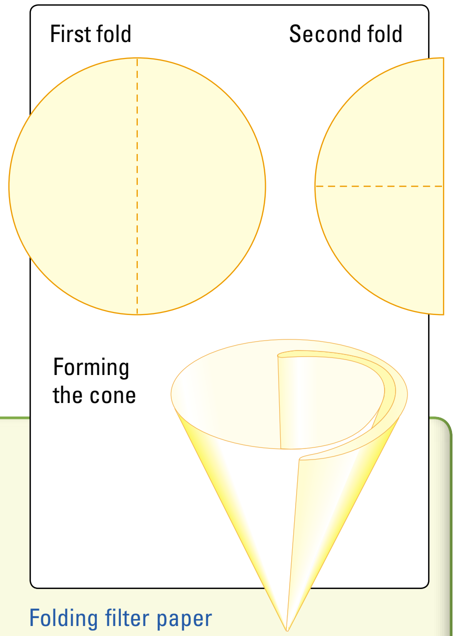


Folding filter paper

INVESTIGATION 5.3

Filtration in the laboratory

AIM To investigate filtration

You will need:

100 mL beaker | *funnel*
filter paper | *conical flask*
glass stirring rod
insoluble substance, such as soil, chalk dust, charcoal

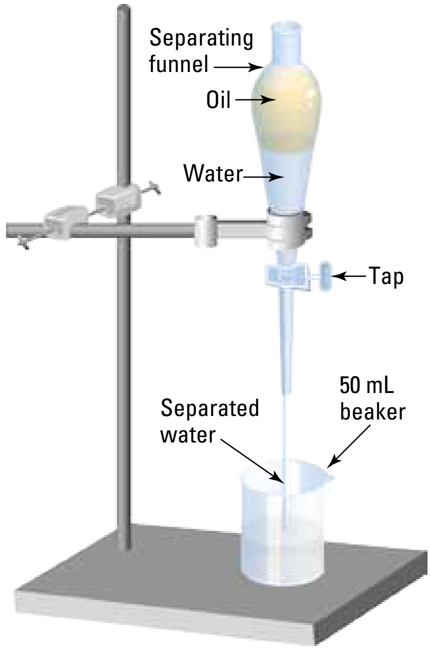
- Half-fill your 100 mL beaker with water.
- Add your insoluble substance to the water and stir with the stirring rod.
- Set up the equipment for filtering as shown in the diagram above.
- Fold the filter paper as shown in the diagram above right.
- Place the filter paper in the funnel and moisten with clean water to hold the filter paper in place.
- Pour your mixture into the filter paper.

DISCUSSION

1. **Describe the appearance of your mixture in the beaker before filtration. Did it form a suspension or sediment, or float on top?**
2. **The liquid passing through the filter into the conical flask is called the *filtrate*. Describe your filtrate.**
3. **Examine your filter paper. The material trapped by the filter paper is called the *residue*. Describe your residue.**
4. **Filter paper is like a sieve with small holes in it. Explain how the filter paper worked like a sieve in this experiment.**

Separating funnel

When one liquid does not mix with another but floats on top of it, a **separating funnel** can be used to separate the two liquids. Oil floats on water. This mixture can be separated using a separating funnel as shown at right. By turning the tap, the lower liquid layer can be drained.



Using a separating funnel to separate oil from water

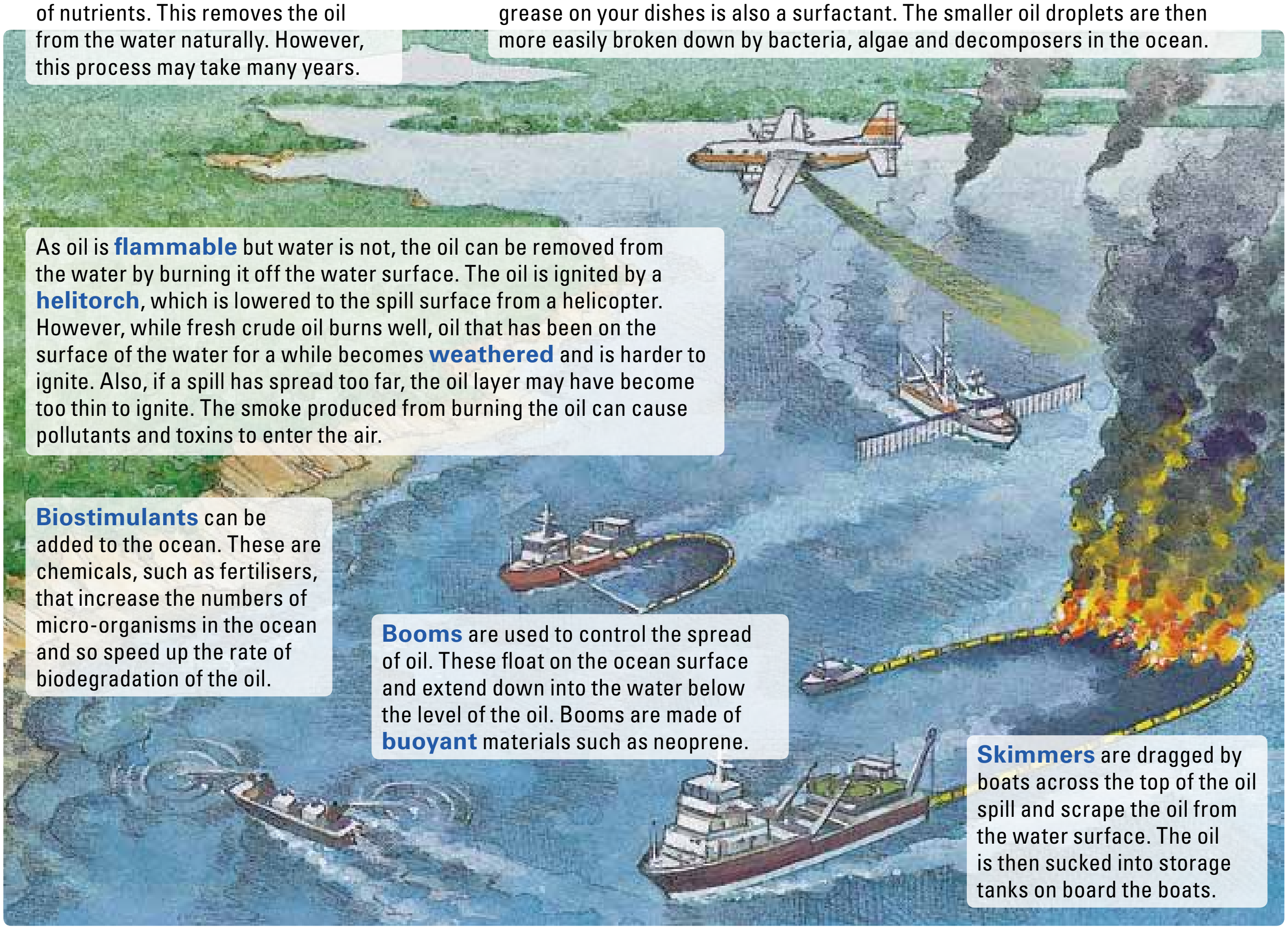
A dirty problem

On 20 April 2010, an explosion on the BP Deepwater Horizon drilling rig caused a massive oil spill into the waters of the Gulf of Mexico. By the time the leak was capped nearly three months later, thousands of square kilometres of ocean were covered with a layer of oil. Oil spills such as this have a tremendous impact on the marine and coastal environment as well as the local economy. In order to minimise the effects of an oil spill, the oil itself had to be separated from the water as quickly as possible.

Separating liquid suspensions can be done in the laboratory by using a separating funnel. But when you have an oil slick that is hundreds of square kilometres in size floating on the surface of the ocean, you obviously can't use a separating funnel to clean up the oil. Instead, oil slicks can be separated from water by considering some of the different properties of oil and sea water.

Biodegradation of the oil occurs when micro-organisms in the ocean break the oil down to use as a source of nutrients. This removes the oil from the water naturally. However, this process may take many years.

Oil spill dispersants can be sprayed onto the oil by helicopters, planes or boats. Dispersants contain substances called **surfactants** that can break up the oil into much smaller droplets. The detergent that you use to break up the grease on your dishes is also a surfactant. The smaller oil droplets are then more easily broken down by bacteria, algae and decomposers in the ocean.



As oil is **flammable** but water is not, the oil can be removed from the water by burning it off the water surface. The oil is ignited by a **helitorch**, which is lowered to the spill surface from a helicopter. However, while fresh crude oil burns well, oil that has been on the surface of the water for a while becomes **weathered** and is harder to ignite. Also, if a spill has spread too far, the oil layer may have become too thin to ignite. The smoke produced from burning the oil can cause pollutants and toxins to enter the air.

Biostimulants can be added to the ocean. These are chemicals, such as fertilisers, that increase the numbers of micro-organisms in the ocean and so speed up the rate of biodegradation of the oil.

Booms are used to control the spread of oil. These float on the ocean surface and extend down into the water below the level of the oil. Booms are made of **buoyant** materials such as neoprene.

Skimmers are dragged by boats across the top of the oil spill and scrape the oil from the water surface. The oil is then sucked into storage tanks on board the boats.

How to clean up an oil spill!

A teabag is a simple filter.

HOW ABOUT THAT!

The tea bag was invented quite by accident by a tea merchant called Thomas Sullivan in about 1903. To cut costs, he sent customers his tea samples in small silk bags rather than a much larger sample of loose leaf tea.

Rather than opening the bags to put the tea in their pots, many customers found that if they left the tea in the bag they didn't have to strain out the tea leaves. Nowadays, paper is used instead of silk and Tetley sells over 200 million teabags a week!

Centrifuging

A mixture can be separated by spinning it very quickly. This method is called **centrifuging**. The spin-dry cycle of a washing machine acts as a centrifuge and a filter. As it spins at high speed, the clothes are forced to the sides of the tub and the water passes out through the holes in the tub. The clothes cannot fit through the holes and so much of the water is removed from them.

In the laboratory, centrifuging is used to separate solid or liquid substances from liquids. The mixture is placed in special test tubes that are spun in a circle at high speeds. The heavier substances are forced to the bottom of the tube and the lighter substances are left near the top.

INVESTIGATION 5.4

Using a centrifuge (teacher demonstration)

AIM To investigate separation using a centrifuge

You will need:

centrifuge

mixture containing iron oxide, lead oxide (red lead) and water

CAUTION *Use red lead in a well-ventilated room. Avoid contact with skin and eyes. Do not dispose of down the sink.*

- Stir the mixture and then pour equal amounts into two separate centrifuge test tubes.
- Put the test tubes on opposite sides of the centrifuge.
- Allow the centrifuge to spin for about a minute.
- Observe the mixture after centrifuging.

DISCUSSION

1. **Describe the mixture after centrifuging.**
2. **Why must the test tubes be placed on opposite sides of the centrifuge?**
3. **Could the separated substances form a mixture again? Explain your answer.**
4. **What type of mixture was the iron oxide, lead oxide and water before centrifuging?**

ACTIVITIES

REMEMBER

1 When filtration separates a mixture of muddy water, identify which part is the
(a) filtrate
(b) residue.

2 Recall what happens to a suspension if it is left to stand for a long time.

3 Recall which method of separation uses spinning to separate the parts of a mixture.

4 Why is it important to clean up oil spills from the ocean?

5 What is biodegradation?

6 Explain how skimmers and booms can be used to control and collect oil from the ocean surface.

THINK

7 Describe the properties of water and dirt that make them ideal to separate using filtration.

8 Describe the properties of tea leaves and water that make them ideal to separate by centrifuging.

9 Early settlers would spin the billy three times in an anticlockwise direction before drinking their tea. Would it make any difference if the billy was spun in a clockwise direction? Explain your answer.

10 During filtration, explain why it is important that the mixture is poured carefully.

11 The air filter and oil filter in a car engine have to be replaced occasionally. Why do you think this is done?

12 Which of the methods of removing spilled oil from water allow the oil to be recovered for use?

13 If micro-organisms in the ocean break down the oil from oil spills, why do we use other oil removal methods such as burning and skimming?

IMAGINE

14 You are out in the bush and the only water available to drink is in a muddy waterhole. You have an empty bottle and a cup. How would you remove the dirt from the muddy water so that you could drink the water?

CREATE

15 Make your own billy tea. Instead of centrifuging the tea, use another method to separate the tea leaves from the tea. Write down your method for separating out the tea leaves. Was it an effective method? Explain your answer.

INVESTIGATE

16 The kidneys act as filters to remove wastes from our blood. Find out more about how the kidneys filter wastes from the blood.

17 What types of paper can be used to filter a suspension? Carry out an investigation that tests a variety of different papers (such as newsprint, tissue paper, brown paper and kitchen towel) for their suitability as filter paper. Write a report on your findings.

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18 Use the **Filtration** interactivity in your eBookPLUS to identify mixtures that can be separated by filtration. **int-0223**

work sheet 5.2 Filtration

Separating blood

About one million donations of blood are made in Australia each year (see page 144). Some of the donations are given to people who have lost blood during surgery, accidents or disasters. Blood is also given to people during the treatment of many diseases, including cancer. These people need to be given a regular supply of blood.

The blood mixture

Blood is a life-giving mixture. It can be separated into four parts: **plasma**, a clear, yellowish liquid; **red blood cells**, which carry oxygen; **white blood cells**, which fight disease; and **platelets**, which clot blood.

Because each part of the blood has a special job to do in our bodies, different problems can be treated with different parts of the blood. In Australia, blood is collected and separated by the Australian Red Cross Blood Service. **Separation** allows doctors to treat a larger number of patients and save many lives.

Not all donations are of whole blood. Depending on their blood type, people may be asked to donate just plasma or platelets.

Blood type	Percentage of population	Most useful donations	Main uses
AB	3%	Plasma	AB plasma can be given to any blood type.
A	38%	Whole blood, plasma or platelets	Common blood type so high demand for these products
B	10%	Plasma	Particularly useful for people with blood diseases, severe burns or trauma
O–	9%	Whole blood or platelets	All products can be given to any blood type.
O+	40%	Whole blood, plasma or platelets	Most common blood type; high demand for these products

Separating by centrifuging

The parts that make up the blood mixture have different properties; the red and white blood cells are heavier than the plasma and platelets. The difference in the mass of these parts means that they can be separated using the process of centrifuging. Centrifuging involves spinning the mixture very quickly. The heavier parts of the mixture are forced to the outer edge of the centrifuge. The lighter parts can then be decanted from the heavier parts.

HOW ABOUT THAT!

The amount of blood in your body depends on how much you weigh. The blood volume of an adult of average weight is about 5 litres, so the standard donation of 470 mL is less than 10 per cent of the donor's total blood volume. This amount is easily replenished by the body. To help avoid fainting during or after a donation, you must be over 18 and weigh more than 50 kg to be a blood donor.

ACTIVITIES

REMEMBER

1 **Explain** why blood is separated into different parts.
2 **Recall** why blood clots do not form in a blood donation.
3 **Identify** which technique is used to separate the different parts of blood.
4 **Describe** which separation technique is used to separate red and white blood cells.

THINK

5 **Explain** why blood is separated in a centrifuge rather than left to settle by itself.
6 **Deduce** what property of plasma and platelets allows them to be separated with a centrifuge.

CREATE

7 Create and **construct** an advertisement to encourage people to donate blood. The advertisement could be in the form of a poster, a song, a set of digital photos or part of a multimedia presentation.

RESEARCH

8 **Investigate** the following facts about blood donation:
(a) how old you need to be to donate blood
(b) the minimum weight blood donors must be
(c) why you cannot donate blood if you have recently had a tattoo done.

Red blood cells

White blood cells not used

Filtration

The mixture of red and white blood cells can be separated by a special kind of filtration. Red cells are used to treat people who have lost blood in an accident or surgery.

Red and white blood cells

Plasma

Platelets

Centrifuge

Further centrifuging separates the plasma solution from the platelets. Plasma is used to treat many diseases.

Plasma and platelets

Centrifuge

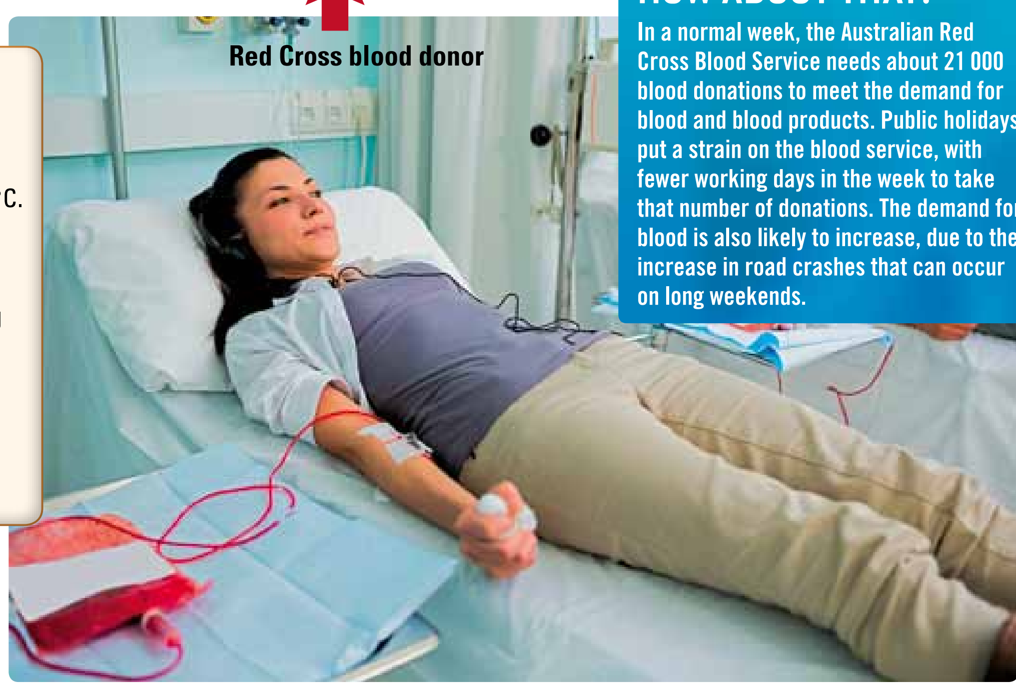
Blood cells are suspended in the plasma. Like other suspensions, blood donations can be separated into parts by spinning. Red and white blood cells are heavier than plasma and platelets, so they are forced to the outside edge of the containers in the centrifuge.

Plasma donation

Some donors give only the plasma from their blood. As the blood is taken out of the donor, it passes through a machine that separates the plasma from the rest of the blood. The blood cells are pumped back into the donor.

Standard whole blood donation

Red Cross blood donor



Once blood is separated, each part has to be stored differently.

- Red blood cells can be stored for 42 days at 2–6 °C.
- Plasma can be frozen for 12 months at –40 °C.
- Platelets are stored for 5 days at 20–24 °C. During this time they have to be moved at least every 12 hours to stop them clumping. (Platelets seal wounds in our bodies by sticking together.)

Blood donation in Australia

HOW ABOUT THAT!

In a normal week, the Australian Red Cross Blood Service needs about 21 000 blood donations to meet the demand for blood and blood products. Public holidays put a strain on the blood service, with fewer working days in the week to take that number of donations. The demand for blood is also likely to increase, due to the increase in road crashes that can occur on long weekends.

Separating solutions

Separating undissolved substances from a liquid is relatively easy compared with separating out substances that have been dissolved into a solution. In order to do this, you need to make use of the fact that the solute and the solvent have different chemical and physical properties.

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eLesson

Distillation

Watch this video lesson to learn how distillation can be used to turn salty water into pure water.

eles-0060

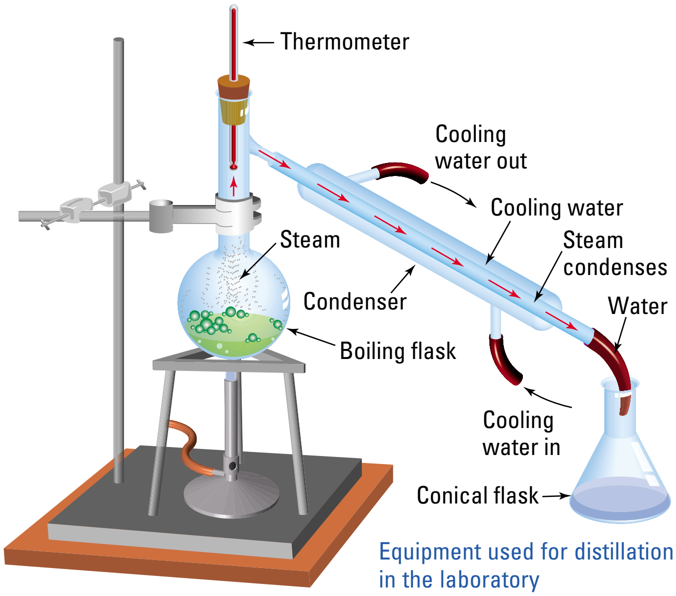
Distillation

Some laboratory experiments require the use of pure water rather than tap water, which contains many different impurities such as chlorine, fluoride, magnesium, calcium and sodium. However, pure water can be separated from tap water by a process called **distillation**. The process of distillation can be used when the substances to be separated have different boiling points.

Distilling water

As you can see in the diagram below, tap water is placed in the boiling flask and heated to the boiling temperature for water, 100 °C. The water boils, **evaporates** and becomes steam. The impurities from the tap water have a higher boiling point than the water and so they remain behind in the boiling flask. The steam travels along the **water condenser**. The steam inside the condenser is cooled to below 100 °C and **condenses** to form liquid water. The condenser is kept cool by running cold water through its outer jacket. The pure water collected in the conical flask is called the **distillate** and can be rightly labelled **distilled water**.

The distillation process is also used to isolate pure essences from plant and animal sources for the perfume industry, to get fresh water from sea water and, on a much larger scale, to separate petrochemical products such as petrol and paraffin from crude oil.



Equipment used for distillation in the laboratory

Evaporation

Evaporation works in a similar way to the distillation process, except that evaporation does not require the solution to reach boiling point. Instead, the water particles absorb a smaller amount of heat energy over a longer period of time; when they have absorbed enough energy, they form water vapour.

Solar distillation

In places where fresh water is scarce, the evaporation method is used in the form of **water stills** to turn salty or otherwise undrinkable water into a purer drinkable form. Water stills heat the impure water solution to the point where the pure water evaporates from the mixture, leaving behind salt and other impurities. The chief advantage of the evaporation method of purifying water is that it can be done with very simple equipment.

The salt that encrusts Lake Eyre was originally left behind 30 000 years ago when the sea water in it evaporated away.

Equipment for solar distillation

Desalination plants

The processes of distillation and evaporation are not suitable for purifying sea water on a scale large enough to supply drinking water to large communities. Several Australian states have built desalination plants in an effort to increase the supply of drinking water to their capital cities. These plants use a process called **reverse osmosis** to separate salt from large quantities of sea water. This involves passing sea water under very high pressure through thin membranes wound in coils. The membranes have very tiny holes in them that allow water through without the salt.

The use of desalination plants is controversial. Two major concerns are that:

- they use a lot of energy, which is supplied by coal-fired power plants. Apart from the pollution caused by these plants, many people feel that they are not **sustainable**; that is, they cannot continue to operate without putting the environment and our future at risk.
- the water flowing back to the sea contains much more salt than normal sea water. It is also warmer. This can affect marine animals and plants that live near the desalination plant.

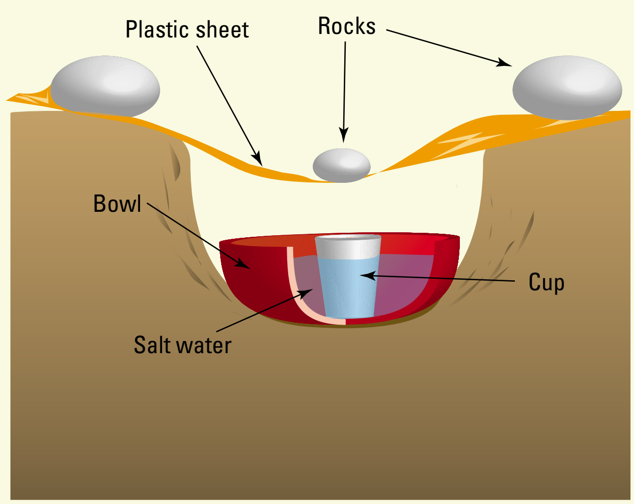
INVESTIGATION 5.5

Making a simple water still

AIM To investigate solar distillation

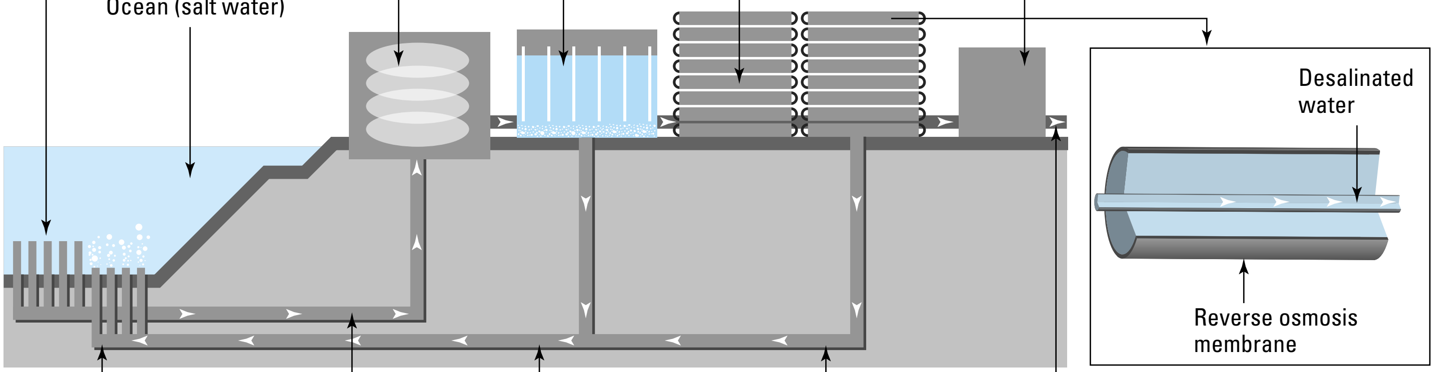
You will need:
trowel
cup
bowl
salt water solution
scissors
plastic bag
some small stones

- Dig a shallow hole in the ground outside. The hole should be a few centimetres deeper than the height of the cup and should be in a spot that gets a lot of sun.
- Put the bowl in the bottom of the hole and put the cup in the middle of the bowl.
- Pour the salt water into the bowl. Don't allow any to get into the cup.
- Cut the side seams of the plastic bag and open it up so that it forms a flat sheet of plastic. Place the plastic over the hole, using small rocks to anchor it in place. Make sure that the hole is completely covered.
- Place a small stone in the middle of the plastic sheet, just above the mouth of the cup.
- Leave undisturbed for a couple of hours then examine the contents of the bowl and the cup.



DISCUSSION

1. How has the water level in the bowl changed?
2. Is there any residue on the walls of the bowl? What do you expect this is made of?
3. How is the water in the cup different from the water in the bowl? You may need to taste it to tell the difference — check with your teacher first!



Typical desalination plant

Crystallisation

In *Investigation 5.5*, you may have found very small salt crystals on the wall of the bowl. This is the solute left behind when the solvent (water) evaporated from the salt water solution. **Crystallisation** occurs when the solvent is removed slowly enough from the solution that the remaining solute particles have the time and mobility to arrange themselves into regularly arranged structures, which we call crystals. The crystals formed by different solutes vary widely in shape. In fact many substances in nature can be identified just by considering the shape of the crystals that they form.

Crystallisation is used if it is more important to collect the solute than the solvent, as the solvent is usually lost to the atmosphere during this process and not collected. Many important pharmaceutical products are purified using this process.

INVESTIGATION 5.6

Fun with crystals

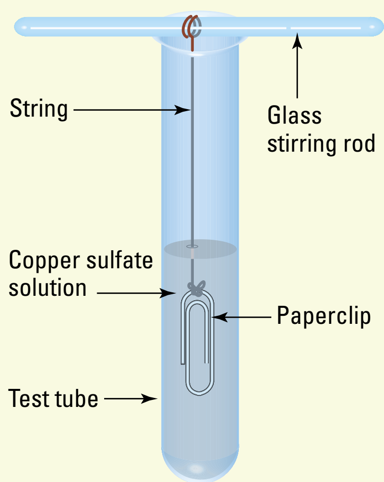
AIM **To investigate crystallisation**

This activity must be done in class with your teacher.

You will need:

2 test tubes
solid copper sulfate (or alum)
a balance
150 mL beaker
3 glass stirring rods
hot water
string
test-tube rack
forceps
microscope (optional)
piece of filter paper
filter funnel
conical flask or beaker
2 paperclips

- Weigh 28 g of the copper sulfate in the beaker.
- Prepare a hot concentrated solution of the copper sulfate by pouring 20 mL of hot water into the beaker. Stir the solution until no more solid will dissolve.
- Pour the blue copper sulfate solution through the filter paper into the conical flask or beaker. The undissolved copper sulfate will remain on the paper.
- Quickly pour equal volumes of the solution into two test tubes. Cool one test tube by putting it under cold running water.
- Tie the string to the glass rod. Attach the paperclip to the end of the string and arrange it as shown at right. Do the same for the other test tube.
- Leave both test tubes to cool overnight in the test-tube rack.
- Remove some crystals using forceps.
- You may wish to view the crystals under a microscope.
- Crystals with interesting shapes can also be made using alum (potassium aluminium sulfate).



DISCUSSION

1. **What can you see in the test tubes?**
2. **Is there any difference in the size of the crystals between the two test tubes?**
3. **How could you make bigger crystals?**

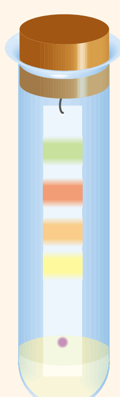
Chromatography

Paints, inks, dyes and food colourings are often mixtures of substances that have different colours. You can separate a mixture of different colours using **paper chromatography**.

In paper chromatography, a liquid soaks through the paper and carries the mixture with it. Some substances in the mixture are carried through the paper faster than others. In this way, the substances in the mixture are separated along the paper.

Chromatography works because different colours have different **solubilities**. Some colours dissolve more easily than others. Water is a very good solvent for many food colours. However, to separate the colours, they are not all placed straight into the water. For paper chromatography, the food colouring is placed on paper just above the solvent. The colours dissolve as the solvent soaks up the paper column. The colours separate because they are washed along the paper at different rates. The less soluble colours move more slowly and travel less distance up the paper. More soluble colours move more quickly up the paper.

How chromatography works



Separated colours
The colours that dissolve more easily are carried further up the filter paper by the solvent. The colours become separated along the paper strip.

Sample of food-colour mixture
A small amount of food colour is placed on the paper, above the level of the solvent.

Solvent
The filter paper is hung so that it just dips into the solvent. The solvent soaks up the strip of filter paper, taking the food colours with it.

INVESTIGATION 5.7

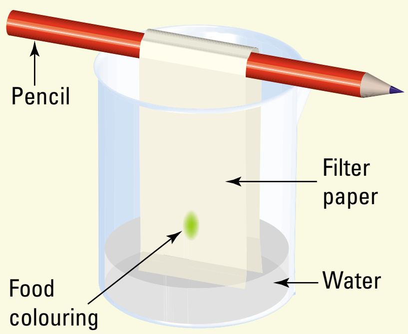
Separating colours

AIM **To investigate paper chromatography**

Each one of the food colourings that cover these chocolates is a mixture of different colours. How can the different colours be separated?

You will need:

food colouring
filter paper
250 mL beaker
ruler
toothpick
scissors
pencil



- Cut a piece of filter paper approximately 10 cm by 3 cm.
- Rule a pencil line 2 cm from the end of the paper.
- Use the flat end of a toothpick to place a small dot of food colouring in the centre of the pencil line on the filter paper.
- Pour tap water into the beaker to a depth of 1 cm.
- Stand the filter paper so that the end just dips into the water (see diagram below). Make sure that you keep the dot of food colouring out of the water.
- Fix the filter paper to a pencil to hold it in the beaker.
- Leave the filter paper to stand until the water has risen almost to the end near the pencil.
- Repeat the experiment with different food colourings.

DISCUSSION

1. **What colours were in the first food colouring tested?**
2. **How do you think the colours are actually separated using this method?**
3. **List the different food colourings that you tested. For each one, write down the colours that made up the food colouring.**

A chromatograph automatically separates mixtures by chromatography.

ACTIVITIES

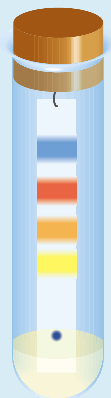
REMEMBER

1 **Recall** which methods of separation can be used to separate the parts of a solution.

2 **Explain** the purpose of the glass cover on a solar water still.

3 **Recall** why water is used as a solvent to separate food colours.

4 **Identify** the colours found in this ink, from:
(a) the fastest moving to the slowest moving
(b) the most soluble to the least soluble.



5 The building of desalination plants is controversial. List two reasons for this.

THINK

6 **Describe** the difference in properties that distillation relies on.

7 **Explain** why crystallisation would not be suitable for purifying water.

8 **Deduce** why cool running water is passed through distillation equipment.

9 **Explain** why the mixture is placed above the level of the solvent in chromatography. (*Hint:* What would happen if the mixture was put in the solvent?)

10 Zoe performs a chromatography experiment on waterproof markers using water as a solvent. Will her experiment work? **Explain** your answer.

USING DATA

11 The table below shows the composition of the substances dissolved in one litre of sea water.

Substance	Amount (g)
Chlorine	19
Sodium	11
Sulfate	3
Magnesium	1.5
Calcium	0.5
Potassium	0.5

(a) Use this information to draw a bar graph, with the substance names on the horizontal axis and the amount (in g) on the vertical axis.
(b) Approximately how many grams of solute are in each litre of sea water?
(c) It is common for ships to have their own distillation equipment allowing pure drinking water to be produced from sea water. If no water is lost during the process, how much pure water could be provided from one litre of sea water? (*Note:* One litre of sea water weighs 1020 grams.)

DESIGN AND CREATE

12 Use chromatography to create colourful designs that can be displayed as scientific art. Fold the filter paper and use different colours to make your designs unique.

13 Design and build a separating machine that separates a mixture of three substances. Create a brochure to advertise your separating machine, including
(a) the name of your separating machine
(b) a diagram of the machine
(c) information on what mixture your machine will separate
(d) instructions for using it
(e) an explanation of why it works
(f) the advantages that your machine has for its particular use.

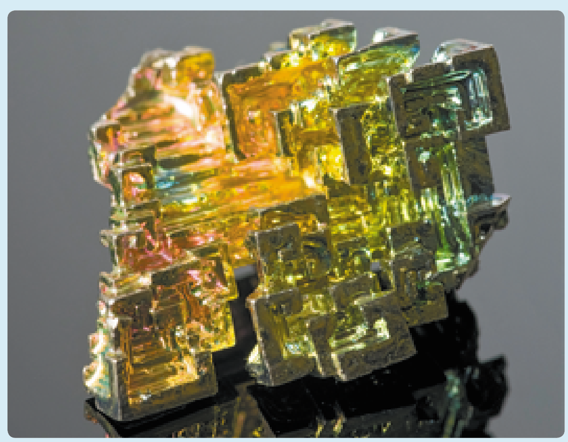
INVESTIGATE

14 **Investigate** how to distil perfume.

15 **Investigate** different types of solvents that could be used to separate pen ink and ink from waterproof markers. Before running the experiment, have your choice of solvents approved by your teacher. As a starting point, you may wish to use methylated spirits.

16 Does the colour of food affect whether people choose to buy and eat it? **Design** an experiment to test your answer.

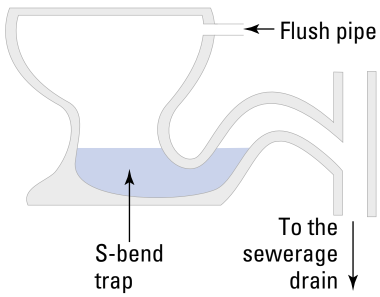
17 The crystal shown below is called a hopper crystal. Use the library and the internet to find out:
(a) what substance the crystal is made from
(b) why hopper crystals rarely form in nature
(c) how these crystals are formed.



eBook*plus* work sheets
5.3 Distillation
5.4 Evaporation and crystallisation
5.5 Chromatography

Down the S-bend

Every time you flush the toilet, have a shower, wash the dishes or your clothes or even clean your teeth, the waste water travels into an underground **sewerage** drain.



The S-bend trap in the toilet fills with clean water to prevent smelly gases from the sewer travelling back into the house.

The waste water is a mixture of human body waste flushed down the toilet, and detergent, dirt, toothpaste, food scraps and other materials washed down the drains. The mixture, which is mostly water, is called **sewage**.

If you live in a major city, the sewage in the drain under your house flows into a larger drain under your street and travels through the sewerage system to a treatment plant. The waste water needs to be treated before it can be returned to the **environment**.

Sydney is presently serviced by 31 sewage treatment plants, which are located along the coast and inland. The three largest coastal plants at Bondi, Malabar and North Head process three-quarters of the city's sewage. Between them, they process nearly 1 billion litres of waste water every day! Of this, over 35 million litres of water is recycled. All of the collected biosolids are treated and then turned over for agricultural use, mostly as fertiliser, and the remaining treated waste water is piped 3 kilometres or so offshore where it is emptied deep in the ocean.

In country centres, treatment plants are usually located on the edge of the town. These plants may discharge treated water into nearby rivers. If there is no local treatment plant, the waste water will flow into a personal sewage treatment system — a **septic tank** buried in the backyard.

A septic tank contains **bacteria** that break down the sewage. A thick, smelly sludge is formed. The sludge sinks to the bottom of the tank and clear water flows out into the surrounding area. The sludge needs to be removed from time to time.

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eLesson

Treating sewage

Watch this video lesson to learn about water and sewage treatment and the use of recycled water in Australia.

eles-0059

Waste water treatment

Waste water contains **suspended** solids, such as bacteria, grit and dirt, as well as some large items like rags and sticks. It also contains many dissolved substances.

The Tank Stream was Sydney's first water supply. It still flows beneath the city's streets.

When the waste water arrives at the sewage treatment plant, it passes through a screen (a wire mesh **filter**) that removes the larger items. The sewage then flows into settling tanks where it is kept for about two hours. In the settling tanks, suspended solids settle to form a sediment, and **floatables** such as oil and plastic collect on top of the sewage and are removed.

The watery part of the sewage flows from the settling tank into secondary treatment. This waste water still contains dissolved substances and bacteria. Secondary treatment takes place by filtering the water though soil and grass or by storing it in a series of one-metre-deep lagoons for two to four months. In the secondary treatment, the bacteria in the waste water break down the dissolved substances to purify the water further. In the lagoons, sedimentation also takes place. The treated water looks clear but it is still not safe to drink.

Think first!

There are many materials that should not be tipped down kitchen, bathroom, laundry or school laboratory sinks. The treated water is eventually released into the sea, but there are many substances that the sewerage system is not designed to treat.

These substances include:

- chemicals such as oven cleaners and insect sprays that are poisonous
- substances like fat and oil that don't dissolve in water.

These substances can eventually find their way to the sea, polluting it and killing or harming animals, plants and other living things (like algae) that live there. Substances like these should be saved for collection by local councils.

Small objects like cotton buds and tampons should not be flushed down the toilet because they can block the filters at treatment plants. These objects can be put out with other household garbage.

Play it safe

The best policy at home is to avoid putting down the sink anything solid or oily, or that you suspect may be poisonous or harmful to living things. Some things that can go down the sink at home in small amounts are:

- drain cleaners
- window cleaners
- kitchen and bathroom cleaners
- disinfectants (unless you have a septic tank).

At school, you should not tip anything down the sink except water, unless your teacher instructs you to.

ACTIVITIES

REMEMBER

1 **Recall** what substances are found in waste water.

2 **Explain** how a septic system works.

3 **Identify** substances that should not be tipped down the kitchen sink.

THINK

4 **Propose** why disinfectants that kill bacteria cannot be poured down a septic system.

5 A certain type of shower provides water at a rate of 11 litres per minute.
  (a) If you have a five-minute shower, **calculate** how much water you would use.
  (b) **Calculate** how much water you would use showering in a year.
  (c) **Calculate** how much water your family would use showering in a year.

6 (a) Make a list of the many ways that people use water in their homes.
  (b) **Propose** ways to reduce water usage.

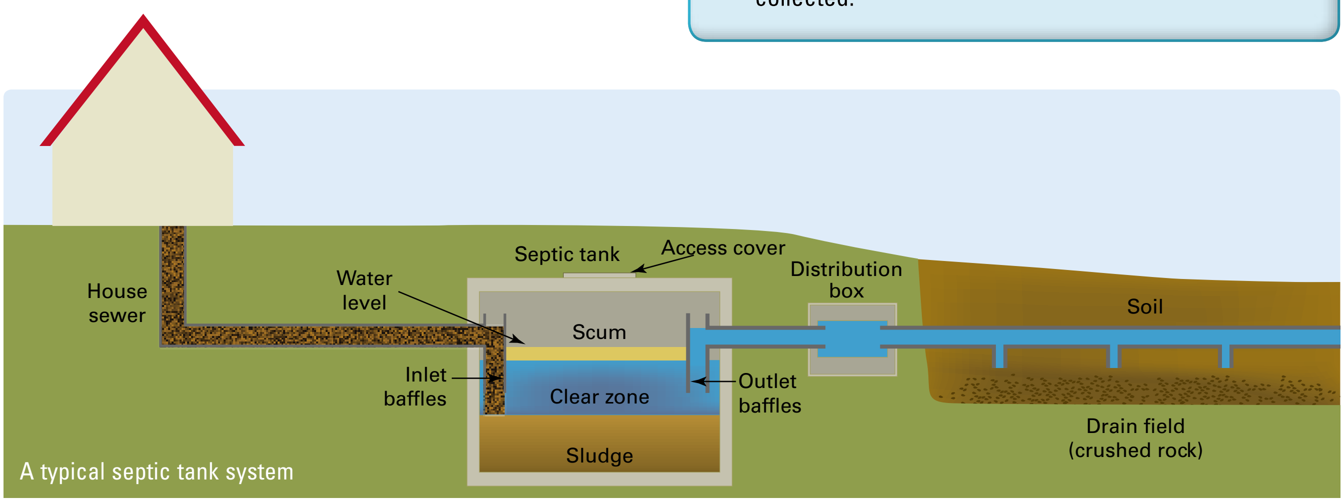
INVESTIGATE

7 **Investigate** where your sewage goes. If you live in the country, ask your local shire or locate your septic system.

8 Find out the kind of treatment (primary or secondary) that is used for Sydney's sewerage system. Where does the treated water go? **Assess** how suitable this system is for a large city like Sydney.

9 Find out more about the Tank Stream that runs below Sydney. What might be the difference between today's water supplies and those of Old Sydney?

10 **Investigate** who is responsible in your area for the collection of waste that cannot be tipped down the kitchen, bathroom or laundry sinks, and how often it is collected.



A typical septic tank system

Fit to drink?

Unwanted substances

Water used for drinking and washing needs to be clean and free of harmful substances. Water supplies can be **contaminated** by dissolved substances or substances suspended in the water. Besides clay, there are a number of other contaminants.

- Human and other animal body wastes contain disease-causing micro-organisms.
- Algal blooms can release poisonous substances into the water. They can also affect the taste and cause odour problems.
- Pesticides and detergents can be washed into rivers and contaminate water supplies.
- Poisonous chemicals may also be washed into rivers.
- Salt dissolved in water can make it unfit for drinking.
- Iron dissolved in water can contaminate it. This is common in bore water.
- High levels of calcium and magnesium salts can cause water to be 'hard', making it difficult to lather. This causes problems in laundries, bathrooms and kitchens.

Sydney's water

The tap water that we drink in Sydney is slightly alkaline (the opposite of an acid) because of the chemicals that have been added to it during the filtration process or that have leached into it from the pipe systems being used. A litre of tap water can contain as much as 150 milligrams of undissolved solids and, on average, 20 mg of calcium, 5 mg of magnesium, 1 mg of fluoride, 10–20 mg of sodium and a lot of other inorganic chemicals, all of which contribute to making Sydney's water much harder than tank water.

However, many of these chemicals are there for a good reason! The calcium in the water supply is mainly in the form of a compound called **lime**. Lime is added to balance the **acidity** of the water caused by adding chlorine and fluoride.

A litre of water also contains about 0.8 mg of **chlorine** and between 0.05 and 1.45 mg of **monochloramine**. These are disinfectants that are used to kill any dangerous bacteria or micro-organisms that may enter the water supply. The amount of disinfectant added to the water varies widely depending on a number of factors. For example, in summer, the warmer water tends to allow bacteria and microbes to increase faster, so more disinfectant is added to kill them. **Fluoride** is also added to help prevent **tooth decay**.

Would you drink this water?

Would you like your water to come out of the tap looking like this? Would you bathe or shower in it? Imagine your clothes after washing them!

Untreated water straight from a water supply such as a dam can be cloudy and contain many dissolved and undissolved particles. It must be treated before it reaches your house.

The cloudiness of the muddy water is caused by tiny clay particles. Muddy water is an example of a colloid. A colloid is a cloudy mixture that contains suspended particles too small to be removed by filtering.

Country water supplies

If you live in a country town, your water probably comes from a nearby river or lake. It is quite likely you would not want to drink that water unless it had been purified. Many country towns have their own water treatment plants. Water is pumped from the river or lake into the treatment plant. The cloudy water contains mud and other substances in suspension, which can be settled out of the water by a process called **flocculation**.

The suspended particles would take a long time to settle if the water were just left standing, and so the chemical **alum** (potassium aluminium sulfate) is added to the cloudy water to make the small particles clump together. These clumps are called **floc**. The floc is heavy enough to settle to the bottom of the tank and form a sediment. The water above the sediment is clear and flows off to the filtering stage.

After flocculation, the clear water is filtered through sand and gravel to remove any leftover suspended substances in the water. Chlorine is added to kill harmful bacteria. The purified water is then pumped to the local water tower, which then supplies the town with drinking water.

Blackwater and greywater

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

Greywater from the laundry can be used on the garden. However, it contains chemicals left over from detergents and other laundry products that could cause damage to plants. Damage can be minimised by selecting detergents that are low in phosphorus and **biodegradable**. Untreated greywater from the kitchen

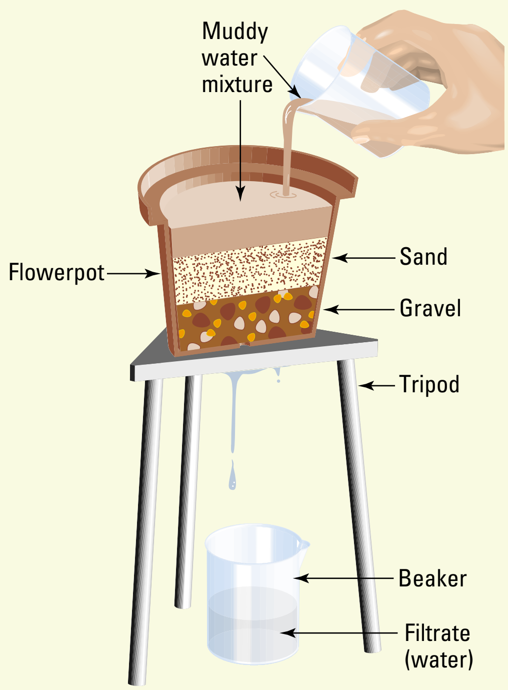
INVESTIGATION 5.8

Treating your own dirty water

AIM To produce clean water

You will need:

muddy water (muddy water made with clay is best)
alum (aluminium sulfate)
limewater
bleach
flowerpot
tripod
sand
gravel
two 250 mL beakers
stirring rod



A flowerpot water filter

- Pour 150 mL muddy water into the beaker.
- Add half a teaspoon of alum and 10 drops of limewater.
- Stir the water to mix the chemicals and allow the floc to form.
- Once you can see the floc forming, allow the water to stand and the floc to settle to the bottom.
- Add gravel and sand to the flowerpot to make the water filter as shown in the diagram at left.
- Decant the water from the beaker into your water filter. Collect the filtrate in a clean beaker.
- Add two drops of bleach (which contains chlorine) to your filtrate.

DISCUSSION

1. **Use a table like the one below to describe your water at each stage of the process. Include the appearance and odour of the water.**

Treating dirty water

Treatment stage	Description of water
Untreated water	
Water after flocculation	
Water after filtering	
Water after chlorination	

2. **Which separation techniques did you use to purify the water?**
3. **Prepare a series of picture diagrams to explain the steps you have taken to purify the water.**

should never be used on gardens because it contains oil, grease and other chemicals that could damage plants.

The safest way to use greywater is to install a greywater treatment system, which removes chemicals that will 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.

A reedbed can be used to treat greywater. Greywater is filtered in a tank filled with layers of sand and gravel; this removes some solids. The water then leaves the bottom of the tank and flows into a reedbed or miniature wetland. Reeds or other plants help to absorb nutrients such as nitrogen and phosphorus, and also take up some of the water.

A reedbed is one way of treating greywater.

ACTIVITIES

REMEMBER

1 **Identify** the chemicals that are added to Sydney's water and **explain** why they are added.

2 **Explain** why chlorine is added to water.

3 **Recall** five substances that can contaminate drinking water.

4 **Describe** the differences between blackwater and greywater.

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

6 **Explain** why alum is added to country water supplies.

THINK

7 If you live in a country town that does not fluoridate the water, **describe** how you could obtain your fluoride.

8 **Describe** a natural method of separating mixtures that takes place in reservoirs over a long period of time.

9 At Taronga Zoo in Sydney, the water in the seal pool is chlorinated to a maximum of 1 part per million, which is less than the amount in swimming pools. **Explain** why such a small amount of chlorine is added to the water.

10 At the Melbourne Zoo seal pool, the water passes through a sand and gravel filter and polyaluminium chloride is added to the water. This chemical acts as a flocculant.
(a) **Define** the term 'flocculation'.
(b) What do you think the flocculant polyaluminium chloride does to the water entering the filter?

INVESTIGATE

11 Waste water in Taronga Zoo is generated by:
- hosing down animal exhibits
- filling animal and ornamental moats
- flushing toilets
- irrigating lawns.

In 1998, it became the first zoo in the world to recycle its own waste water. **Investigate** the methods it uses to recycle the water.

12 The seal pool at Taronga Zoo and many swimming pools are vacuumed using a pool vacuum cleaner. **Investigate** how this type of vacuum cleaner works.

13 The seal pool at Taronga Zoo is also contaminated by the seals' own waste (the seals' sewage). **Investigate** how the amount of seal waste going into the main seal pool is minimised.

14 **Compare** the different brands of water filters available. Report on their cost, efficiency and ease of use. **Explain** why people consider the use of these filters to be necessary.

eBook*plus* work sheet 5.6 Water treatment assess on

FOCUS activity

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Blue-green algae has grown in a lake. It forms a fine, green suspension in the water. The local council wants to make the water clear again so that fish and other living organisms can safely inhabit the lake. **Propose** a method that you would use to solve the local council's problem. Remember that your method should not harm the fish already in the lake.

Access more details about focus activities for this chapter in your eBookPLUS.

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1 Copy and complete the table below to **summarise** what you know about separation techniques.

Method	How it works	An example of its use
Filtration		
Decanting		
Crystallisation		
Distillation		
Centrifuging		
Separating funnel		
Chromatography		

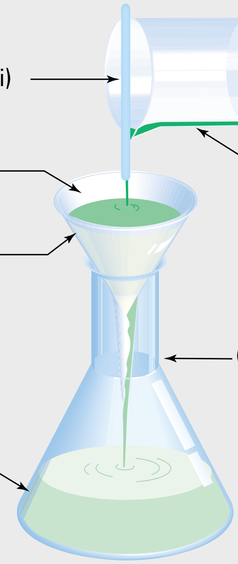
2 You have been asked to analyse some salt-contaminated soil and to **propose** a method for separating the salt from the soil.
(a) Write out the method that you would use to obtain pure dry salt and pure dry soil.
(b) Draw a labelled diagram showing how your equipment would be set up for each stage of your separation.

3 During an experiment, a teacher accidentally dropped some steel drawing pins into a bowl of sugar. **Propose** two methods that could be used to remove the drawing pins from the sugar. Briefly **explain** each method.

4 Black instant coffee is a mixture of coffee powder and hot water. **Identify** which substance is the:
(a) solute
(b) solvent
(c) solution.

5 Pasta is cooked by boiling it in water. It sinks to the bottom of the saucepan when it is left to stand.
(a) **Identify** what type of mixture the pasta and water is.
(b) **Describe** two different methods that could be used to separate the pasta.
(c) Which of the two techniques is best for separating the pasta and water? **Explain** your answer.

6 The following diagram shows a mixture being filtered in a school laboratory.
(a) **Identify** each of the items or substances labelled (i) to (vii).
(b) **Explain** the purpose of the stirring rod.



7 **Describe** what properties allow the following substances to be separated from a mixture.
(a) Peas from a mixture of peas and water
(b) Oil from a mixture of oil and water
(c) Gold particles from a mixture of sand and creek water
(d) Cream from cow's milk

8 **Recall** one good reason why each of the following objects or substances should not be tipped down the sink or flushed in a toilet.
(a) Fat and oil
(b) Cotton buds
(c) Oven cleaner

9 **Assess** whether each of the following statements is true. If the statement is false, replace the word in *italics* with the correct word.
(a) *Chromatography* can be used to separate substances with different solubilities.
(b) The *heavier* parts of a mixture are forced to the outer edge of a centrifuge when it spins.
(c) Suspensions contain *soluble* particles in a liquid.
(d) A suspension can be separated in a *centrifuge*.
(e) Milk is a *solution*.
(f) Emulsions are a type of *colloid*.

10 **Explain** why blood collected from the Red Cross Blood Service needs to be separated before it is used.

11 **Describe** the purpose of an S-bend in a kitchen sink pipe.

12 **Identify** which of the following separation techniques are used in a water treatment plant. You may select more than one answer.
A Filtration
B Chromatography
C Centrifuging
D Sedimentation
E Crystallisation

13 Oil floats on water. When detergent is added, the oil forms droplets in the water that do not settle. What type of mixture has been formed? **Justify** your answer.

TEST YOURSELF

1 **Identify** which of the following substances is a mixture.
A Gold
B Distilled water
C Air
D Carbon dioxide gas (1 mark)

2 **Identify** what would be the best method to use to separate iron filings from a mixture of sand, iron filings and salt.
A Filtering
B Magnetic separation
C Sieving
D Adding water to the mixture and then filtering (1 mark)

3 A sample of muddy river water can be described as
A an emulsion.
B a solution.
C a colloid.
D a suspension. (1 mark)

4 Centrifuging works best to separate substances with particles that have different
A solubilities.
B masses.
C colours.
D temperatures. (1 mark)

5 Read the story at right and use the information to answer the questions below.
(a) Write down what you think Marco would have said to his son. **Explain** the two methods clearly. (3 marks)
(b) **Propose** three questions that Flavius would have asked in return. (3 marks)
(c) *Extension.* **Construct** a flow chart that shows the steps involved in each salt harvest process using appropriate scientific terminology to **describe** changes of state and separation techniques.
Spend some time researching ancient methods of salt separation before creating your flow chart. If using the internet, use search words such as 'ancient salt production', 'Roman times salt' or 'salt evaporation'.

An ocean of salt

Salt has been used by civilisations for centuries to preserve meats, cure hides, make cheese and other foods and as flavouring in cooking. Salt was essential for life. Some communities even used salt instead of money as a form of payment. A community grew wealthy from its ability to produce salt.

Salt was mined from the ground, in the form of rock salt, or collected from sea water. The sea water, sometimes called brine, was evaporated and the salt collected. The brine was either heated over a wood fire or collected in shallow pools and left to heat in the sun.

'There's a whole ocean out there — full of salt — we just need to get it out of the water!', Marco remembered his grandfather saying. Marco lived during ancient Roman times. He lived in a town off the coast of the Mediterranean Sea. Marco himself now worked in the business his grandfather had started. He, too, marvelled at how he used the sun and winds to separate salt from sea water.

This day was special; it marked the day his son, Flavius, would first work at the salt business. As they reached the hill, they smelled smoke from the wood fires and looked out over the flat natural basin where salty water collected in shallow pools. Flavius saw that the smoke was from fires burning under large rectangular lead pans. Marco turned to his son and explained the two ways they separated salt from sea water.

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work sheet
5.7 Separating mixtures puzzle
5.8 Separating mixtures summary

STUDY CHECKLIST

MIXTURES

- ☐ **distinguish** between pure substances and mixtures and give examples of each **5.1**
- ☐ **recall** that a mixture can be separated according to specific properties of its components **5.1, 5.4, 5.6**
- ☐ **identify** some common mixtures **5.1, 5.2, 5.6**

SOLUTIONS

- ☐ **identify** the solute and solvent in common solutions **5.2**
- ☐ **describe** the difference between dilute, concentrated and saturated solutions **5.2**
- ☐ appreciate that water is a common solvent in solutions **5.2, 5.3, 5.6**
- ☐ **distinguish** between solutions and suspensions **5.3**
- ☐ **define** the terms 'colloid' and 'emulsion' **5.3**

SEPARATING SUSPENSIONS

- ☐ **describe** the processes of filtering, sieving, decanting and centrifuging **5.4**
- ☐ **compare** the effectiveness and limitations of these processes **5.4**
- ☐ **describe** common household uses of these separation techniques **5.4**
- ☐ **recall** how filtering and centrifuging are used in the isolation of blood products **5.5**

SEPARATING SOLUTIONS

- ☐ **describe** the processes of distillation, evaporation, crystallisation and chromatography **5.6**
- ☐ **explain** how distillation and evaporation may be used to purify water **5.6**

APPLICATIONS AND USES OF SCIENCE

- ☐ **describe** the processes used to separate materials in recycling plants **5.1**
- ☐ **describe** the processes by which sewage is treated **5.7**
- ☐ **evaluate** the appropriateness of current sewage treatment systems **5.7**
- ☐ appreciate that water often needs treating before it is drinkable **5.6, 5.8**
- ☐ **recall** common contaminants found in water **5.8**
- ☐ **identify** chemicals that are often added to water supplies and their purpose **5.8**
- ☐ **describe** how blood is separated into its components **5.5**
- ☐ **recall** how desalination plants separate fresh water from sea water **5.6**
- ☐ **explain** the process of homogenisation **5.3**

SUMMARY

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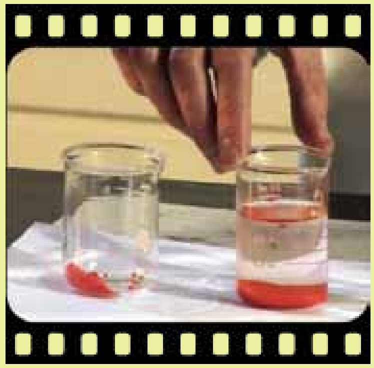
Digital documents

Individual pathways

Activity 5.1 Investigating mixtures doc-10545	**Activity 5.2** Analysing mixtures doc-10546	**Activity 5.3** Investigating mixtures further doc-10547

eLessons



Centrifuging
Learn how to separate a solid from a liquid using a centrifuge in a step-by-step process as a scientist demonstrates how to separate lead oxide from water.
Searchlight ID: eles-0061

Distillation
Watch a scientist guide you through the process of distillation, which can be used to turn salty water into pure water.
Searchlight ID: eles-0060

Treating sewage
Be swept down the plug hole and learn about the processes of sewage treatment, as well as the many uses of recycled water in Australia. A worksheet is attached to further your understanding.
Searchlight ID: eles-0059

Lavoisier and hydrogen
Watch a video from *The story of science* about the discovery of the elements.
Searchlight ID: eles-1772

Interactivities

'Time Out' mixtures
This exciting interactivity challenges you to identify whether a series of liquid mixtures are suspensions, solutions or emulsions. You must answer quickly before your time runs out.
Searchlight ID: int-0224

Filtration
This interactivity tests your skills in recognising which commonly used mixtures can be separated by the process of filtration.
Searchlight ID: int-0223

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The diamond flush

SEARCHLIGHT ID: PRO-0070

Scenario

Having only just been toilet trained, your little brother seems fixated on dropping stuff into the toilet and flushing it away. He has flushed away all sorts of things — Lego blocks, shopping lists, dog biscuits and even the occasional goldfish get put down the U-bend. It all seemed very funny until one day when he flushed away some really valuable things including a diamond ring, a pair of tiny diamond stud earrings, a wallet and a cultured pearl necklace. Your mum is absolutely frantic; but maybe, if you can track down where in the sewerage system they went, you have a chance of getting some things back for her!

Your task

Choose one of these valuable items and determine the most likely place that the missing object will be found. To do this, you will need to research the pathway taken by the sewage after it leaves your house and the different processes that the sewage (and the object) will be subjected to as it undergoes treatment. You will then put together a PowerPoint presentation that explains the pathway along which the object will have travelled once it left the house, the sewage treatment separation systems it would have passed through and where in the treatment system it is most likely to be found.

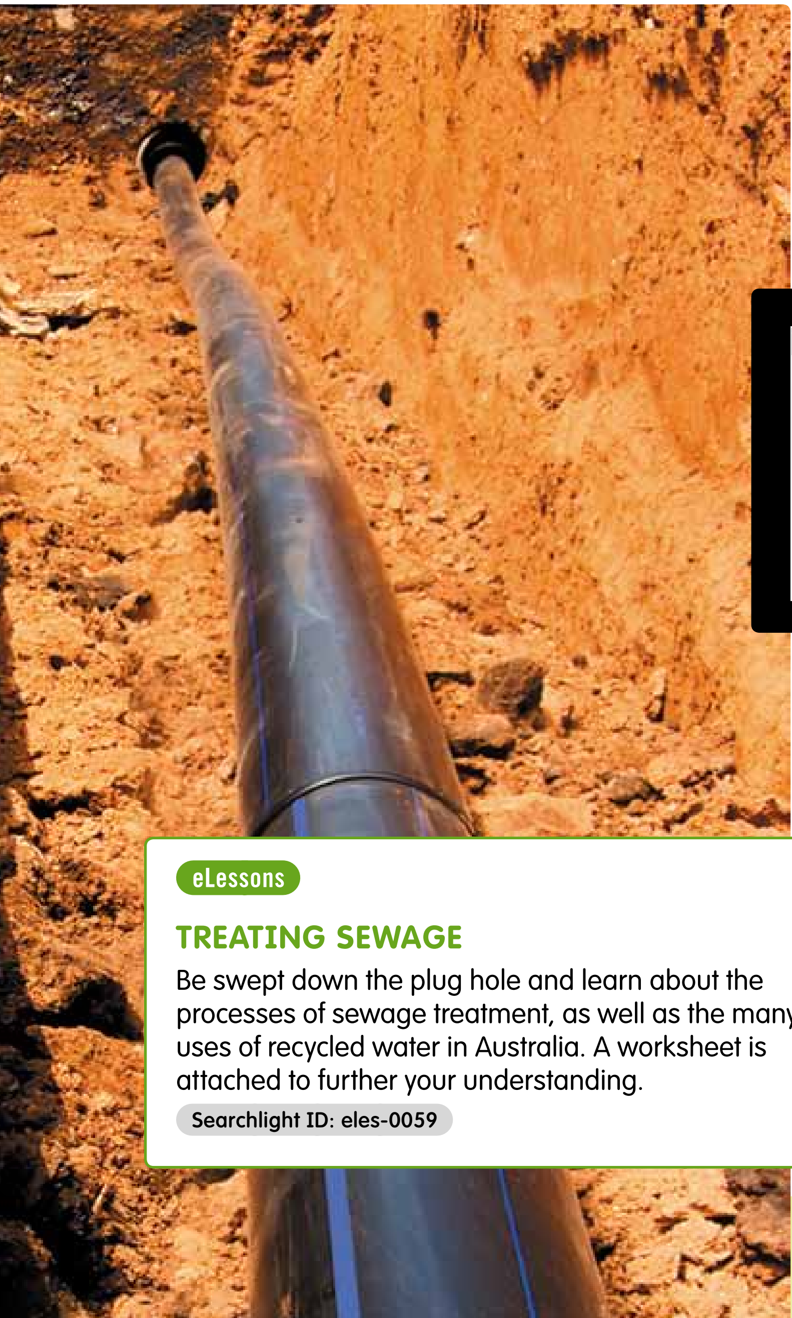
Process

- Open the ProjectsPLUS application for this chapter located in your eBookPLUS. Watch the introductory video lesson and then click the 'Start Project' button to set up your project group. You can complete this project individually or invite other members of your class to form a group. Save your settings and the project will be launched.
- Navigate to your Research Forum. Here you will find a number of pre-loaded topics that you may need to research in order to find the missing item. These include: Your sewerage system; How sewage is treated; Separation methods; and Characteristics of precious metals and stones. You may also add other research topics that you think may help you in your task.

- Enter the information that you find as articles under your topics in the Research Forum. You should find at least two sources (other than the textbook) to help you discover information about your local sewerage system and how your sewage is treated. You can view and comment on other group members' articles and rate the information that they have entered. When your research is complete, print out your Research Report to hand to your teacher.
- Visit your Media Centre and download the PowerPoint template. You may change the design of the slides to suit your presentation and you may add extra slides as required. Use your research notes to create an organised, well-structured presentation. Avoid making your slides overly full.
- Your Media Centre also includes images that you may like to incorporate into your PowerPoint slides.

SUGGESTED SOFTWARE
- ProjectsPLUS
- Microsoft PowerPoint
- Word Draw, Paint or other drawing software
- Word processing software

Your ProjectsPLUS application is available in this chapter's Student Resources tab inside your eBookPLUS. Visit www.jacplus.com.au to locate your digital resources.



MEDIA CENTRE

Your Media Centre contains:
- a PowerPoint template
- a variety of images that you can use in your presentation
- a selection of useful weblinks
- an assessment rubric.

eLessons

TREATING SEWAGE

Be swept down the plug hole and learn about the processes of sewage treatment, as well as the many uses of recycled water in Australia. A worksheet is attached to further your understanding.

Searchlight ID: eles-0059