

# 5

# Separating mixtures

The chocolate centres and different-coloured outer coatings of the sweets below are mixtures of other substances. Chocolate is a mixture including cocoa, butter, sugar and milk. The outer coating is a mixture of sugar, flavours and

colours. In fact, all of the ingredients of both the chocolate centre and outer coating, except sugar, are also mixtures. Sugar is an example of a **pure substance**. Any substance that is not a mixture is a pure substance.

## OVERARCHING IDEAS

- Patterns, order and organisation
- Form and function
- Systems

## SCIENCE UNDERSTANDING

Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques.

### Elaborations

Recognising the differences between pure substances and mixtures and identifying examples of each

#### Identifying the solvent and solute in solutions

Investigating and using a range of physical separation techniques such as filtration, decantation, evaporation, crystallisation, chromatography and distillation

Exploring and comparing separation methods used in the home

## THINK ABOUT MIXTURES

- What makes a fizzy drink fizz?
- Why does a car need a filter?
- How can you get fresh water from sea water?
- What do a vacuum cleaner and tea strainer have in common?
- What happens to your waste after you flush the toilet?
- Where is the cream in homogenised milk?

## 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 won't.

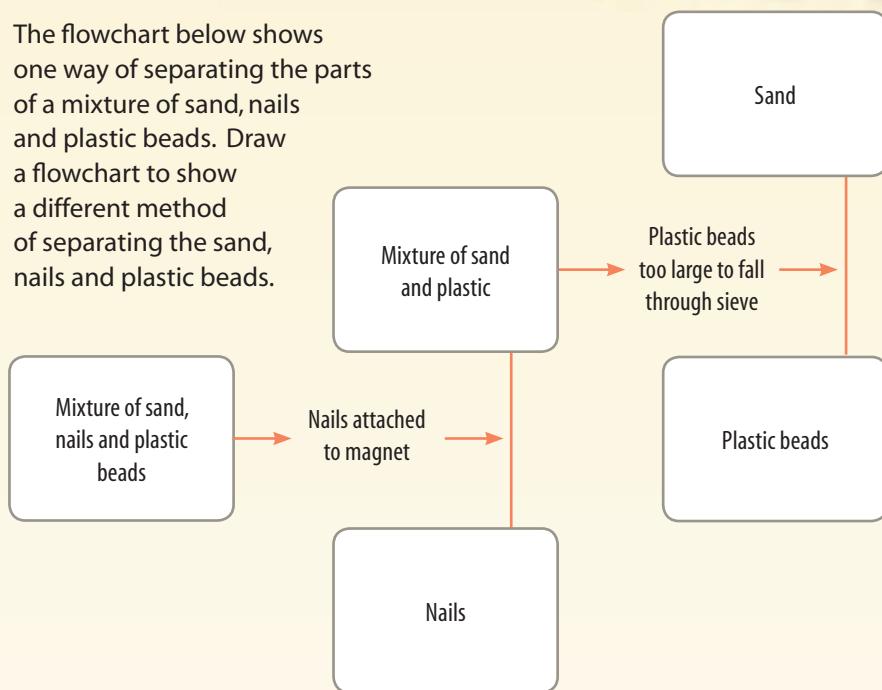
### THINK

- Suggest another method of separating the nails from the sand.
- What difference in properties does your suggested method use to separate the substances?



### THINK AND CREATE

- The flowchart below shows one way of separating the parts of a mixture of sand, nails and plastic beads. Draw a flowchart to show a different method of separating the sand, nails and plastic beads.



### INQUIRY: INVESTIGATION 5.1

#### Design and separate

##### KEY INQUIRY SKILLS:

- processing and analysing data and information
- planning and conducting

##### Equipment:

sand (about 250 mL)

A3 paper

'dead' matches

plastic container  
(about 500 mL)

small pebbles

water as required

steel paperclips

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

- 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 flowchart like the one above to show how each part was separated from the mixture.

# What's in a fizzy drink?

## Looking at solutions

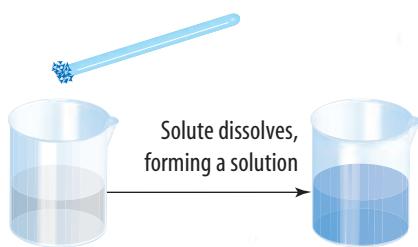
The 'fizz' in fizzy drinks is the carbon dioxide gas that is dissolved in the flavoured liquid. Carbon dioxide is pumped into bottles or cans at high **pressure**. The bottles and cans are then sealed to keep the carbon dioxide **dissolved** in the water. When you open the container, the pressure is reduced and the carbon dioxide bubbles out.

Like most substances, fizzy drinks are mixtures of other substances. If you look at the label on a bottle or can of soft drink, you will see that, as well as carbon dioxide, it also contains sugar, food colouring, flavouring and preservative. Preservatives stop the substances in soft drinks from going off. Flavourings are added to make the drink taste more pleasant and food colouring is added to make the drink look more attractive.

All of these substances are dissolved in water. A mixture of one substance dissolved in another is called a **solution**. The substance that dissolves is called the **solute**. The substance that the solute dissolves in is called the **solvent**. Solutions in which water is the solvent are called **aqueous solutions**. Water is a good solvent because many chemicals can dissolve in it. Fizzy soft drinks are aqueous solutions.

Substances that dissolve in a liquid are said to be **soluble**. Those that do not dissolve are said to be **insoluble**.

Adding  
a soluble  
substance  
to a liquid



When carbon dioxide is dissolved you can't see that it's there. When you open the container, the pressure is reduced. Adding a sugar-coated mint lolly makes all the carbon dioxide bubble out at once.



## INQUIRY: INVESTIGATION 5.2

### Soluble in water?

#### KEY INQUIRY SKILL:

- processing and analysing data and information

#### Equipment:

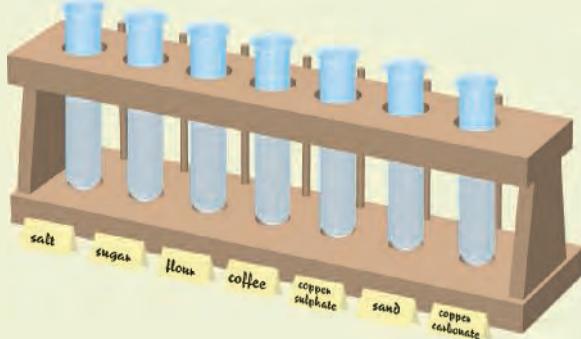
safety glasses and laboratory coat

heatproof mat

7 test tubes in a test-tube rack

spatula

samples of salt, sugar, flour, coffee, sand, copper sulfate and copper carbonate



- Half-fill each of the test tubes with cold water.
- Label the test tubes: salt, sugar, flour 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?	Soluble or insoluble?
Salt		
Sugar		
Flour		

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

#### DISCUSS AND EXPLAIN

- Which of the substances dissolved in water?
- How can you tell if a substance has dissolved?
- How can you tell that a substance has not dissolved?

## INQUIRY: INVESTIGATION 5.3

### Froth and bubble

#### KEY INQUIRY SKILLS:

- questioning and predicting
- processing and analysing data and information

#### Equipment:

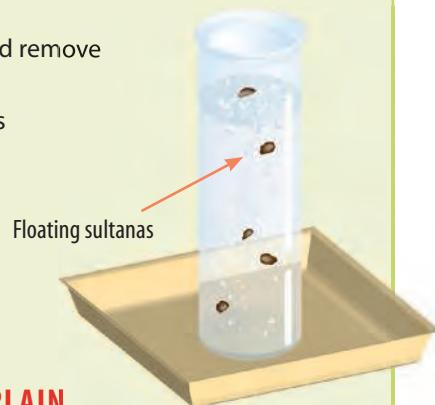
vinegar stirring rod

bicarbonate of soda gas jar

spatula sultanas

plastic tray

- Stand the gas jar on a plastic tray and pour the vinegar into the gas jar until it is 2 cm from the top.
- Add a spatula of bicarbonate of soda and several sultanas.
- Stir the vinegar and remove the stirring rod.
- Watch the sultanas as they rise and fall in the gas jar.



#### DISCUSS AND EXPLAIN

- Explain how the sultanas rise to the surface.
- When the sultanas get to the surface why do they drop back to the bottom?
- Try other things in the gas jar to see whether they can be carried to the surface.

### 'Do-it-yourself' fizz

You can make carbon dioxide gas using two chemicals found in your kitchen — vinegar and bicarbonate of soda.

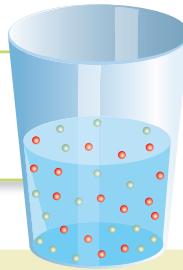
When these two chemicals are mixed in the experiment described above, a **chemical reaction** takes place. The vinegar and bicarbonate of soda change into new substances. One of these new substances is the gas carbon dioxide, a pure substance and the same gas that is in fizzy drinks. The rough surface of the sultanas allows the carbon dioxide bubbles to collect on the surface. The carbon dioxide bubbles rise, carrying the sultanas with them. When the bubbles reach the surface, they burst and the sultanas sink to the bottom.

# A matter of concentration

When more solute is dissolved in a solvent, the solution is said to be more **concentrated**. For example, by adding more and more sugar to a cup of hot water, you are making the solution more and more concentrated. Eventually the solution gets so concentrated that no more sugar will dissolve in it. When no more solute can be dissolved in a solvent, the solution is **saturated**.

You could make a solution of sugar and water less concentrated by adding more water. This process, where more solvent is added, is called **dilution**. When you add water to bottled cordial you are diluting it.

In a solution, the particles of one substance (the solute) are spread evenly throughout the other (the solvent). The particles of the solute are too small to be seen.



The cordial in these glasses is a coloured solution. Can you tell which has the greatest concentration of cordial syrup?

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 Is fizzy soft drink a solution, solvent or solute?
- 2 List the solutes likely to be found in a bottle or can of fizzy soft drink.
- 3 What leaves a fizzy drink to cause it to go flat?
- 4 What substance is added to cordial to make it more dilute?
- 5 Describe how an aqueous solution is different from other solutions.

### THINK

- 6 Copy and complete this table by filling in the 'Solvent' and 'Solutes' columns.

Solution	Solvent	Solutes
Soft drink		
Sea water		
Swimming pool water		
Jelly		
Cup of coffee		

- 7 A bottle of soft drink left lying in the sun may burst open. Explain why.
- 8 What is the difference between a concentrated solution and a saturated solution?

- 9 What substance should you add to salt water to make it:
  - (a) more concentrated
  - (b) less concentrated?

### INVESTIGATE

- 10 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.
- 11 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?
- 12 Design your own experiment to test whether a fizzy drink will go flat faster when it's cold or when it's warm. Remember to use a **fair test**. You must keep everything the same except the one thing that you want to test.
- 13 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?
- 14 Find out how much sugar can be dissolved in 200 mL of water at room temperature and what difference an increase in temperature of 10°C makes.

work  
sheets

- 5.1 Soluble or insoluble?
- 5.2 Mail room mayhem

# Kept in suspension

There are many ways of separating mixtures in a laboratory. Some methods are simple and quick and others need expensive equipment and take some time.

No matter how hard you try, you can't dissolve sand in water; sand is insoluble. If you shake up the sand and water in a sealed jar, the sand spreads through the water, forming a cloudy **suspension**. When you stop shaking the jar, the particles of sand are suspended in the water briefly, but they soon settle to the bottom, forming a **sediment**. Muddy water is also a suspension, but most of the particles in mud are smaller than sand particles so it takes much longer for them to settle to the bottom. Some insoluble substances don't form suspensions but float on top of the liquid.

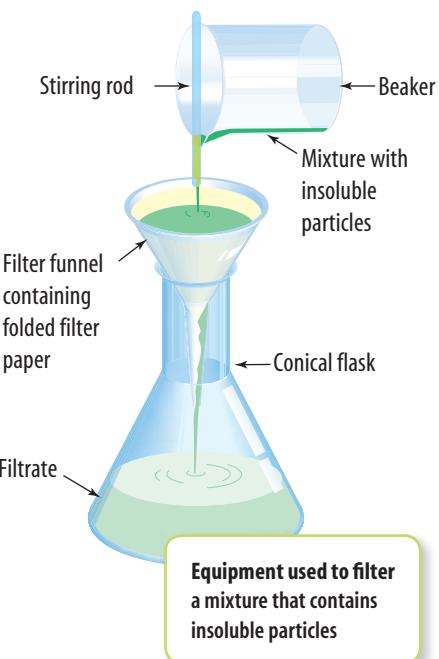
What do a vacuum cleaner, tea strainer and protective face mask have in common? They are all devices for separating particles from suspensions by **filtration**. In the laboratory, filtration is carried out using filter paper, but there are many other useful methods of filtration that are used in the home and in industry. In filtration, solutions, solvents 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 mixture using filter paper in a funnel as shown on the right.



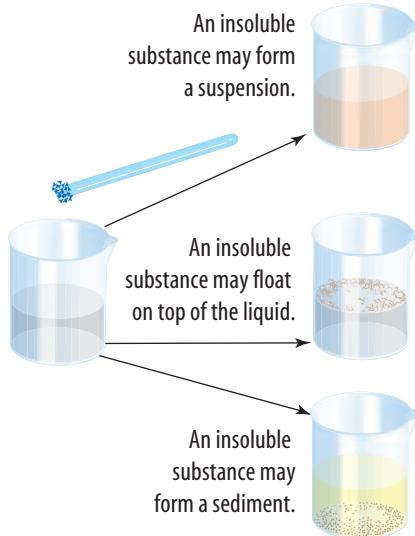
- (a) A face mask filters dust from the air.
- (b) A car air filter removes dust particles from the air.
- (c) A vacuum cleaner contains a filter bag which traps the dust as air is sucked through it.
- (d) A food strainer separates the chips from the oil.

## Sift and separate

The particles of solutes dissolved in a solution are so small that they can't be seen, and they can't be separated from a solution by filtration.



### Adding an insoluble substance to a liquid



### Sink or float: mixing solids with liquids



### WHAT DOES IT MEAN?

The word *residue* comes from the Latin word **residuum**, meaning 'left over'.

The word *aqueous* comes from the Latin word **aqua**, meaning 'water'.

## INQUIRY: INVESTIGATION 5.4

### Filtration in the laboratory

#### KEY INQUIRY SKILL:

- processing and analysing data and information

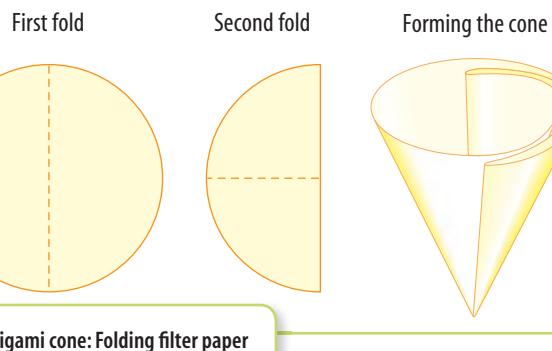
#### Equipment:

100 mL beaker      funnel      filter paper  
glass stirring rod      conical flask  
insoluble substance, such as soil, chalk dust or 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 top diagram on the previous page.
- Fold the filter paper as shown in the diagram below.
- 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.

#### DISCUSS AND EXPLAIN

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



### More mixtures

Some mixtures are neither solutions nor suspensions. A mixture that contains suspended particles too small to settle or be removed by filtering is called a **colloid**. Unlike solutions, which are clear, colloids are cloudy. Colloids can be formed by solids, liquids or gases. Examples of colloids include mist,

cappuccino froth, whipped cream and paint. An **emulsion** is a colloid in which one liquid is spread evenly through another and the liquids don't settle out into layers. Homogenised milk and mayonnaise are examples of emulsions.

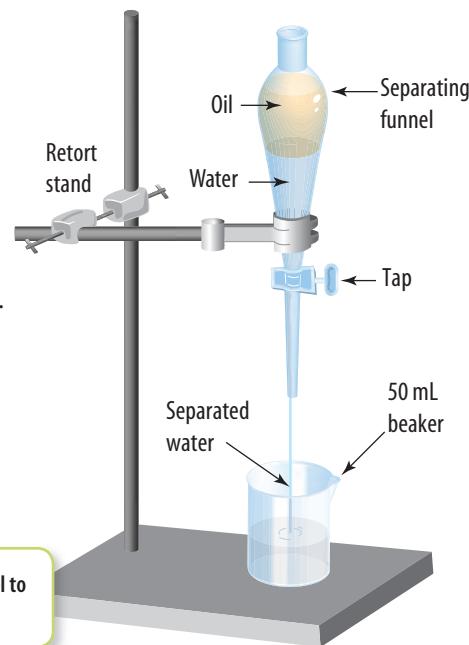
### Settling down

There are a number of ways of separating mixtures that are not solutions. The simplest method of separating a mixture of a liquid and an undissolved solid is **decanting**. The solid is allowed to settle to the bottom of the container, forming a sediment. The liquid is then carefully poured off the top. Decanting can be used to separate most of the mud from muddy water. After the mud has settled, the water can be poured off. If the water is still cloudy, it can be filtered to remove the remaining undissolved particles.

Aboriginal 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.

### The 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 on the right.



# 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.



## WHAT DOES IT MEAN?

The word **centrifuge** comes from the Latin words **centrum**, meaning 'centre', and **fugere**, meaning 'flee from'.



## eLesson



### 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.

eles-0011

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 Replace each of the following expressions with a single word.
  - (a) Liquid in which a substance dissolves
  - (b) Insoluble particles dispersed in a liquid
  - (c) Liquid passing through filter paper
  - (d) Substance that dissolves in a liquid
  - (e) What is formed when a solute dissolves in a solvent
  - (f) Material deposited on a filter
  - (g) An insoluble substance that sinks to the bottom
- 2 Describe what happens to a suspension if it is left to stand.
- 3 How can you distinguish a colloid from:
  - (a) a suspension
  - (b) a solution?
- 4 Which types of substances mix with each other to form emulsions?

### THINK

- 5 The drawing on the left of page 185 shows a variety of commonly used filters. Think of some other filters used in the home. Construct a four-column table like the one below to describe the filters.

Filter	Mixture	Residue	Filtrate
Vacuum cleaner	Air and dust	Dust	Air
Food strainer	Chips and hot oil	Chips	Oil

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

- 7 List some examples of separating mixtures in the kitchen using:
  - (a) filtration
  - (b) decanting.

### IMAGINE

- 8 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?

### INVESTIGATE

- 9 The kidneys act as filters to remove wastes from our blood. Find out more about how the kidneys filter wastes from the blood.
- 10 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, kitchen towel and so on) for their suitability as filter paper. Write a report on your findings.
- 11 An oil spill at sea can ruin the local environment and kill wildlife. Find out when and where the worst oil spill disasters have occurred and how the oil was separated from the water.



- 12 Classify a series of liquid mixtures as suspensions, solutions or emulsions by completing the **Time Out: 'Mixtures'** interactivity in your eBookPLUS.int-0224
- 13 Identify which commonly used mixtures can be separated by the process of filtration by completing the **Filtration** interactivity in your eBookPLUS.int-0223



→ 5.3 The pool shop

# Separating blood

About one million donations of blood are made in Australia each year. 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. The blood cells and platelets are separated from blood donations by spinning in a refrigerated centrifuge. Further centrifuging separates the platelets and different types of blood cells.

### HOW ABOUT THAT!

The average human body contains between 5 and 7 litres of blood. During exercise, each drop of blood passes through the heart about 8 times every minute. The blood travels through blood vessels. The total length of a person's blood vessels is about 800 000 km! Compare this with the **circumference** of the Earth, which is about 40 000 km. How amazing is that!



### 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



### 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.

### Standard whole blood donation



## INQUIRY: INVESTIGATION 5.5

### Using a centrifuge

(teacher demonstration)

#### Equipment:

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 then pour equal amounts into two separate centrifuge test tubes.

- Place the test tubes on opposite sides of the centrifuge.
- Allow the centrifuge to spin for about a minute.
- Observe the mixture after centrifuging.

### DISCUSS AND EXPLAIN

- 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?

## UNDERSTANDING AND INQUIRING



### Centrifuge

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

Plasma and platelets



### 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.



### Red Cross blood donor



### REMEMBER

- 1 List the four components that the blood from donors is separated into.
- 2 Explain why blood is separated into different parts.
- 3 Which technique is used to separate the different parts of blood?

### THINK

- 4 Explain why blood is separated in a centrifuge rather than left to settle by itself.
- 5 Identify the property of plasma and platelets that allows them to be separated with a centrifuge.

### CREATE

- 6 Create 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 AND REPORT

- 7 In an average week, the Australian Red Cross Blood Service needs about 21 000 blood donations to meet the need for blood and blood products. Research and report on the following questions.
  - (a) How old do you need to be to donate blood?
  - (b) What is the minimum body weight required of blood donors?
  - (c) Why are you not allowed to donate blood if you have recently had a tattoo?

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 together. (Platelets seal wounds in our bodies by sticking together.)

# Separating solutions

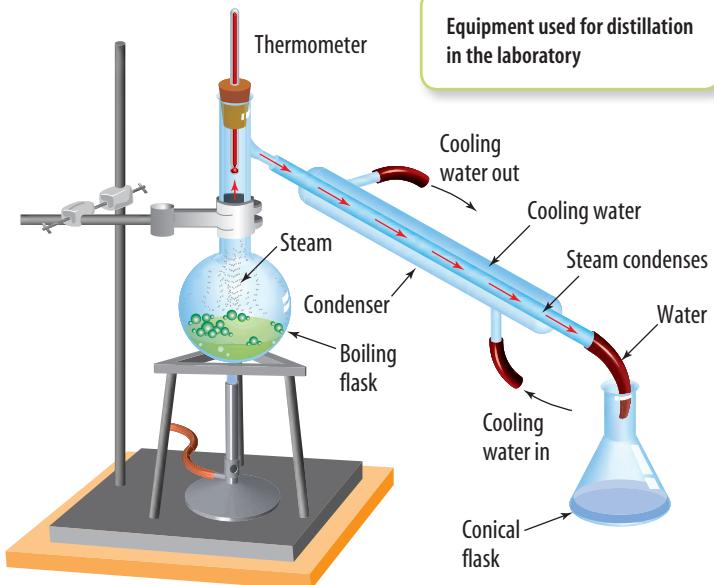
Imagine being stranded on a small, sandy island with no fresh water to drink. You are surrounded by the sea. But you can't drink the sea water; it will dehydrate you even further. You have to find a way of separating the water from the salt dissolved in it. What can you do?

## What's the solution?

Sea water is a solution. Separating the solute from the solvent from a solution is usually much more difficult than separating undissolved substances from a liquid. Filtration won't work — the dissolved particles are too small. Neither will decanting or centrifuging. You can't even see the dissolved particles. The answer lies in the fact that the solvent and solute have different properties. In the case of salt water, when heated to 100°C the water evaporates and boils away, leaving the salt behind as solid crystals.

## Distillation

In the laboratory pure water is produced by a process called **distillation**. Tap water is placed in the boiling



flask (see the diagram above) and heated to the boiling temperature for water, 100°C. The water boils, **evaporates** and becomes steam. 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 impurities in the water are left behind in the boiling flask.

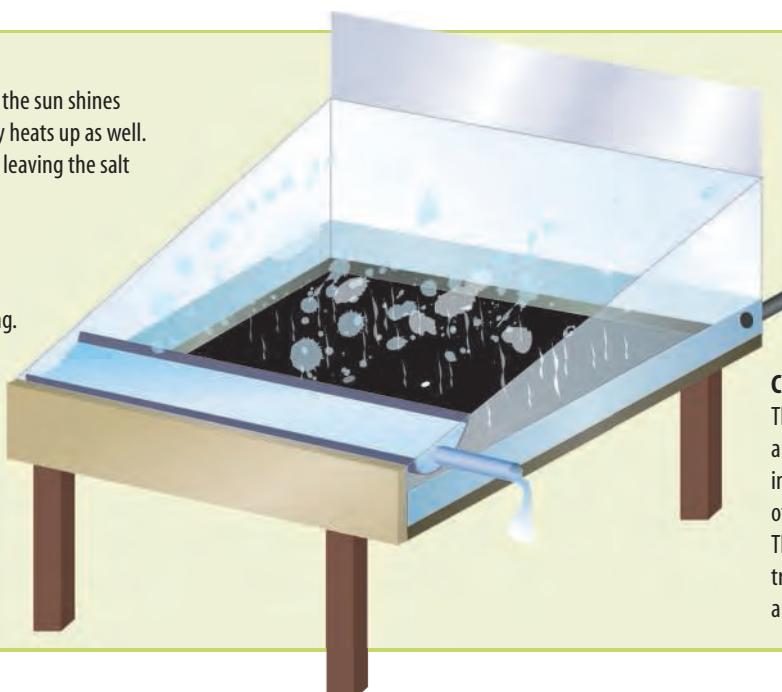
### Black tray

The black tray warms up when the sun shines on it. The salty water in the tray heats up as well. The water begins to evaporate, leaving the salt behind.

### Glass cover

The glass cover stops the evaporated water from escaping. When the **water vapour** reaches the glass, it begins to cool down. The vapour turns back into liquid water.

**Solar distillation.** The sun's energy can be used to distill sea water.



### Reflector

The reflector helps to direct sunlight onto the tray.

### Clean water trough

The liquid water trickles down along the glass cover and falls into a trough. This water is free of salt and other impurities. The salt remains in the black tray, where it can be collected and used for other purposes.

Distillation can be used to separate pure water from sea water. It can also be used to separate a mixture of two liquids as long as they boil at different temperatures.

## Evaporation

Pure water can be separated from salty water without boiling it. The salt and other impurities are left behind. The process takes longer, but the energy of the sun can be used to evaporate the water. The solar still shown on the previous page could be used to produce small amounts of pure water from salt water.

When evaporation is used to separate pure water from salty water the salt is left behind as crystals. If it is more important to collect the solute than the solvent, this process of separation is called **crystallisation**. Table salt is produced by the process of crystallisation, using energy from the sun to evaporate sea water or water from salt lakes.

## The desert island solution

In places where fresh water is scarce, a simple water still like the one below could be used to evaporate and collect pure water. If the water is

muddy or not clear it should be filtered first to separate the undissolved particles. On a desert island a handkerchief could be used as a filter.

## Large-scale separation

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. Two Australian states have built desalination plants in an effort to increase the supply of drinking water to their capital cities. Both of these plants, one in Western Australia and the other in Victoria, 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 which allow water through without the salt.

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

- they use a lot of energy, which is supplied by coal-fired power plants. Apart from the pollution caused by these plants there are many who feel that they are not **sustainable**. That is, they cannot continue to operate without putting the environment and our future at risk.

### INQUIRY: INVESTIGATION 5.6

#### Making a simple water still

##### KEY INQUIRY SKILL:

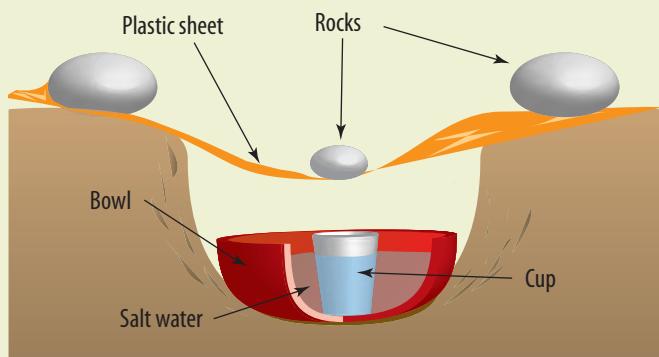
- processing and analysing data and information

##### Equipment:

trowel	cup
bowl	saltwater solution
scissors	plastic bag
some small rocks	

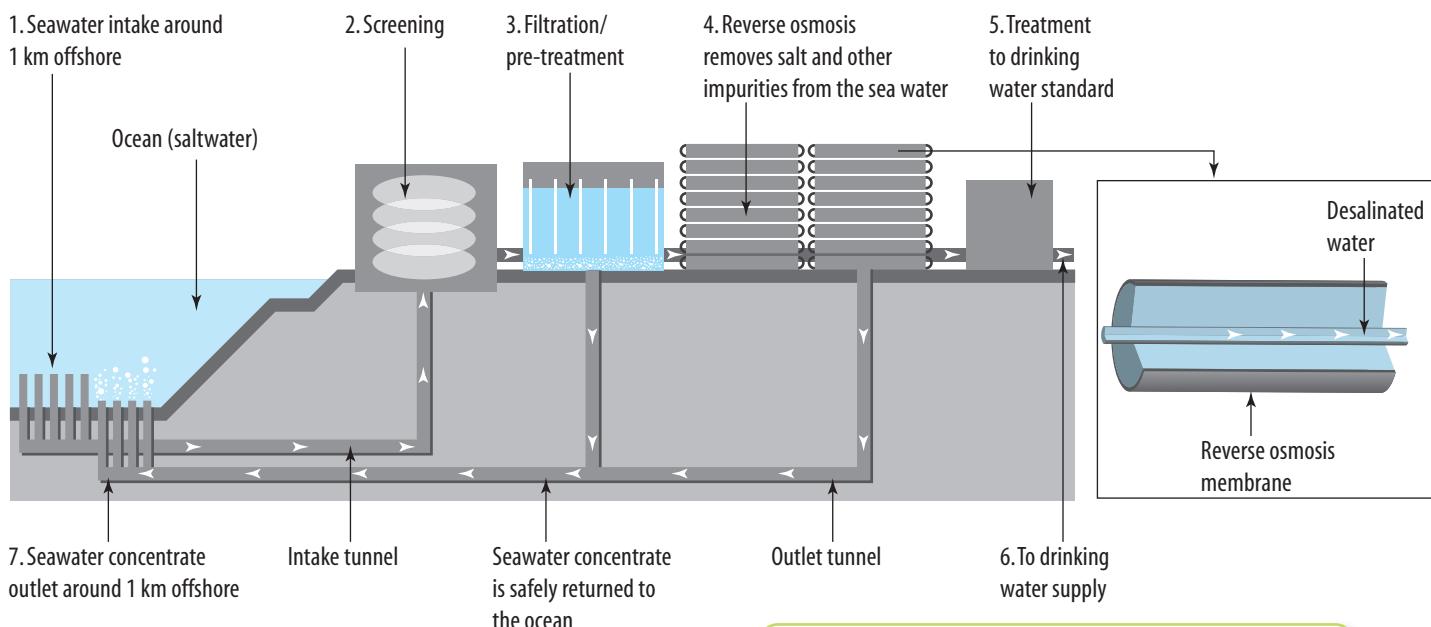
- Dig a shallow hole in the ground outside. The hole should be a few centimetres deeper than the height of the cup and should be in a spot that gets a lot of sun.
- Put the bowl in the bottom of the hole and put the cup in the middle of the bowl.
- Pour the salt water into the bowl. Don't allow any to 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 rock 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.



##### DISCUSS AND EXPLAIN

- 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!



- 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.

## 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 carrying 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.

### HOW PAPER CHROMATOGRAPHY WORKS

#### Sample of coloured solution

A small amount of the solution is placed on a strip of filter paper 2 cm from its end.

#### Solvent

The filter paper is hung so that the sample is just above the level of the solvent.

#### Separated colours

The colours dissolve as the solvent soaks up the paper strip. The more soluble colours move more quickly and travel further up the strip than the less soluble colours.



How the Victorian desalination plant at Wonthaggi separates water suitable for drinking from sea water

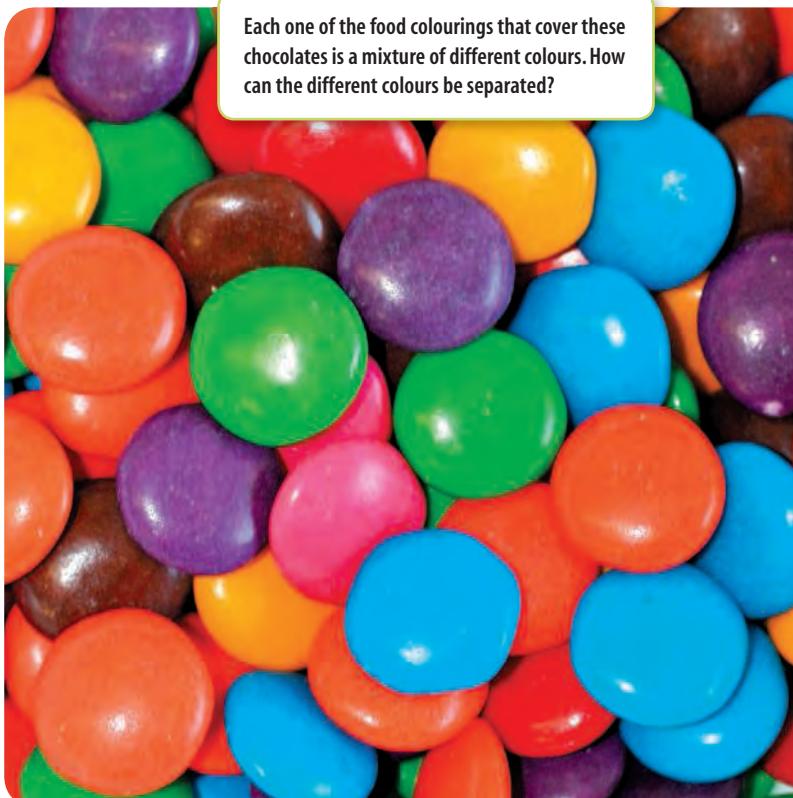
#### eBook plus eLesson



##### Distillation

Watch a scientist guide you through the process of distillation, which can be used to turn salty water into pure water.

eles-0060



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

## INQUIRY: INVESTIGATION 5.7

### Separating colours

#### KEY INQUIRY SKILL:

- processing and analysing data and information

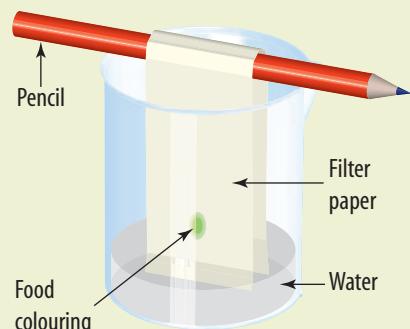
#### Equipment:

food colouring	toothpick
filter paper	scissors
250 mL beaker	pencil
ruler	

- 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. 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 top.
- Repeat the experiment with different food colourings.



#### DISCUSS AND EXPLAIN

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

## UNDERSTANDING AND INQUIRING

#### REMEMBER

- Distillation can be used to separate a mixture of two liquids. What difference in properties between the two liquids allows this to be done?
- What is the purpose of the glass cover on the solar still illustrated on page 190?
- Explain how evaporation and crystallisation are different from each other.
- Identify the colours found in this ink, from:
  - the fastest moving to the slowest moving
  - the most soluble to the least soluble.
- The building of desalination plants is controversial. List two reasons for this.



#### DESIGN AND CREATE

- Design and build a separating machine that will separate a mixture of three substances. Create a brochure to advertise your separating machine which includes:
  - the name of your separating machine
  - a diagram of the machine
  - information on what mixture your machine will separate
  - instructions for how to use it
  - an explanation of why it works
  - the advantages that your machine has for its particular use.

#### THINK

- Explain why cool, running water is passed through the distillation equipment shown top right of page 190.
- Explain why crystallisation is not suitable to purify water.
- Explain why the mixture is placed above the level of the solvent rather than in the solvent in a chromatography experiment.
- Zoe performs a paper chromatography experiment on waterproof markers using water as a solvent. Will her experiment work? Explain your answer.
- Describe all the properties you can think of for:
  - salt
  - sand
  - water.
- Explain how you would separate the parts of a mixture of salt, sand and water. Use the properties that you considered in question 11.

#### INVESTIGATE

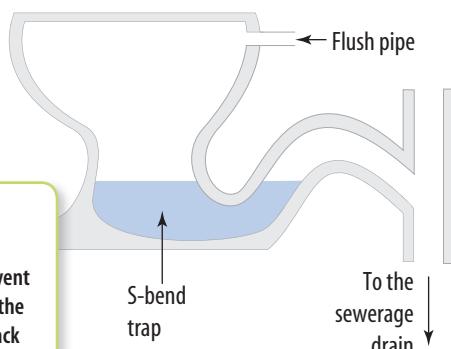
- An oil spill at sea can ruin the local environment and kill wildlife. Research and report on each of the following.
  - Find out how environmental and other authorities clean up oil spills at sea. List the properties of oil that allow each method to succeed.
  - When and where did the worst oil spill disaster occur and how was the oil separated from the sea water?
- Investigate how to distill perfume.
- Use the **Chromatography** weblink in your eBookPLUS to watch a simple time-lapse chromatography animation.



- 5.4 Heating and distillation  
5.5 Crystallisation and distillation

# Systems: 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** system.



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, 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**.

The design of treatment plants normally involves consultation between your state or territory government, engineers, scientists including biologists and environmental scientists, and local community groups. In country centres, treatment plants are usually located on the edge of the town.

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.

## 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.

When the waste water arrives at the sewage treatment plant for primary treatment, it passes through a screen (a wire mesh **filter**) which removes



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### Treating sewage

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

eles-0059

This advanced lagoon sewage treatment system is part of Melbourne Water's Western Treatment Plant in Werribee and covers 11 000 hectares in area. Some of this treated water is recycled and used for agriculture, horticulture and other applications.

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 through 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.

## Recycled water

In some countries around the world, fresh water is so scarce that treated sewage is used as drinking water. This recycled water goes through additional processes to ensure that it is safe to drink.

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



In Australia, treated sewage is discharged into the sea or rivers. Australia is the second driest continent on Earth. (The driest continent is Antarctica.) With a growing population and the threat of climate change and less rainfall in our biggest cities, Australians may one day have to think seriously about using recycled water as drinking water.

The city of Toowoomba, in southern Queensland, was forced to consider adding recycled water to its three dams in 2006 when their capacity fell below 20 per cent. There seemed to be little choice. Toowoomba's economy relied on the influx of tourists visiting the city to see its beautiful parks and gardens.

The Toowoomba City Council proposed that a quarter of the recycled water from its sewage treatment plant be discharged into its dams. After long and sometimes bitter debate, the voters of Toowoomba rejected the proposal. The vote was 38 per cent in favour and 62 per cent against.

## 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.

Such 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.



Fat and oil don't dissolve in water.

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.

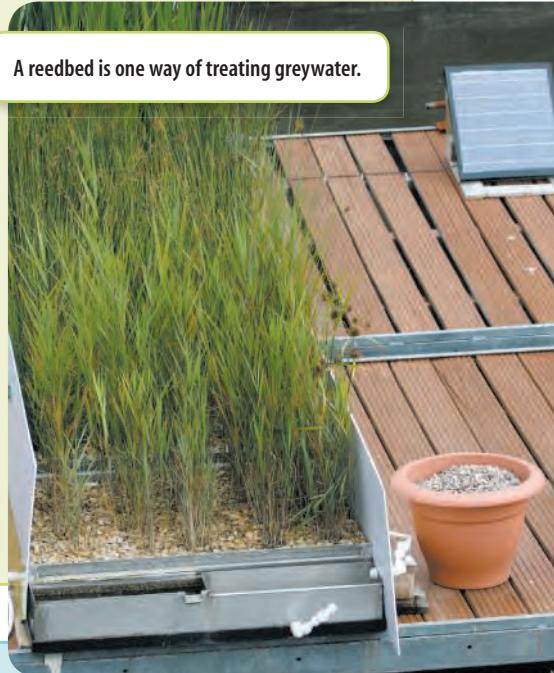
## BLACKWATER AND GREYWATER

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, which could cause damage to plants. Damage can be minimised by selecting detergents which are low in phosphorous and **biodegradable**. Untreated greywater from the kitchen 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 is one way of treating greywater.



## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 List five examples of substances other than human body waste that can be found in waste water.
- 2 How does a septic system work?
- 3 Suggest why disinfectants that kill bacteria cannot be poured down a septic system.
- 4 Describe the differences between blackwater and greywater.
- 5 Describe two ways in which greywater can be used on gardens without damaging plants.

### THINK

- 6 A certain type of shower provides water at a rate of 11 L per minute.
  - (a) If you have a five-minute shower, how much water do you use?
  - (b) How much water would you use showering in a year?
  - (c) How much water would your family use showering in a year?
- 7 Make a list of substances that should not be tipped down the kitchen sink.

- 8 Suggest what the role of each of engineers, biologists and environmental scientists would be in the development of a sewage treatment plant.
- 9 Would you be prepared to drink recycled water — in the form of properly treated sewage — if it was declared safe by environmental authorities? Give reasons for your answer.

### INVESTIGATE

- 10 Find out the kind of treatment (primary or secondary) that is used for the treatment system in the capital city of your state or territory. Where does the treated water go? How suitable do you think this system is for a large city?
- 11 If you have access to recycled water, compare its appearance and odour with that of tap water. Do NOT drink the recycled water as it will not have been treated properly for safe drinking.
- 12 Find out 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.

work  
sheet

→ 5.6 What do you know?

# 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 or 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.

## Keeping water safe

The water supplies of most of Australia's biggest cities comes from very large protected catchment areas. In the catchment areas surrounding dams and reservoirs, human habitation is not allowed and public access to these areas is strictly controlled. This reduces contamination of

the water as it flows through and over the ground and into the dam or reservoir. The water is stored for up to five years in the major reservoirs. During this time it is purified by settling and other natural processes.

Some chemicals are commonly added to major city water supplies to make drinking water safe and healthy.

- Chlorine is added in very small amounts to kill harmful micro-organisms, which might cause diseases. It keeps the water safe to drink up to the moment it reaches your tap.
- Fluoride is added to protect your teeth from decay.
- Lime is also added to balance the acidity of the water caused by adding chlorine and fluoride.

## 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!

The cloudiness of the muddy water is caused by tiny clay particles. Muddy water is an



Would you drink it?

example of a colloid. Recall that 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** (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 pumped to the local water tower which then supplies the town with drinking water.

## INQUIRY: INVESTIGATION 5.8

### Treating your own dirty water

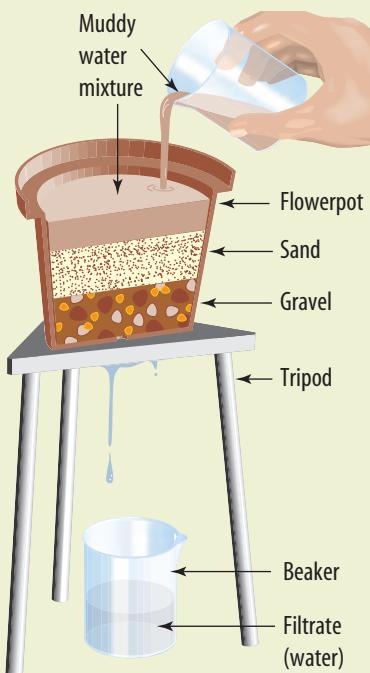
#### KEY INQUIRY SKILL:

- processing and analysing data and information

#### Equipment:

muddy water (muddy water made with clay is best)	
alum (aluminium sulfate)	limewater
flowerpot and tripod	bleach
2 × 250 mL beakers	sand
stirring rod	gravel

- 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.
- 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.
- 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	

#### DISCUSS AND EXPLAIN

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

## UNDERSTANDING AND INQUIRING

#### REMEMBER

- List five substances that can contaminate drinking water.
- What chemicals are added to most city water supplies?
- Explain why chlorine is added to drinking water.
- Why is alum added to country water supplies?

#### THINK

- If you live in a country town that does not fluoridate the water, how could you obtain your fluoride?
- What natural method of separating mixtures takes place in reservoirs over a long period of time?
- 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 used in swimming pools. Suggest why such a small amount of chlorine is added to the water.
- 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.
  - Define flocculation.
  - What do you think the flocculant polyaluminium chloride does to the water entering the filter?

#### INVESTIGATE

- Swimming pools and the seal pool at the zoo are vacuumed using a pool vacuum cleaner. Find out how this type of vacuum cleaner works.
- One of the main problems with the water in the seal pool at the zoo is the contamination from the seals themselves (their sewage). Find out how the seal waste going into the main pool is minimised.
- List some examples of emulsions used in the home and explain what each example is used for.

work sheet

5.7 Clean and clear?



Seal of approval: A seal at the Melbourne Zoo.

# Separation in industry

Separating the useful material from a mixture is often a problem in industry. In mining, the mineral ores that are needed are mixed with useless rock called gangue. In the dairy industry, the cream has to be separated from the milk before it can be put into containers for sale.

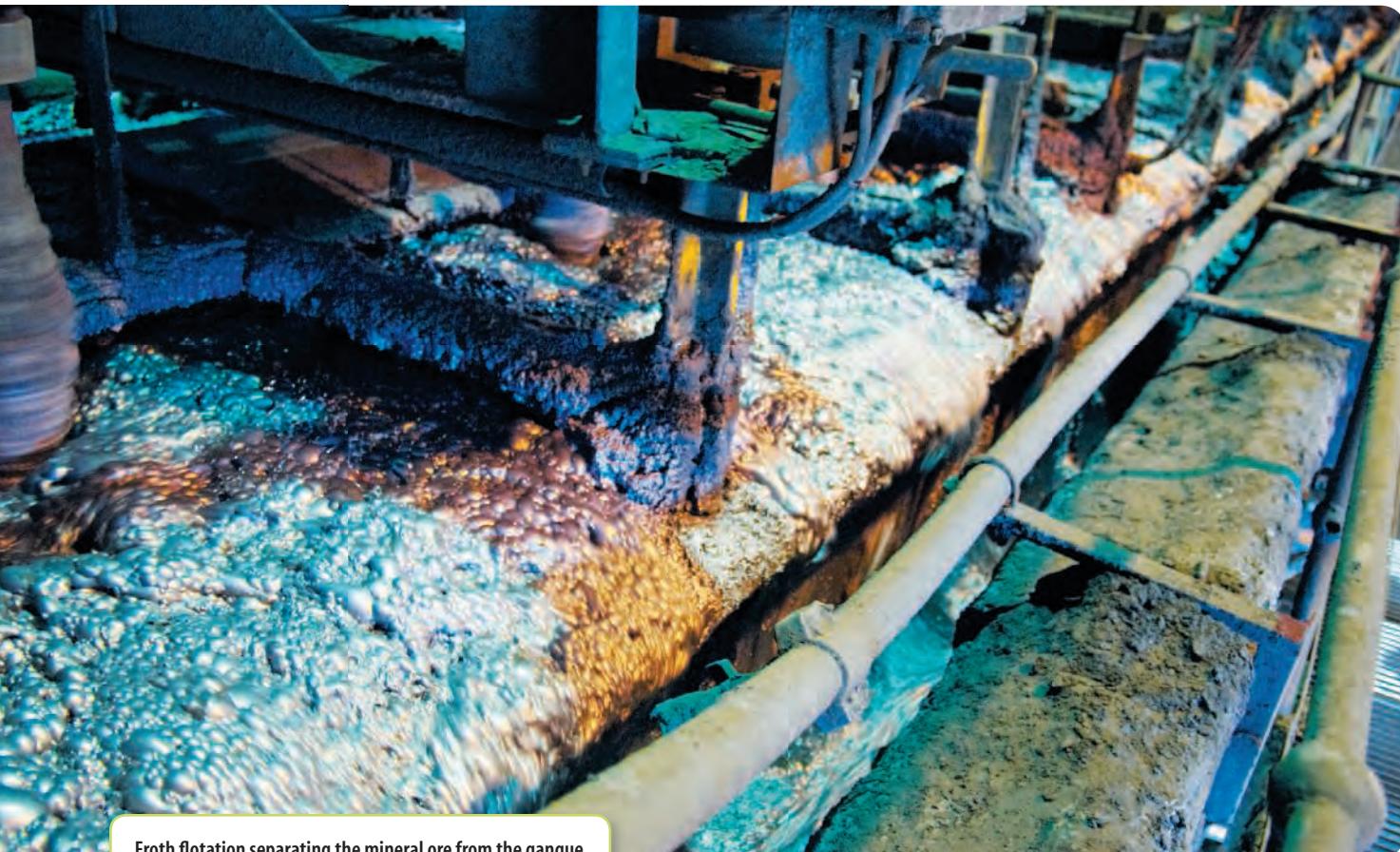
## Separating mixtures in mining

### COPPER

The metal copper is used in hot water pipes, electrical wiring and even in the coins we use. Copper is found in rocks in the Earth's crust in the form of mineral ores. Before the copper can be purified, the copper ore has to be separated from the gangue.

The mixture of gangue and copper ore which is dug out of the ground is in solid lumps. These lumps have to be crushed to a fine powder before the copper ore and gangue can be separated. Crushing takes place in a ball mill. This is a long barrel containing lots of heavy steel balls. As the barrel is rotated, the steel balls crush the lumps into a fine powder.

Once the copper ore and gangue are crushed, the copper ore is separated from the gangue by a process called **froth flotation**. The crushed mixture is mixed with water and some special chemicals, and stirred. Bubbles of air are blown into the bottom of the container and the copper ore is carried to the surface by the bubbles. The gangue sinks to the bottom of the tank and the copper ore is skimmed off the top of the liquid. The copper ore is then treated to extract the pure copper which can then be used to manufacture the many copper products we use.



Froth flotation separating the mineral ore from the gangue

## INQUIRY: INVESTIGATION 5.9

### Separation by flotation

#### KEY INQUIRY SKILL:

- evaluating

#### Equipment:

jar and lid	sawdust
sand	teaspoon

- Half fill the jar with water.
- Add a teaspoon of sand and a teaspoon of sawdust.
- Place the lid on the jar firmly and shake vigorously.
- Allow the jar to stand.
- Use a spoon to remove the sawdust.

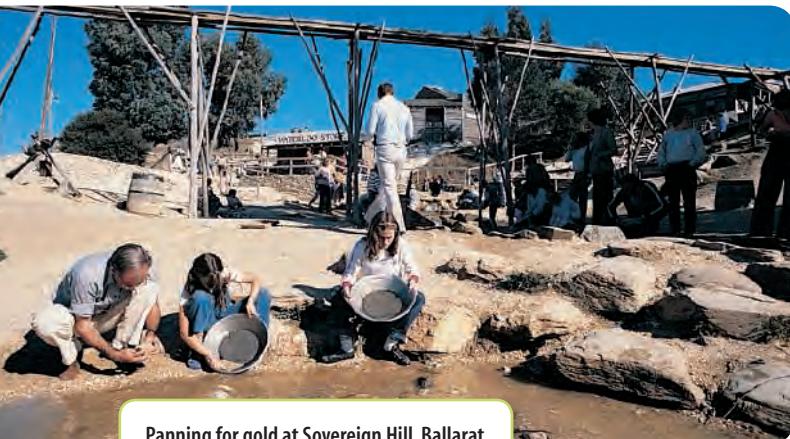
#### DISCUSS AND EXPLAIN

- In this experiment, which substance represented the gangue?
- Which substance represented the mineral ore?
- How is the method of separation in this experiment different from the froth flotation method used to separate copper ore from the gangue?

### GOLD

Gold obtained from the ground is also mixed with unwanted rock. After grinding in a ball mill, the mixture of crushed rock and gold is mixed with water. The gold can be separated from the mixture using **gravity separation** because the gold is heavier than the rock. The mixture is spun and the gold sinks to the bottom.

In the same way, panning for gold by swirling the pan allows the heavier gold to settle in the pan while the lighter gravel and sand swirl out of the pan with the water.



Panning for gold at Sovereign Hill, Ballarat

### Separation in the dairy industry

Cows' milk is a mixture of watery milk and fatty cream. If fresh milk straight from the cow is left to stand, the cream will float to the top of the milk. The milk that you buy as homogenised full cream milk contains both the milk part and the cream mixed together. Very fine droplets of cream are dispersed evenly throughout the watery milk.

Skim milk is the watery milk part without the cream. Milk is separated from the cream at the dairy using a centrifuge. The cows' milk is fed continuously into the centrifuge at one end; as the milk is spun in the centrifuge, the lighter cream separates from the heavier skim milk and each part is continuously collected at the other end.



A Westfalia Separator centrifuge is being used here to separate cream from milk.

Skim milk powder is made by evaporating about half of the water from the skim milk. A fine mist of this skim milk is then sprayed into a current of hot air, so that more water evaporates. The powdery dry milk is collected from the bottom of the chamber.

## Separation in the wine industry

Winemakers use a variety of separation techniques in the production of wine. Presses are used to separate the juice from the grapes. A large plate is lowered onto grapes in a container, pressing until the juice is forced out of the grape skins. Some winemakers still use the ancient method of pressing using a large wooden basket. A plate is lowered onto the grapes and the juice flows out through the openings in the basket.

Filtration is used to remove solid impurities in wine, but the microscopic particles in wine that make it cloudy are separated by a process similar to flocculation. Winemakers call this process 'fining'. They add agents such as egg whites, gelatin (an animal protein) and casein (a protein found in milk) that bond with the particles, making them larger so that they sink to the bottom of the tank or barrel. The remaining wine is clear.

Fortified wines such as apera (originally called sherry) and muscat are made by distilling wine to separate and remove water from alcohol and other dissolved substances that give the wine its flavour. The remaining mixture is called spirit, which is added to other wines to fortify, or strengthen, them and make them sweeter.

## Chromatography in industry

Chromatography is used in the food industry to detect more than just food colours. Food scientists can tell us what other ingredients have been added to food.

Chromatography can also identify pesticides and harmful chemicals that have entered our food from the water in creeks and dams, or from soil **pollution**.

**Forensic scientists** use gas chromatography to detect a range of substances, including traces of illegal drugs. They can also

use chromatography to compare mixtures found at crime scenes with those found on suspects. Many mixtures contain a unique combination of substances. For example, ink from different pens is slightly different, even if the colours look the same.

The separating technique of chromatography is used to detect substances in blood and urine. In medical laboratories, samples of blood or urine are tested for drugs and alcohol. Abnormal levels of vitamins and hormones in a person's blood can also be detected using chromatography.

A chromatograph automatically separates mixtures by chromatography.



### UNDERSTANDING AND INQUIRING

#### REMEMBER

- 1 Describe how copper ore is separated from unwanted rock.
- 2 Describe how copper ore is carried to the surface during froth flotation.
- 3 How is gold separated from unwanted rock?
- 4 How are skim milk and skim milk powder separated from whole milk?
- 5 List three uses of chromatography in industry.

#### THINK

- 6 What type of separation is used when panning for gold?
- 7 Does homogenised milk contain cream? Where is it?
- 8 Which pure substance is present in milk and unfortified wine?

#### INVESTIGATE

- 9 Crude oil is a mixture of many different chemicals. Find out how crude oil is separated into the many different chemicals it contains.



5.8 Separation techniques

# Essential recycling

## Essential recycling

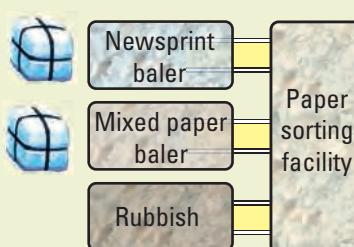
To preserve resources for future generations the **recycling** of materials is essential. Items such as paper, all plastic bottles and containers, glass, aluminium and steel can be recycled and made into new products. Recycling reduces the amount

of waste that goes to **landfill** and saves precious natural resources such as trees and bushland.

Many **manufacturing processes** pollute the environment. Recycling and reusing materials reduces the need to manufacture from **raw materials**. Fortunately, most local councils have a recycling program.

### Paper sorting facility

All paper and cardboard is manually sorted to ensure that there are no plastic bags or other non-paper items in the mixture. Paper and cardboard is baled and sent to paper mills for reprocessing. At the mill, paper is shredded and mixed with water (pulped) to make new paper products such as cardboard boxes.



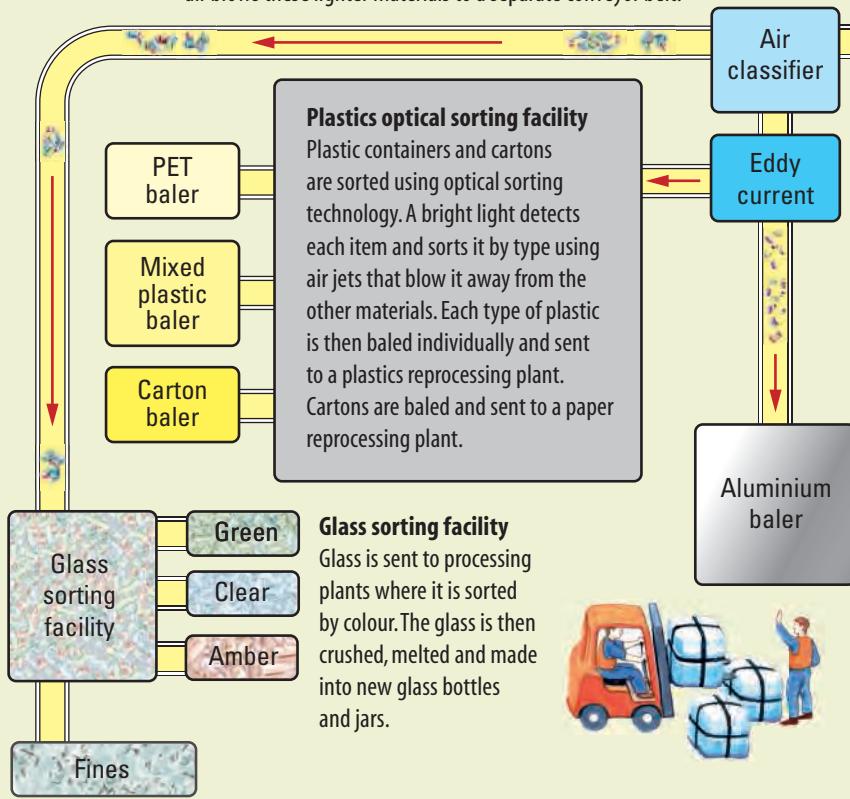
### Trommel

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.



### 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.

### Steel magnet

### Steel baler

### Magnet

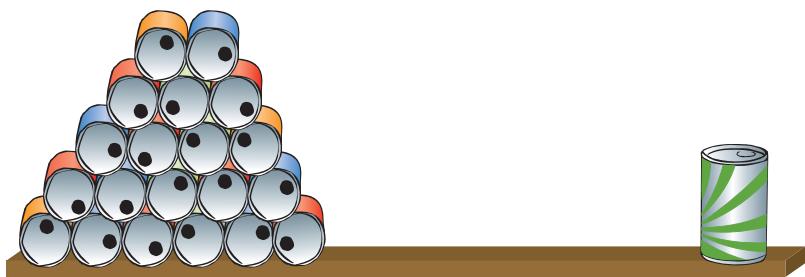
Steel cans are separated from other containers using a magnet. The steel is collected in a separate container, ready to be sent to steel manufacturers. Material that is not attracted to a magnet continues along the conveyor belt.

# 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. This is most easily done by hand — that is, separating by sight. We can see the differences between the types of rubbish, and we know which items can be recycled.

## HOW ABOUT THAT!

How does the recycling of cans and bottles save oil, coal and gas? It takes energy from fossil fuels to run the equipment that mines and processes the materials that make new cans and bottles. Recycling also reduces the amount of raw materials that need to be taken from the ground and processed.



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.

## UNDERSTANDING AND INQUIRING

### REMEMBER

- 1 List at least two reasons why recycling is good for the environment.
- 2 Describe how paper and cardboard are separated from other recyclable materials.
- 3 What happens to recycled glass after it is separated from other materials in a recycling plant?

### THINK

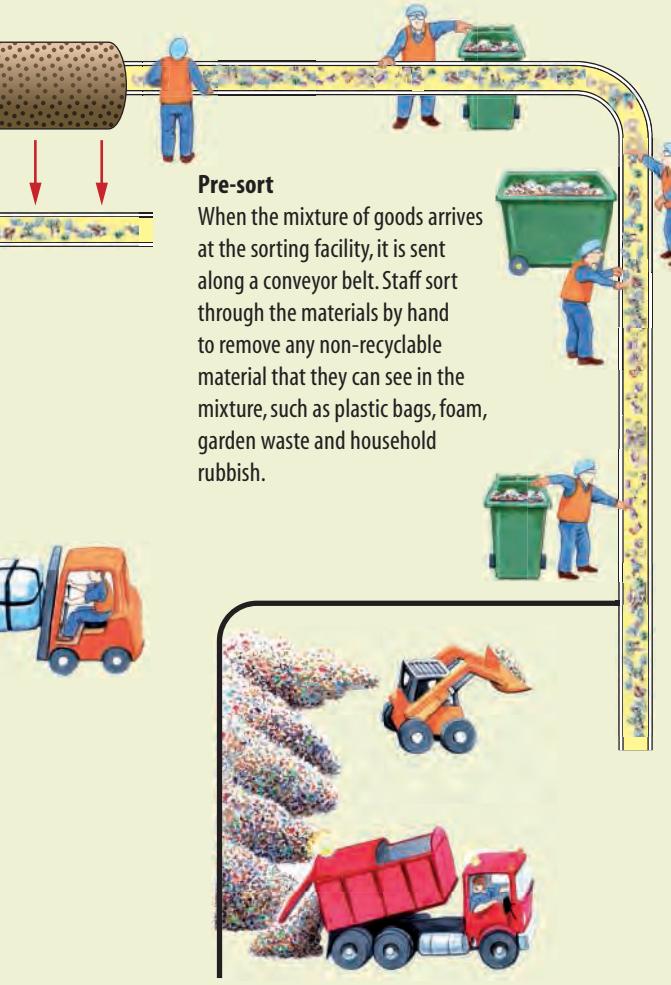
- 4 Construct a table like the one below to show the following information about separating recyclable rubbish.
  - (a) The methods used to separate different types of material in a recycling plant
  - (b) For each method, the material removed from the flow of rubbish
  - (c) The properties of the recycled material that allowed it to be separated from the mixture

Method	What is removed?	Properties

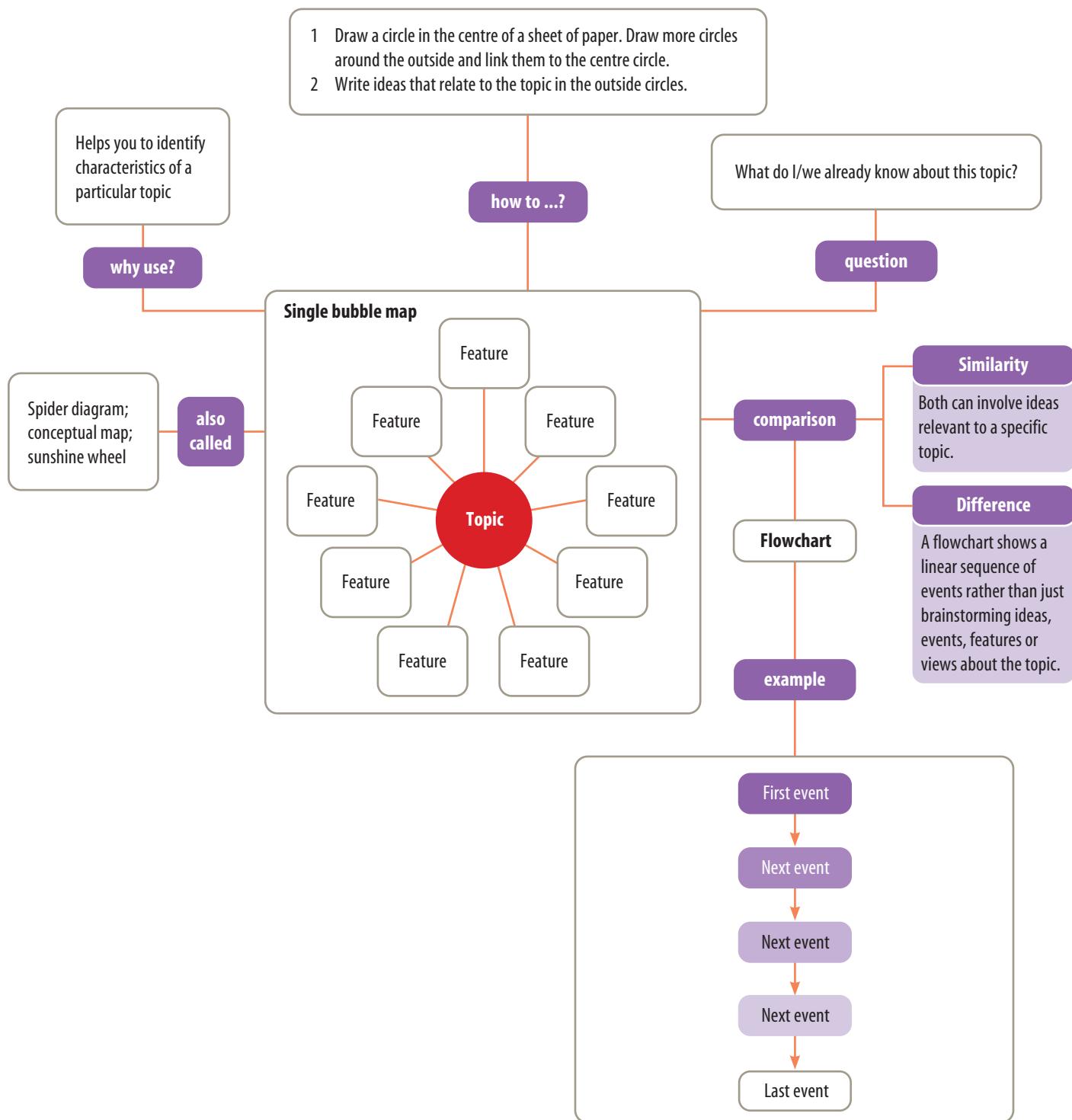
- 5 Explain why the same type of magnet is not used for separating both aluminium and steel cans.
- 6 Why do people, rather than machines, manually separate some of the recycling mixture?

### CREATE

- 7 Design and construct a poster or brochure that explains which plastics can be recycled. Check with your local council for its recycling guidelines. Compare the properties of plastics that can be recycled with those that can't.



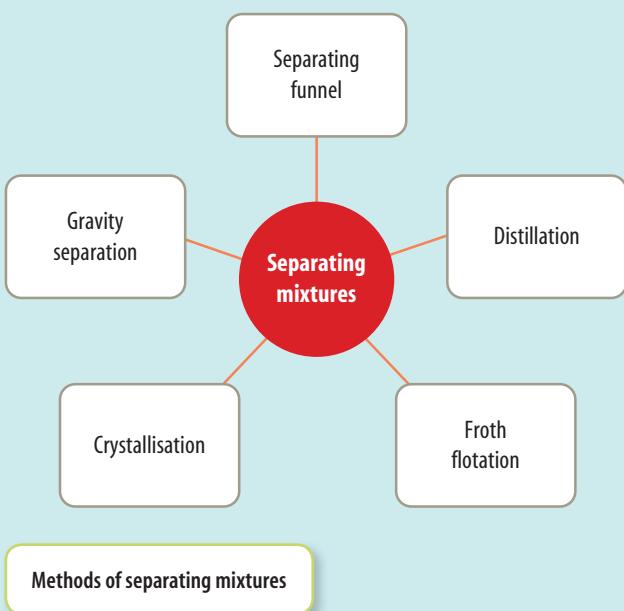
# Single bubble maps and flowcharts



## UNDERSTANDING AND INQUIRING

### THINK AND CREATE

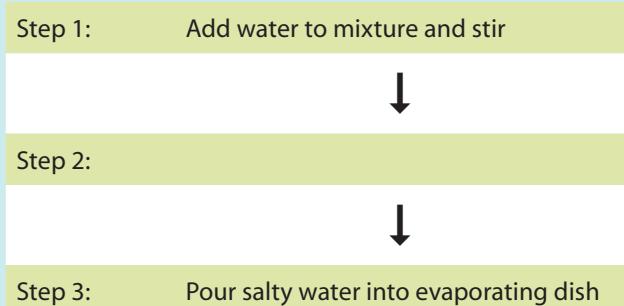
- 1 The single bubble map below identifies some of the methods used to separate mixtures. Draw your own single bubble map, adding as many additional bubbles as you can. You are doing very well if you can fill ten bubbles.



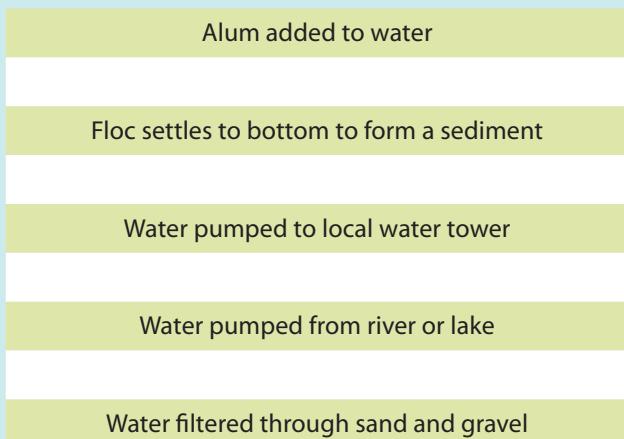
- 2 Draw a single bubble map that identifies substances and objects that should not be tipped down the kitchen sink.



- 3 Draw flowcharts to show the steps involved in separating:
- salt from a mixture of sand, salt and water in a beaker
  - copper ore from the rocks dug out of a copper mine (see section 5.7).
- 4 Copy and complete the following flowchart to show how salt can be recovered from a mixture of salt and sand.



- 5 Arrange the following steps in the correct order and construct a flowchart to show how country water supplies are purified.



- 6 An unfortunate bush camper has accidentally mixed water with the kerosene that he needs to fuel his camp stove. Help him out by drawing a flowchart showing how to separate the water from the kerosene.  
(Hint: Kerosene does not dissolve in water.)
- 7 (a) Design a mixture that can be separated using as many as possible of the methods you have seen in this chapter. List the components of the mixture and challenge another student to find a step-by-step method of separation.
- (b) Design a mixture that cannot be separated.

work  
sheet

5.9 Single bubble maps and flowcharts

### MIXTURES

- distinguish between pure substances and mixtures and give examples of each
- recall that a mixture can be separated according to specific properties of its components
- identify some common mixtures

### SOLUTIONS AND SUSPENSIONS

- identify the solute and solvent in common solutions
- appreciate that water is a common solvent in solutions
- distinguish between solutions and suspensions
- define the terms 'colloid' and 'emulsion'

### SEPARATING MIXTURES

- describe the processes of filtering, sieving, decanting, distillation, evaporation, crystallisation, chromatography and using a separating funnel
- compare the effectiveness and limitations of these processes
- describe common household uses of these separation techniques
- recall how filtering and centrifuging are used in the isolation of blood products
- explain how distillation and evaporation may be used to purify water

### SCIENCE AS A HUMAN ENDEAVOUR

- describe how blood is separated into its components
- describe the processes by which sewage is treated
- evaluate the appropriateness of current sewage treatment systems
- appreciate that water often needs treating before it is drinkable
- recall common contaminants found in water
- identify chemicals that are often added to water supplies and their purpose
- describe the process of flocculation in the treatment of water
- describe examples of the separation of mixtures in industry by froth flotation, gravity separation, centrifuging, distillation and chromatography
- describe the processes used to separate materials in recycling plants

### INDIVIDUAL PATHWAYS

**Activity 5.1**  
Investigating separation  
**doc-2858**

**Activity 5.2**  
Analysing separations  
**doc-2859**

**Activity 5.3**  
Designing separations  
**doc-2860**

eBook plus

eBook plus

## Summary

### 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

### 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

# LOOKING BACK

**1** 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.

**2** Black instant coffee is a mixture of coffee powder and hot water. Which substance is:

- (a) the solute?
- (b) the solvent?
- (c) the solution?

**3** How can you tell, just by looking, whether a mixture in water is a solution or a suspension?

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

Method of separation	Description of how it works	An example of how it is used in the home or in industry
Filtration		
Distillation		
Crystallisation		
Flocculation		
Decanting		
Separating funnel		
Centrifuging		
Chromatography		

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

**6** How would you separate the sand from a mixture of sand and sawdust? Construct a flowchart to show the steps you would use.

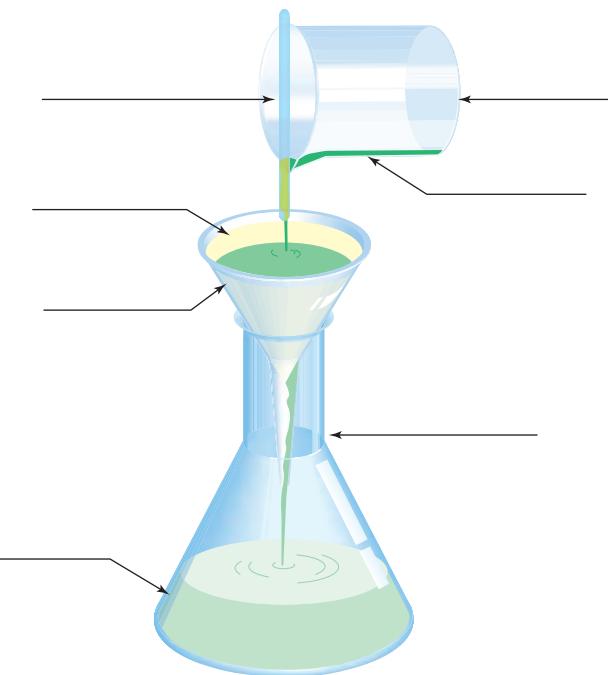
**7** Imagine you dropped nails in the sawdust in woodwork class. Propose two reliable ways of separating the nails from the sawdust.

**8** You have been asked to analyse some salt-contaminated soil and to propose a method for separating the salt from the soil.

- (a) Outline 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.

**9** The diagram below shows a mixture being filtered in a school laboratory.



- (a) Copy the diagram and add the missing labels.
- (b) What is the purpose of the stirring rod?

**10** Pasta is cooked by boiling it in water. It sinks to the bottom of the saucepan when it is left to stand.

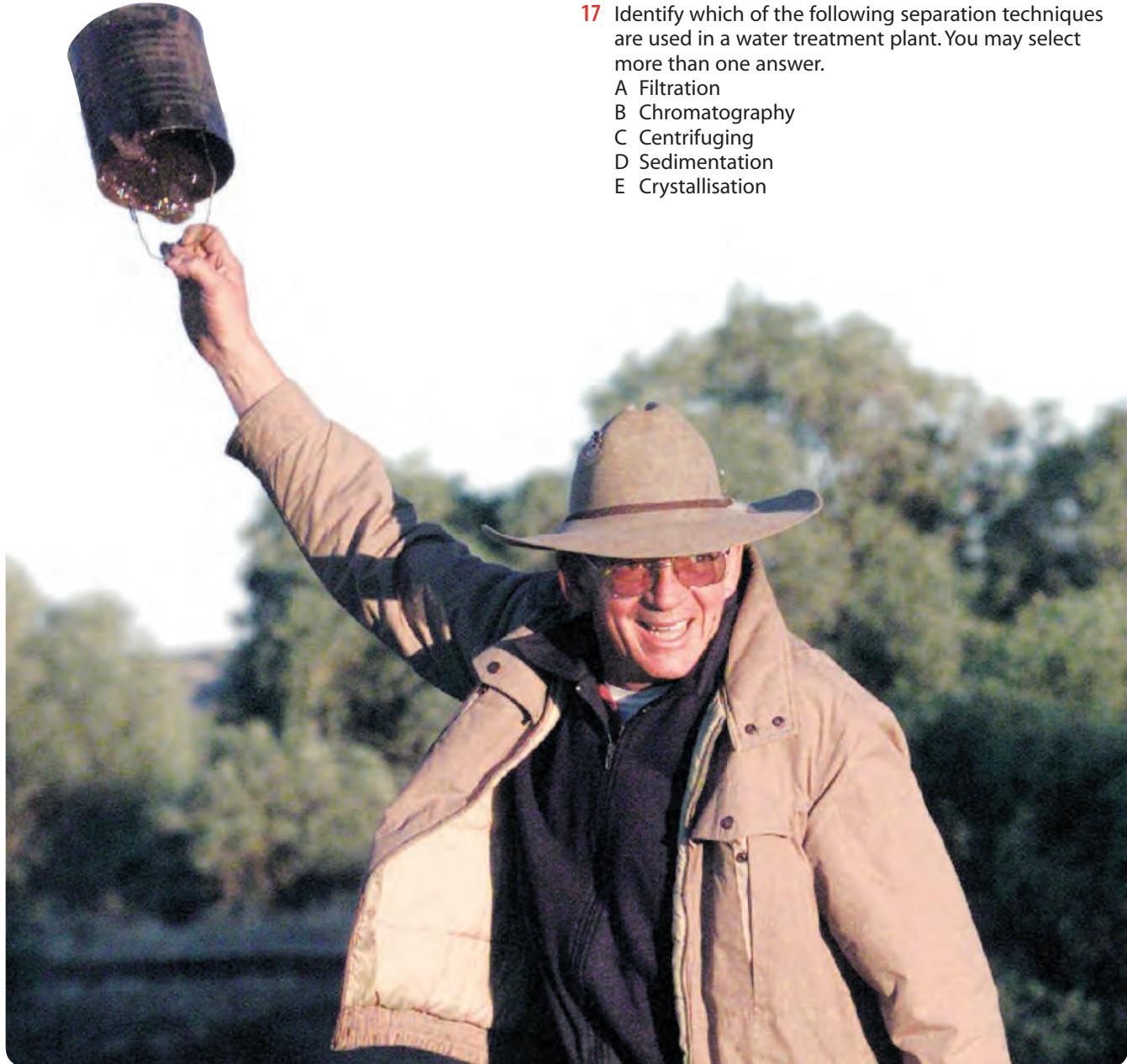


- (a) Which type of mixture is the pasta and water?
- (b) Describe two different methods that could be used to separate the pasta.
- (c) Which of the two techniques is best for separating the pasta and water? Explain your answer.

**11** Identify which of the following substances is a mixture.

- (a) Silver
- (b) Distilled water
- (c) Smoke
- (d) Nitrogen gas

- 12** A water sample taken from a river that shows a brown colour is most likely to be:  
(a) a solution.  
(b) a colloid.  
(c) a suspension.  
(d) an emulsion.
- 13** A separating funnel works when two substances have different:  
(a) melting points.  
(b) colours.  
(c) densities.  
(d) solubilities.
- 14** This man (below) is making billy tea.  
(a) Which method of separation is being used?  
(b) Where are the tea-leaves after the separation?



- 15** 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*.
- 16** Identify the properties that 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 cows' milk
- 17** 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

- 18 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.



- 19 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, your method should not harm the fish already in the lake.
- 20 Muddy water is an example of a colloid. How is a colloid different from other suspensions?
- 21 Mayonnaise is an example of an emulsion, which is a type of colloid. How is an emulsion different from other colloids?
- 22 How does flocculation make the particles in a suspension settle out?
- 23 Explain why blood collected by the Red Cross Blood Service needs to be separated before it is used.
- 24 What is the purpose of the S-bend in the toilet?
- 25 Describe the two separating processes in a recycling plant that are done by sight.
- 26 State 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 or oil  
(b) Cotton buds  
(c) Oven cleaner
- 27 Explain why chlorine is added in small amounts to the water supplies of many cities.
- 28 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.  
(b) Propose three questions that Flavius would have asked in return.  
(c) Extension — Construct a flowchart that shows the steps involved in each salt harvest process using appropriate scientific terminology to describe changes of state and separation techniques.  
(d) Spend some time researching ancient methods of salt separation before creating your flowchart. 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.



work  
sheets

- 5.10 Summing up
- 5.11 Looking back: Separating mixtures
- 5.12 Science literacy

## 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.



- 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.

### 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.

- 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 in 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



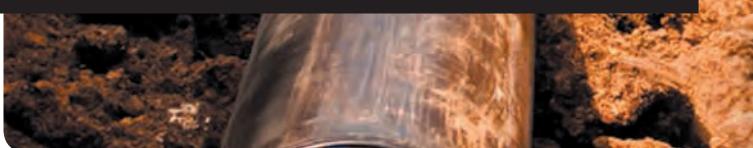
Your ProjectsPLUS application is available in this chapter's Student Resources tab inside your eBookPLUS. Visit [www.jacplus.com.au](http://www.jacplus.com.au) to locate your digital resources.



#### 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.



The screenshot shows a mobile device displaying an eLesson titled "Treating sewage". The screen includes a navigation bar with "eLesson", "Worksheets", and "Acknowledgements". Below the navigation is a video player showing a circular wastewater treatment pond with water flowing over a concrete structure. To the right of the video player is a "PodPack" download button and a link to download the eLesson for iPod or other media players. At the bottom of the screen, there is a "DIRECT LINK" and the website address <http://www.jacplus.com.au/secure/SearchlightSearchbox=eles-0059>. The JacarandaPLUS logo is visible in the bottom right corner.

## eLesson

### 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