TOPIC 5
Separating mixtures

5.1 Overview

Any substance that is not a mixture is a pure substance. When coloured watercolours are applied to paper, sometimes the colours in the inks separate. This means that each ink is made up of separate colours. This technique is called chromatography. What other techniques can be used to separate mixtures?

5.1.1 Think about Mixtures

assessON

- What makes a fizzy drink fizz?
- How does the Red Cross separate the red and white blood cells from the blood of donors?
- 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?

LEARNING SEQUENCE

5.1	Overview	201
5.2	What's in a fizzy drink?	203
5.3	Kept in suspension	206
5.4	Separating blood	210
5.5	Separating solutions	213
5.6	Systems: Down the S-bend	220
5.7	Fit to drink?	223
5.8	Essential separation	225
5.9	Essential recycling	229
5.10	Thinking tools: Single bubble maps and flowcharts	232
5.11	Project: The diamond flush	234
5.12	Review	235

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5.1.2 Your quest

A world of mixtures

The ground that you stand on, the air that you breathe and the oceans of the Earth are all mixtures. For example, air is a mixture of many gases, including nitrogen, oxygen and carbon dioxide. Ocean water is a mixture of pure water, salt and many other substances. Even the fresh water in lakes and rivers is not pure and always contains small amounts of other substances.

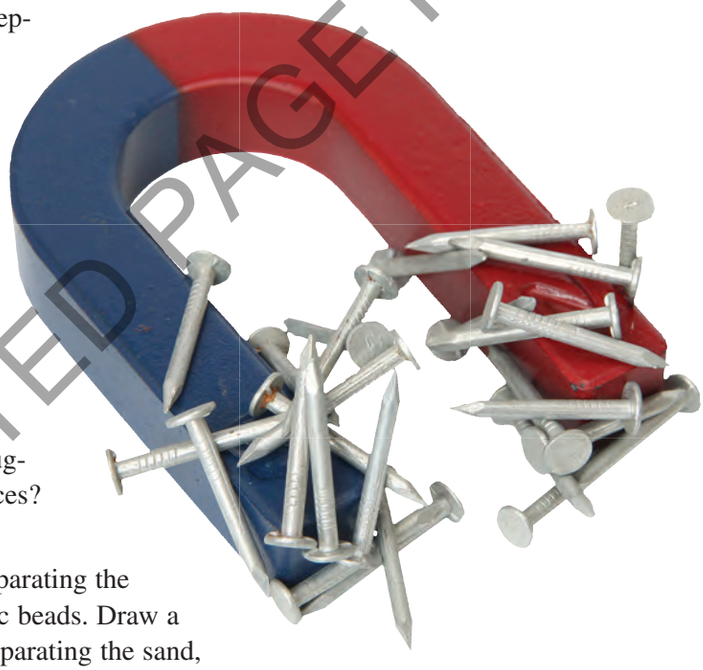
Think

1. Are the rocks and soil on Earth also mixtures that can be separated? How?

Separating mixtures

Unlike pure substances, mixtures are usually easy to separate into their different parts. For example, 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.

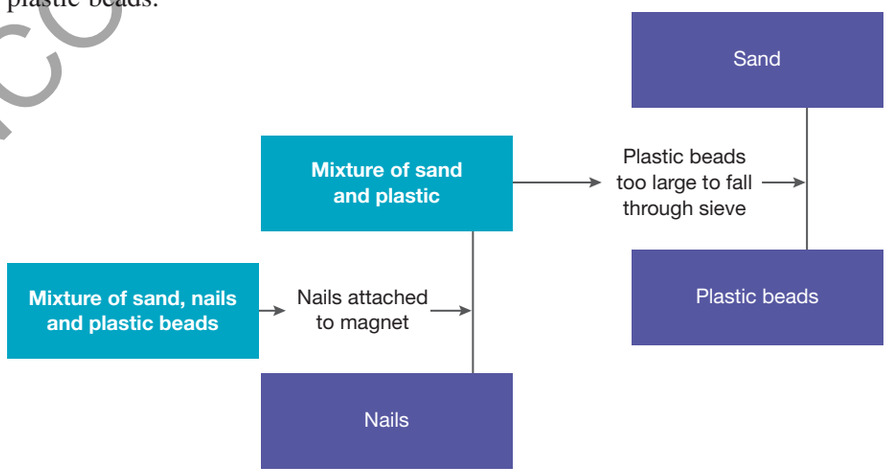


Think

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

Think and create

4. 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.



INVESTIGATION 5.1

Design and separate

AIM: To plan and carry out a method of separating the four parts of a mixture

Materials:

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

Method and results

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.

1. 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.
2. 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.
3. On A3 paper, draw a flowchart like the one on the previous page to show how each part was separated from the mixture.

5.2 What's in a fizzy drink?

5.2.1 Looking at solutions

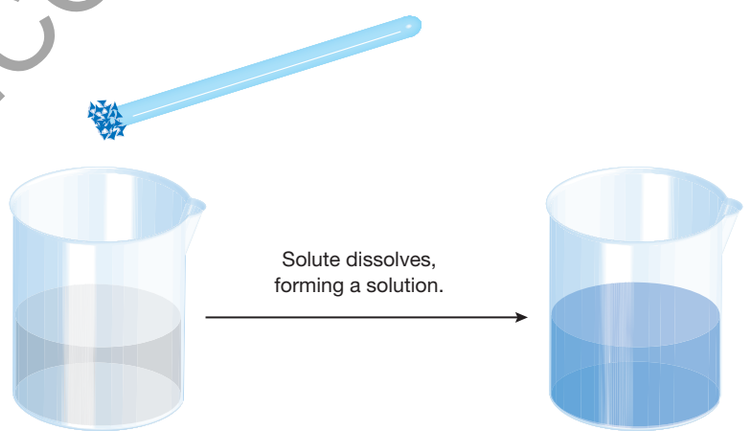
The 'fizz' in fizzy drinks is the carbon dioxide gas that is dissolved in the flavoured liquid. Carbon dioxide is pumped into bottles or cans at high **pressure**. The bottles and cans are then sealed to keep the carbon dioxide **dissolved** in the water. When you open the container, the pressure is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

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.

Adding a soluble substance to a liquid



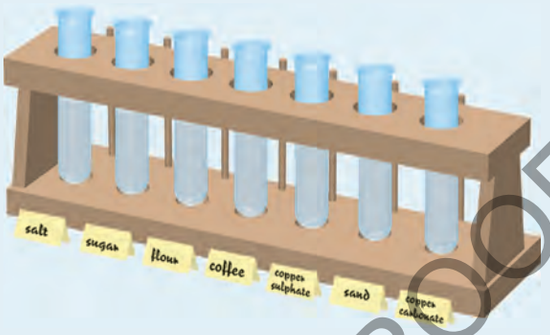
INVESTIGATION 5.2

Soluble in water?

AIM: To test a range of substances for solubility

Materials:

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



Method and results

- 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.

1. 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.

2. Decide whether each mixture is soluble or insoluble. Record this in the table.
3. Which of the substances dissolved in water?

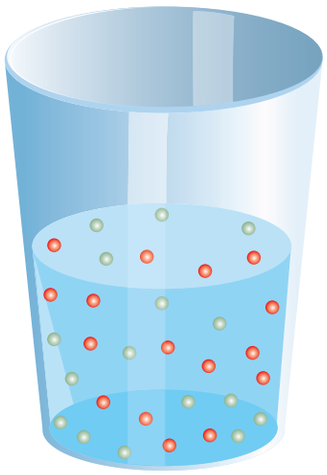
Discuss and explain

4. How can you tell if a substance has dissolved?
5. How can you tell that a substance has not dissolved?

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**.

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.



5.2.2 '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 Investigation 5.3, 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.

5.2.3 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

INVESTIGATION 5.3

Froth and bubble

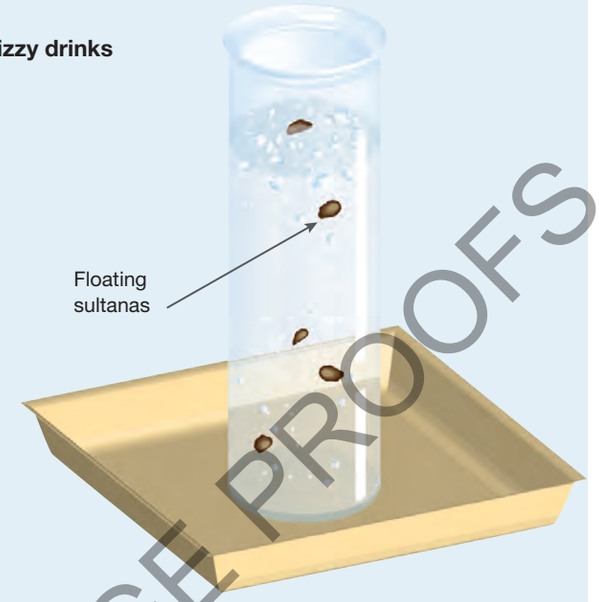
AIM: To model the separation of carbon dioxide from fizzy drinks

Materials:

vinegar
bicarbonate of soda
spatula
plastic tray
stirring rod
gas jar
sultanas

Method and results

- 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

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

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.

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

5.2 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

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.

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Complete this digital doc: Worksheets 5.1: Soluble or insoluble?
Searchlight ID: doc-19823

Complete this digital doc: Worksheet 5.2: Mail room mayhem
Searchlight ID: doc-19824

5.3 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.

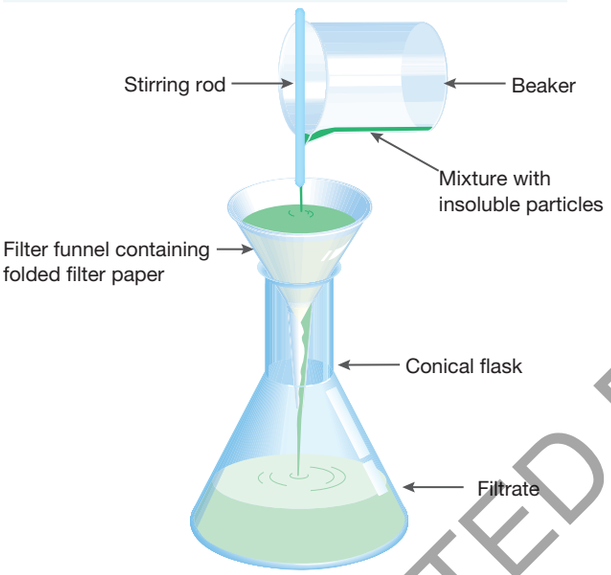
What do a vacuum cleaner, tea strainer and protective face mask have in common? They are all devices for separating particles from suspensions by **filtration**. In the laboratory, filtration is carried out using

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 below.

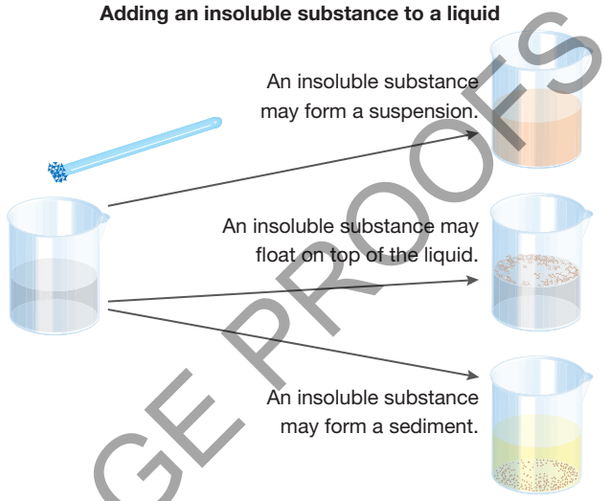
5.3.1 Sift and separate

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.

Equipment used to filter a mixture that contains insoluble particles



Adding an insoluble substance to a liquid



WHAT DOES IT MEAN?

The word *residue* comes from the Latin word *residium*, meaning 'left over'.
The word *aqueous* comes from the Latin word *aqua*, meaning 'water'.

5.3.2 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.

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

5.3.3 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.

INVESTIGATION 5.4

Filtration in the laboratory

AIM: To use filtration to separate substances in a mixture

Materials:

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

Method and results

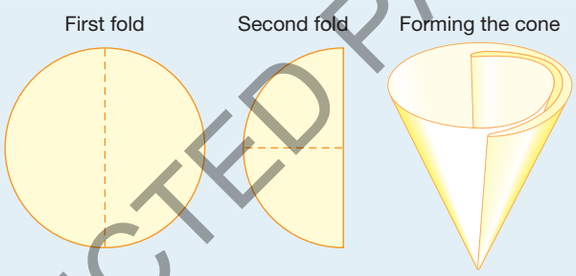
- Half-fill your 100 mL beaker with water.
- Add your insoluble substance to the water and stir with the stirring rod.
- Set up the equipment for filtering as shown in the diagram on the previous page.
- Fold the filter paper as shown in the diagram below.
- Place the filter paper in the funnel and moisten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

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.

Discuss and explain

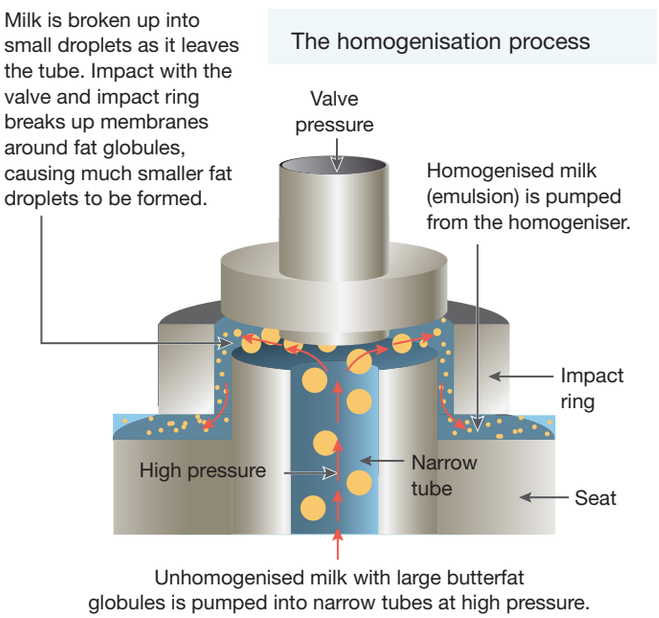
4. Filter paper is like a sieve with small holes in it. Explain how the filter paper worked like a sieve in this experiment.

Origami cone: Folding filter paper



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.

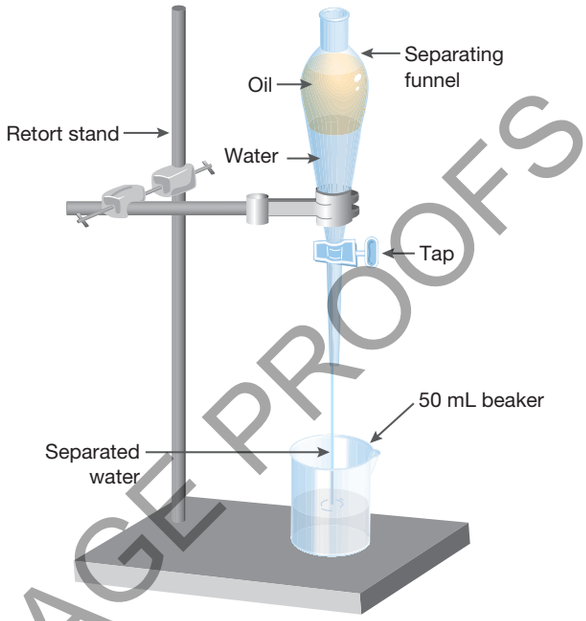
The homogenisation process



5.3.4 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.

Using a separating funnel to separate oil from water



5.3.5 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'.

5.3 Exercises: Understanding and inquiring

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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. Think of some 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.

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Watch this 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.
Searchlight ID: eles-0061

Try out this interactivity: Time Out: 'Mixtures'
Searchlight ID: int-0224

Try out this interactivity: Filtration
Searchlight ID: int-0223

Complete this digital doc: Worksheet 5.3: The pool shop
Searchlight ID: doc-19825

5.4 Separating blood

Science as a human endeavour

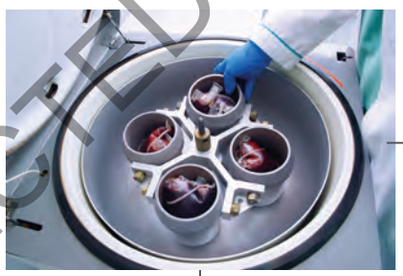
About one million donations of blood are made in Australia each year. Some of the donations are given to people who have lost blood during surgery, accidents or disasters. Blood is also given to people during the treatment of many diseases, including cancer. These people need to be given a regular supply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

Red cross blood donor

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



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 edges of the containers in the centrifuge.

Centrifuge

Plasma and platelets

Centrifuge

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

Platelets

Plasma

Red and white blood cells

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.

White blood cells not used

Red blood cells

5.4.1 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.

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.)

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

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!

5.4 Exercises: Understanding and inquiring

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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?

5.5 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 would dehydrate you even further. You have to find a way of separating the water from the salt dissolved in it. What can you do?

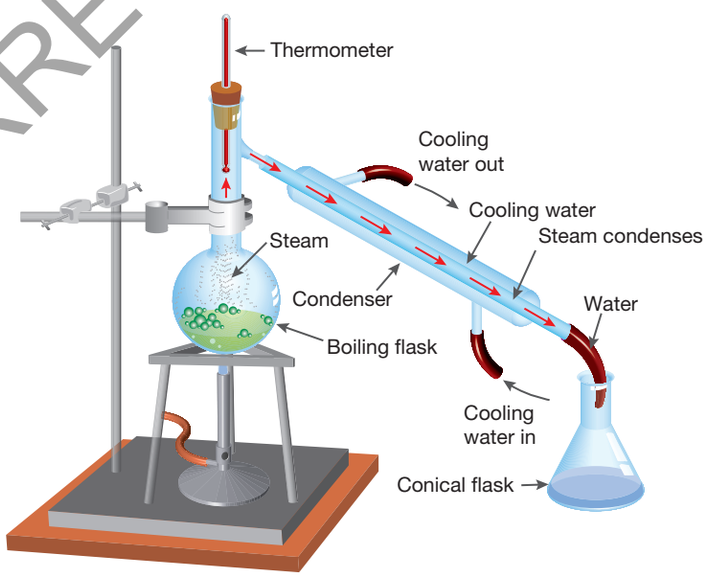
5.5.1 What's the solution?

Sea water is a solution. Separating the solute from the solvent in 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.

5.5.2 Distillation

In the laboratory, pure water is produced by a process called **distillation**. Tap water is poured into the boiling flask (see the diagram below) 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.

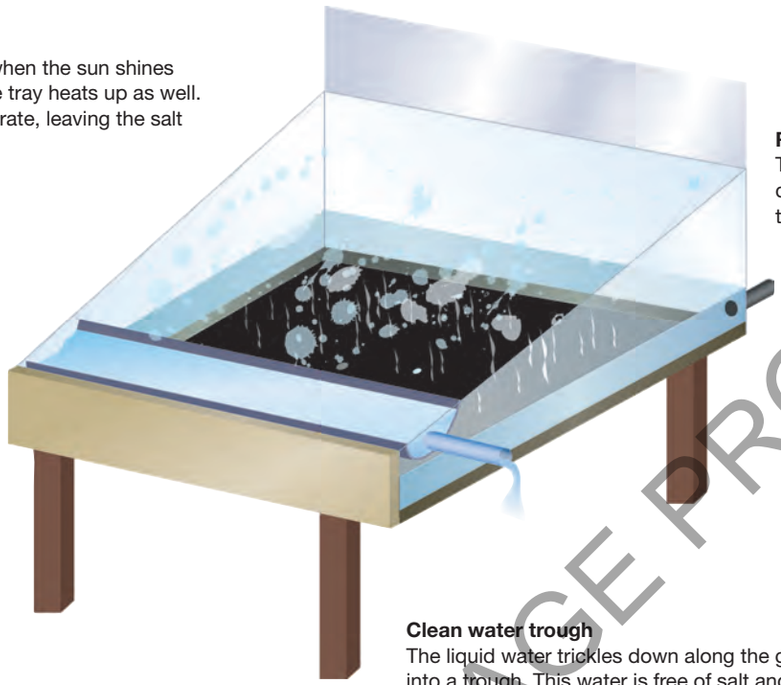
Equipment used for distillation in the laboratory



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

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.



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.

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.

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.

5.5.3 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 above 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.

5.5.4 The desert island solution

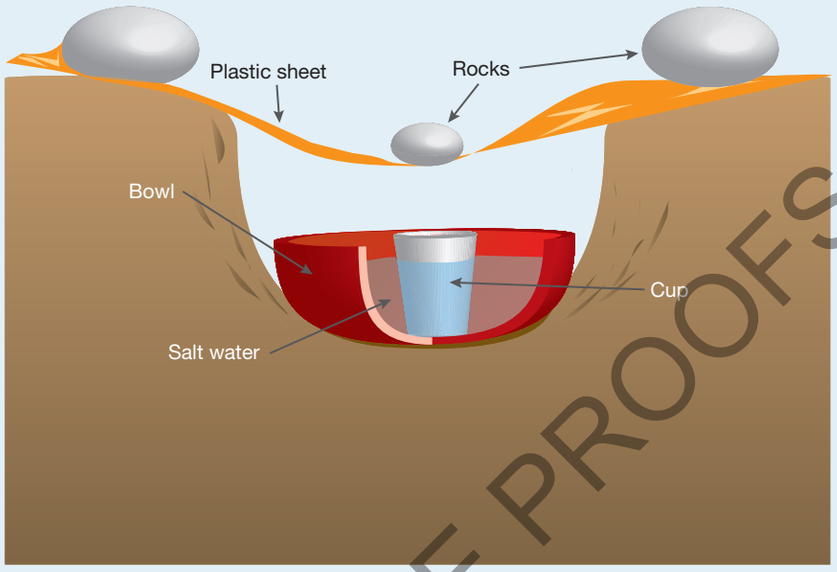
In places where fresh water is scarce, a simple water still like the one on the next page could be used to evaporate and collect pure water. If the water is muddy or not clear, it should be filtered first to separate the undissolved particles. On a desert island a handkerchief could be used as a filter.

INVESTIGATION 5.5

Making a simple water still

AIM: To use a simple still to separate salt from salt water

Materials:
trowel
bowl
scissors
some small rocks
cup
saltwater solution
plastic bag



Method and results

- 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 salt water 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!

5.5.5 Large-scale separation

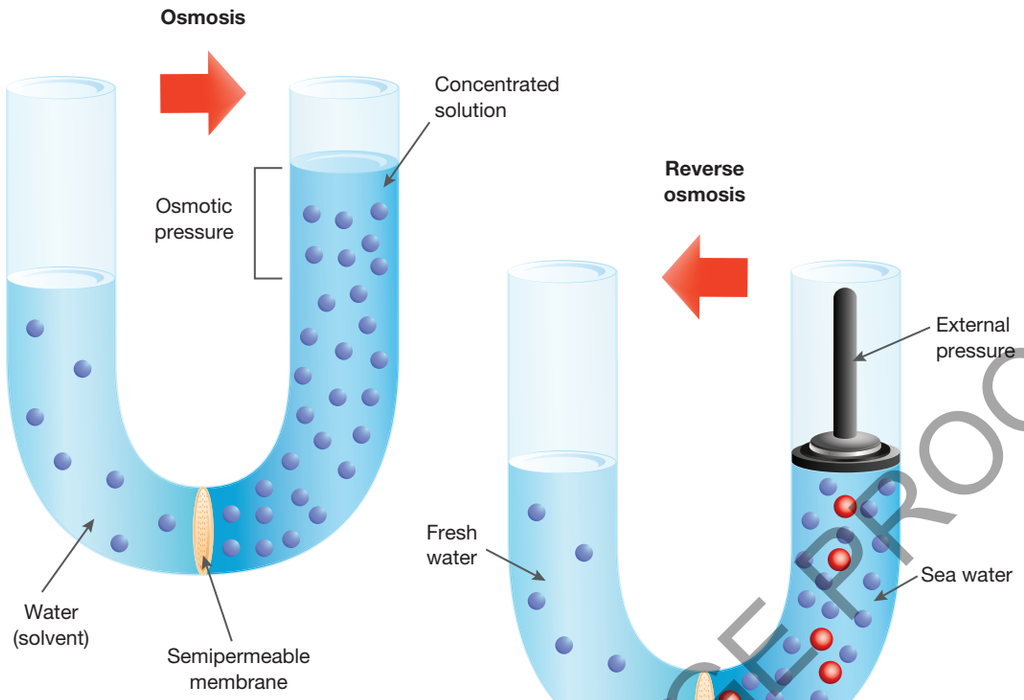
The processes of distillation and evaporation are not suitable for purifying sea water on a scale large enough to supply drinking water to large communities. In New South Wales, Victoria, Western Australia and South Australia, desalination plants have been built. In all of these plants, a process called **reverse osmosis** is used to separate salt from large quantities of sea water.

In the process of **osmosis**, water moves through a very thin membrane from an area of low salt concentration to an area of high salt concentration. This continues until the concentration of salt is the same on both sides of the membrane. The membrane has tiny holes that allow water to pass through without the salt. In reverse osmosis, the water is forced under very high pressure to flow through the membrane in the opposite direction.

In desalination plants, sea water is pumped under high pressure through thin membranes in coils. The pure water that has passed through is directed to drinking water supply tanks. The very salty water left behind is pumped back into the sea.

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

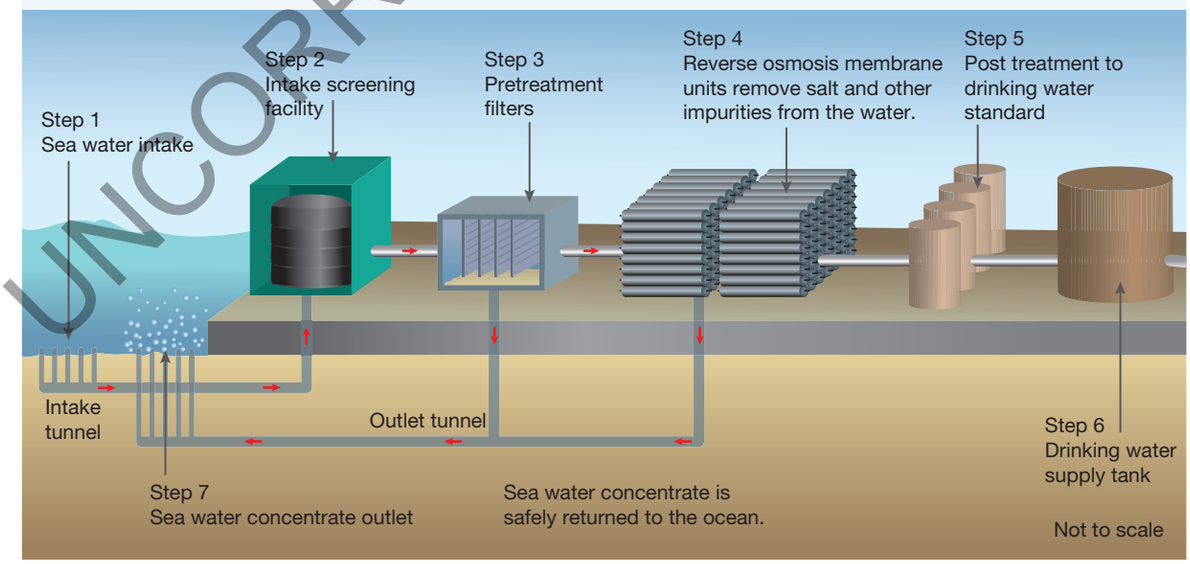
- they use a lot of energy, which is usually supplied by coal-fired power plants. Apart from the pollution caused by these plants, there are many who feel that they are not **sustainable**. That is, they cannot



continue to operate without putting the environment and our future at risk. In some cases, the large amounts of energy used are offset by constructing wind farms or by supporting other renewable sources of energy.

- the water flowing back to the sea contains much more salt than sea water. It is also warmer. This poses a threat to marine animals and plants that live near the desalination plant. The threat can be reduced by choosing suitable locations for the salty water outlet. This requires scientific studies by marine biologists and other scientists. In the case of the Wonthaggi plant in Victoria, the outlet is around 1 kilometre offshore.

Example of a desalination plant



5.5.6 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.

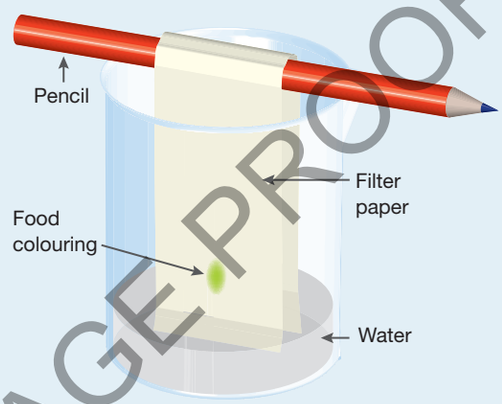
INVESTIGATION 5.6

Separating colours

AIM: To use paper chromatography to separate substances in food colouring

Materials:

food colouring
toothpick
filter paper
scissors
250 mL beaker
pencil
ruler



Method and results

- 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.

1. What colours were in the first food colouring tested?
2. List the different food colourings that you tested. For each one, write down the colours that made up the food colouring.

Discuss and explain

3. How do you think the colours are actually separated using this method?

HOW PAPER CHROMATOGRAPHY WORKS

Sample of coloured solution

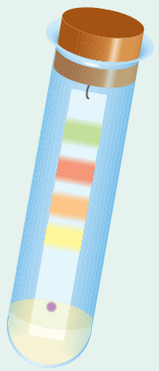
A small amount of the solution is placed on a strip of filter paper 2 cm from its end.

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.



INVESTIGATION 5.7

Crystallisation

AIM: To observe separation by crystallisation

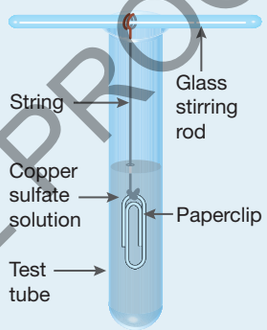
This activity must be done in class with your teacher.

Materials:

test tube
solid copper sulfate (or alum)
a balance
150 mL beaker
glass stirring rod
hot water
string
test-tube rack
piece of filter paper
filter funnel
conical flask or beaker
paperclip

Method and results

- 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 the solution into a test tube.
- Tie the string to the glass rod. Attach the paperclip to the end of the string and arrange it as shown at right.
- Leave to cool overnight in the test-tube rack.



1. Describe the changes that have taken place in the test tube.

Discuss and explain

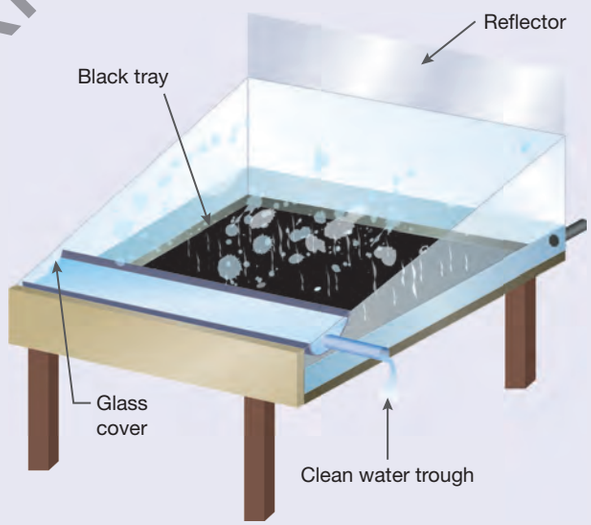
2. Identify the solid substance that has formed.
3. What do you think was the purpose of the paperclip?

5.5 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

Remember

1. Distillation can be used to separate a mixture of two liquids. What difference in properties between the two liquids allows this to be done?
2. What is the purpose of the glass cover on the solar still illustrated below?



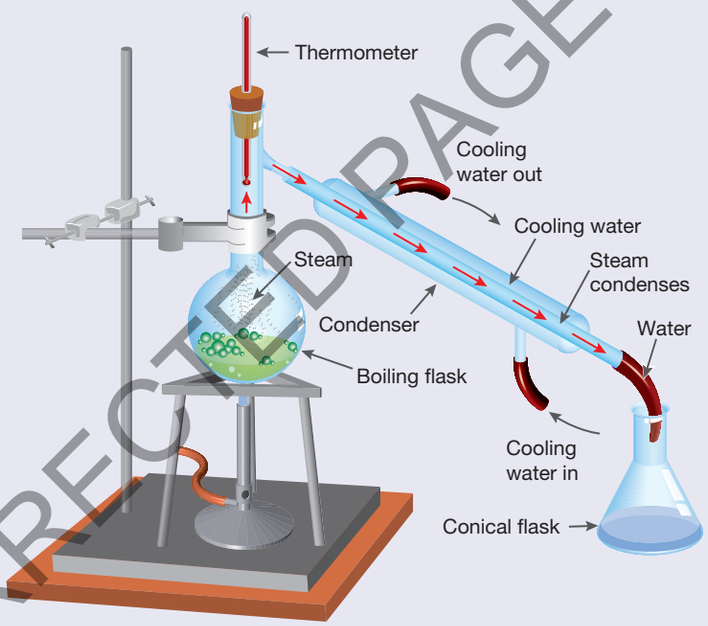
3. Explain how evaporation and crystallisation are different from each other.
4. Identify the colours found in this ink, from:
   (a) the fastest moving to the slowest moving
   (b) the most soluble to the least soluble.
5. What process is used to separate salt from sea water in Australian desalination plants?
6. The building of desalination plants is controversial. List two reasons for this.

Design and create

7. Design and build a separating machine that will separate a mixture of three substances. Create a brochure to advertise your separating machine that includes:
   (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 how to use it
   (e) an explanation of why it works
   (f) the advantages that your machine has for its particular use.

Think

8. Explain why cool, running water is passed through the distillation equipment shown below.



9. Explain why crystallisation is not suitable to purify water.
10. Explain why the mixture is placed above the level of the solvent rather than in the solvent in a chromatography experiment.
11. Zoe performs a paper chromatography experiment on waterproof markers using water as a solvent. Will her experiment work? Explain your answer.
12. Describe all the properties you can think of for:
    (a) salt
    (b) sand
    (c) water.
13. Explain how you would separate the parts of a mixture of salt, sand and water. Use the properties that you considered in question 12.

Investigate

14. An oil spill at sea can ruin the local environment and kill wildlife. Research and report on each of the following.
    (a) Find out how environmental and other authorities clean up oil spills at sea. List the properties of oil that allow each method to succeed.
    (b) When and where did the worst oil spill disaster occur and how was the oil separated from the sea water?
15. Investigate how to distill perfume.

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Watch this eLesson: 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

Complete this digital doc: Worksheet 5.4: Heating and distillation
Searchlight ID: doc-19826

Complete this digital doc: Worksheet 5.5: Crystallisation and distillation
Searchlight ID: doc-19827

5.6 Systems: Down the S-bend

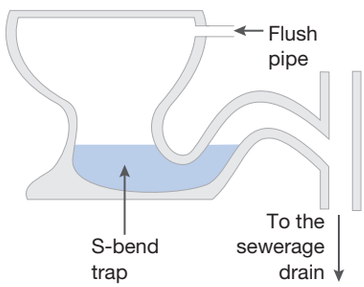
Every time you flush the toilet, have a shower, wash the dishes or your clothes or even clean your teeth, the waste water travels into an underground **sewerage** system.

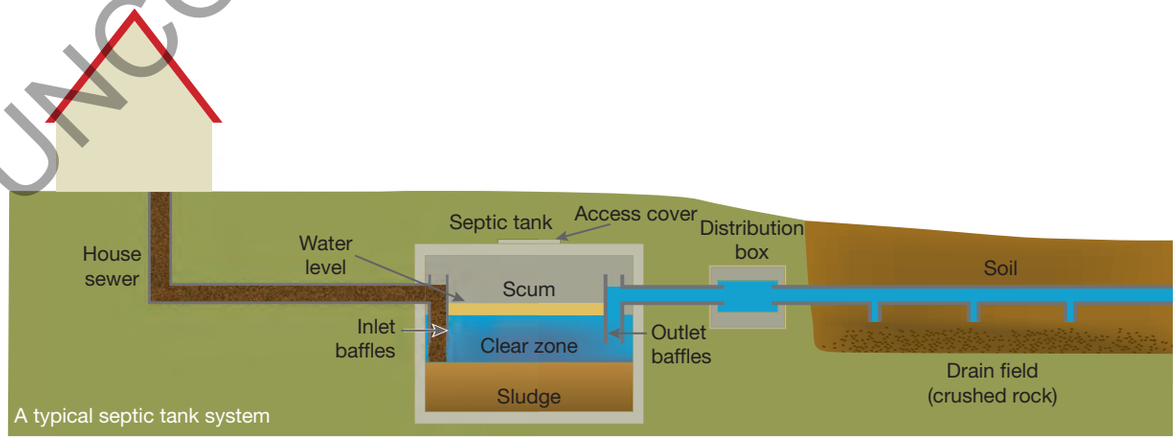
The waste water is a mixture of human body waste flushed down the toilet, detergent, dirt, toothpaste, food scraps and other materials washed down the drains. The mixture, which is mostly water, is called **sewage**.

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 flows into a personal sewage treatment system — a **septic tank** buried in the backyard.

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





A typical septic tank system

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.

5.6.1 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**) 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.

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 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.

5.6.2 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 (such as algae) that live there. Substances like these should be saved for collection by local councils.

Small objects such as 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.

5.6.3 Play it safe

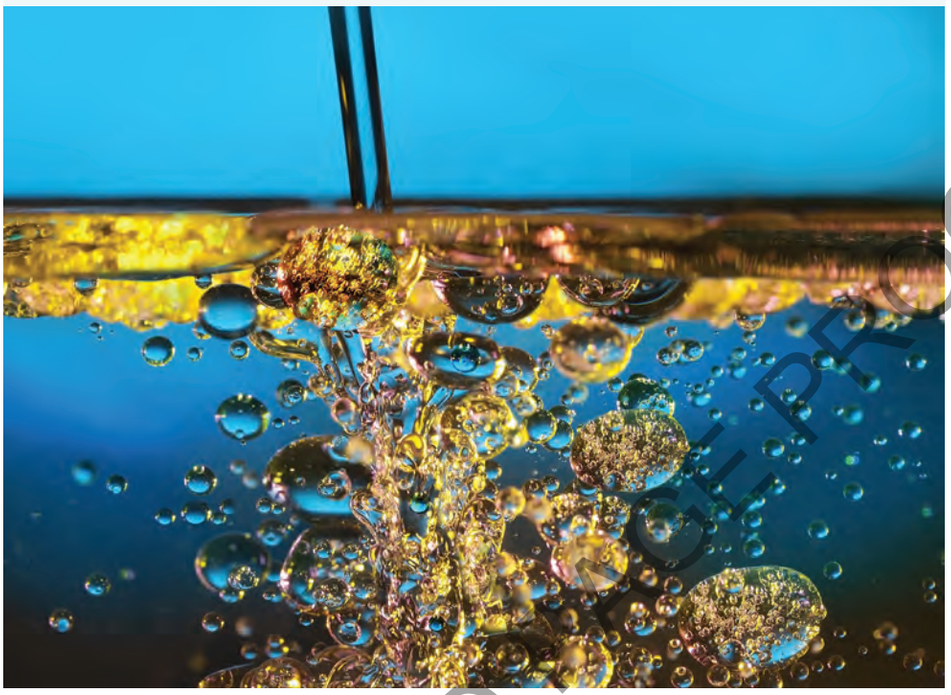
The best policy at home is to avoid putting down the sink anything solid or oily, or that you suspect may be poisonous or harmful to living things. Some things that can go down the sink at home in small amounts are:

- 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.

Fat and oil don't dissolve in water.



5.6 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

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. Describe two methods of separation used during the primary treatment of sewage.
4. What separation process takes place in lagoons during the secondary treatment of sewage?
5. Suggest why disinfectants that kill bacteria should not be poured down a septic system.

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.

Investigate

9. Find out the kind of treatment (primary or secondary) that is used for the sewage 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?
10. 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.

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Watch this eLesson: Treating sewage
Watch this video lesson to learn about water and sewage treatment and the use of recycled water in Australia.
Searchlight ID: eles-0059

Complete this digital doc: Worksheet 5.6: What do you know?
Searchlight ID: doc-19828

5.7 Fit to drink?

Science as a human endeavour

5.7.1 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.

5.7.2 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 it?

5.7.3 Would you drink this water?

Would you like your water to come out of the tap looking like what is in the glass below? 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 example of a colloid. Recall that a colloid is a cloudy mixture that contains suspended particles too small to be removed by filtering.

5.7.4 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 potassium 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.

INVESTIGATION 5.8

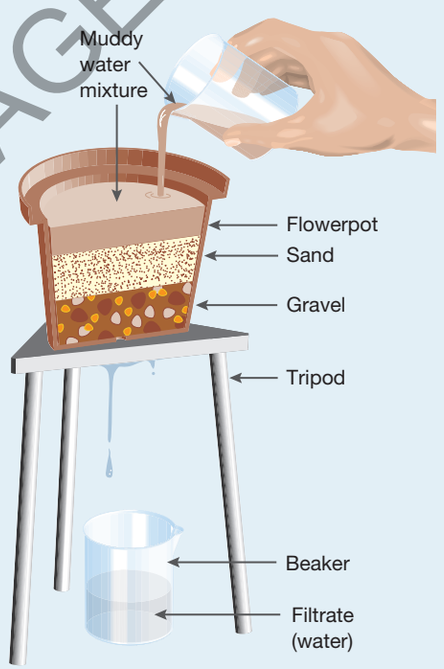
Treating your own dirty water

AIM: To separate clean water from dirty water

Materials:

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

A flowerpot water filter



Method and results

- 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.

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	

Discuss and explain

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.

5.7 Exercises: Understanding and inquiring

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Remember

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

Think

5. If you live in a country town that does not fluoridate the water, how could you obtain your fluoride?
6. What natural method of separating mixtures takes place in reservoirs over a long period of time?
7. Among the swimming pool products that are claimed to clarify pools or make them 'crystal clear' are super-floc, power floc and supa-floc.
   (a) Use the names to deduce the name of the process used by these products to assist in the separation of unwanted particles from the pool water.
   (b) Which process of separation takes place after the product has done its job?

Investigate

8. Home swimming pools are vacuumed using a pool vacuum cleaner. Find out how this type of vacuum cleaner works.
9. Seal pools at Melbourne Zoo and Taronga Zoo are kept free from contamination by a combination of filtration, chemical treatment with ozone, and a process called foam fractionation. Foam fractionation is used to remove solid seal waste, food waste, algae and other small particles from the pool without the use of a flocculant. Find out how a foam fractionator works.
10. List some examples of emulsions used in the home and explain what each example is used for.

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Complete this digital doc: Worksheet 5.7: Clean and clear?
Searchlight ID: doc-19829

5.8 Essential separation

Science as a human endeavour

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.

5.8.1 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.

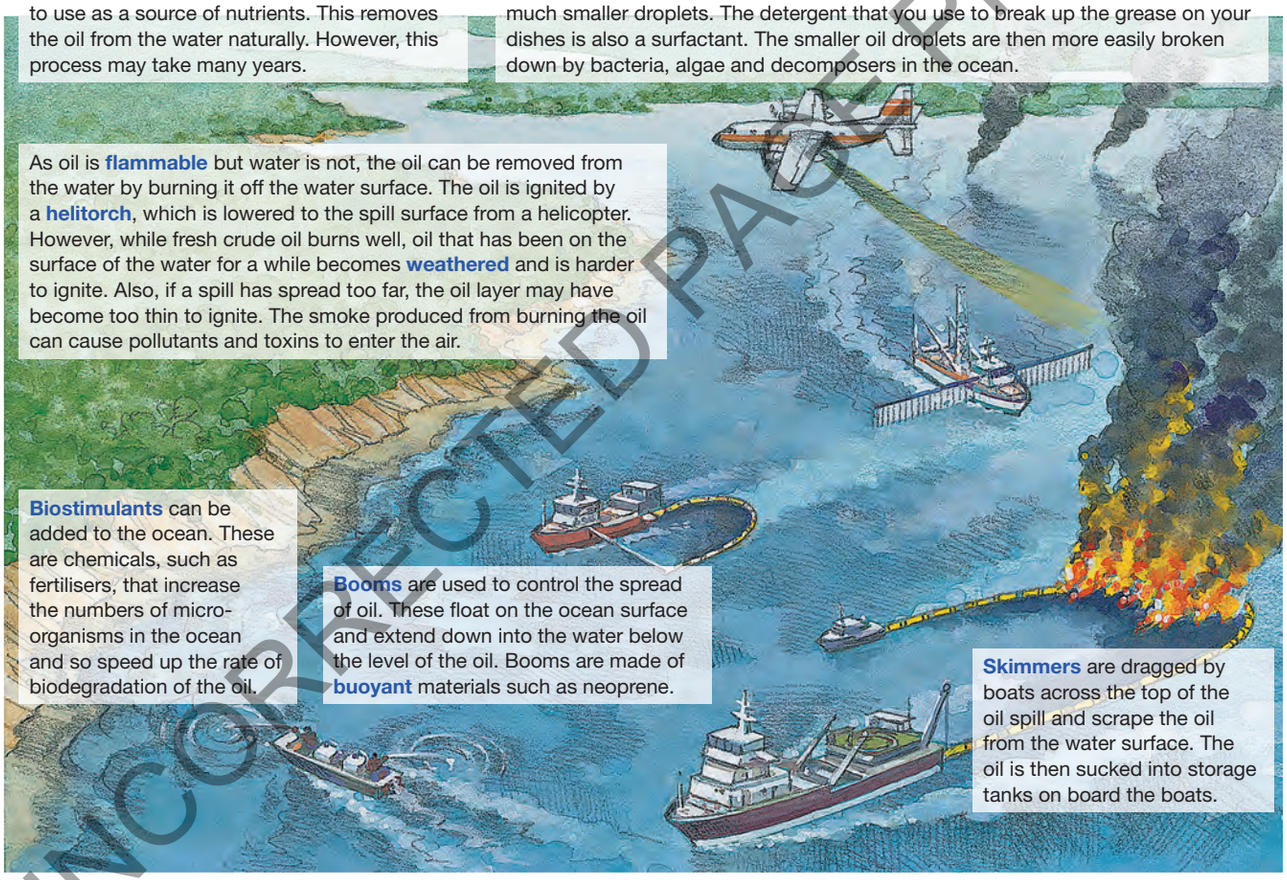
The mixture of gangue and copper ore that is dug out of the ground is in solid lumps. These lumps have to be crushed to a fine powder before the copper ore and gangue can be separated. Crushing takes place in a ball mill. This is a long barrel containing lots of heavy steel balls. As the barrel is rotated,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

How are oil spills cleaned up?

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. The slick covered thousands of square kilometres of ocean. Such a slick can be cleaned up by considering some of the different properties of oil and sea water.

How to clean up an oil spill!



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

INVESTIGATION 5.9

Separation by flotation

AIM: To model the separation of the gangue from mineral ore

Materials:

jar and lid *sawdust*
sand *teaspoon*

Method and results

- 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

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

5.8.2 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 floats 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.

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.

5.8.3 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 eggwhite, 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.

5.8.4 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.

5.8 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

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. Smoke stacks are used in many production plants and power stations to release waste gases and hot particles into the atmosphere. In some of these smoke stacks, an electrostatic precipitator is used to separate smoke, dust and other small particles and droplets from the waste gases before they are released into the atmosphere. Research and report on how electrostatic precipitators work.
10. Crude oil is a mixture of many different chemicals. Find out how crude oil is separated into the many different chemicals it contains.
11. Investigate the processes used to separate olive oil from the other liquids and solids in olives.

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Complete this digital doc: Worksheet 5.8: Separation techniques
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5.9 Essential recycling

Science as a human endeavour

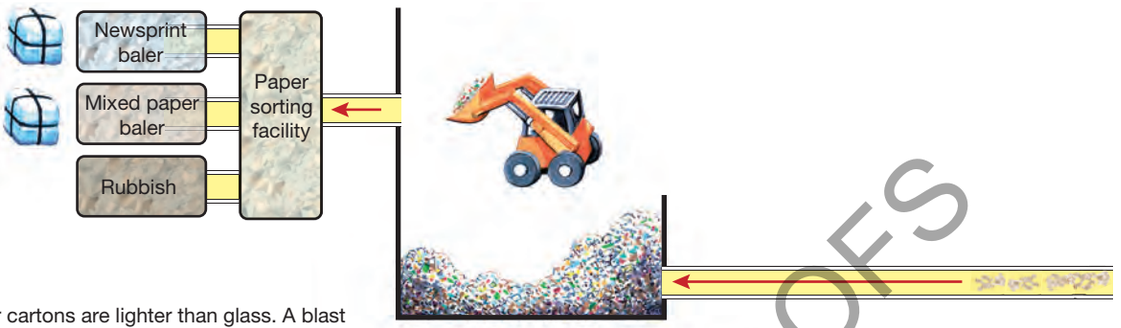
5.9.1 Essential recycling

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.

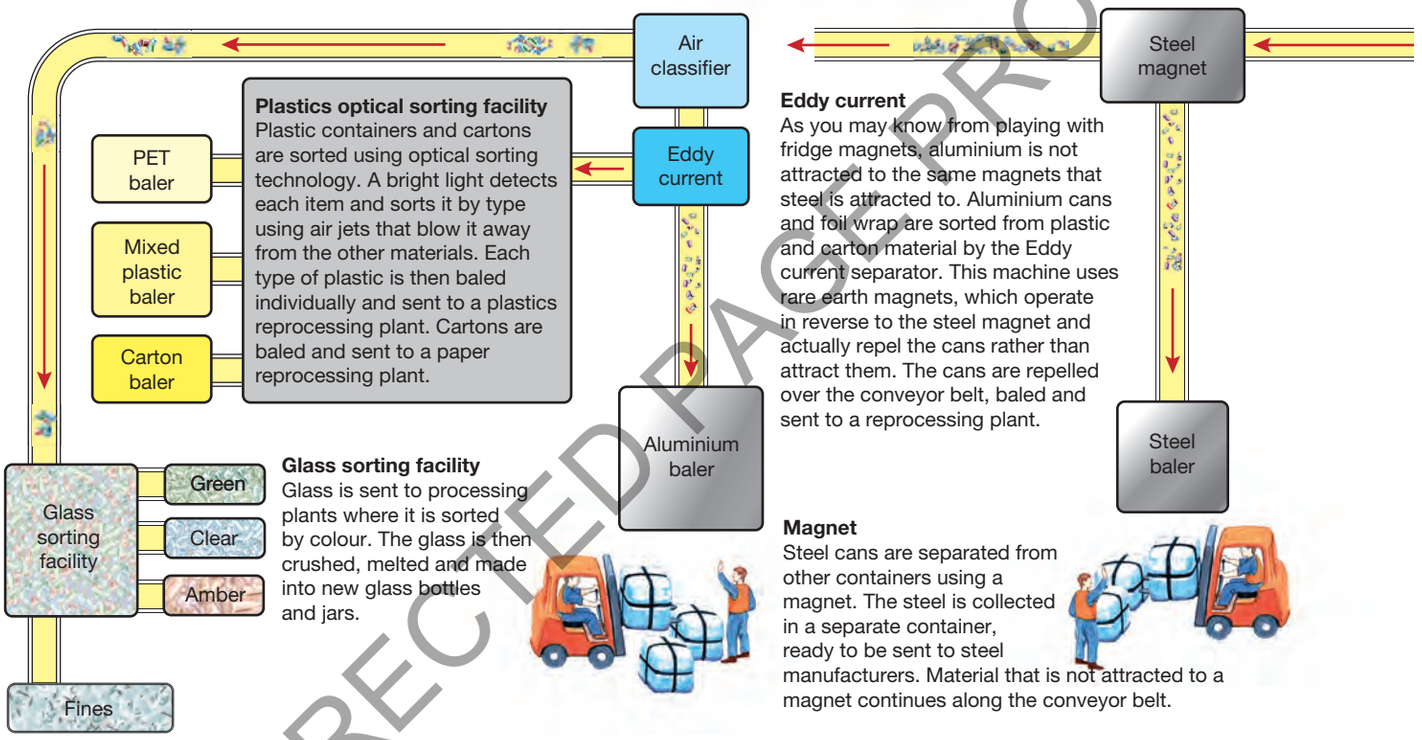
5.9.2 Separating by sight

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.

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.



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



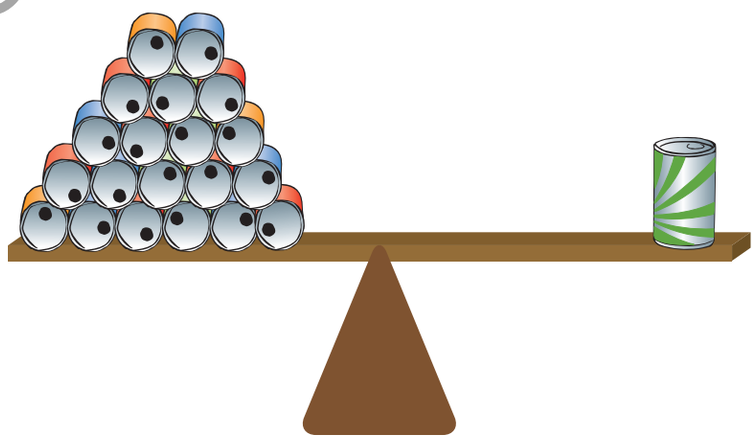
Plastics optical sorting facility
Plastic containers and cartons are sorted using optical sorting technology. A bright light detects each item and sorts it by type using air jets that blow it away from the other materials. Each type of plastic is then baled individually and sent to a plastics reprocessing plant. Cartons are baled and sent to a paper reprocessing plant.

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.

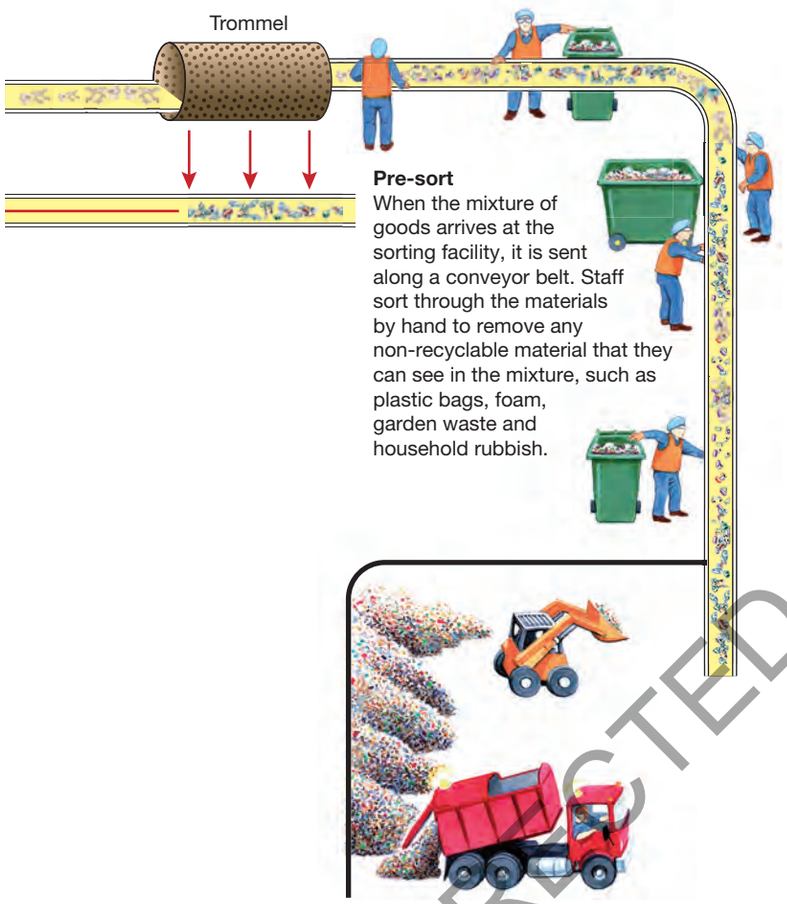
Glass sorting facility
Glass is sent to processing plants where it is sorted by colour. The glass is then crushed, melted and made into new glass bottles and jars.

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.

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.



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.



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.

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.

5.9 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

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 allow it to be separated from the mixture

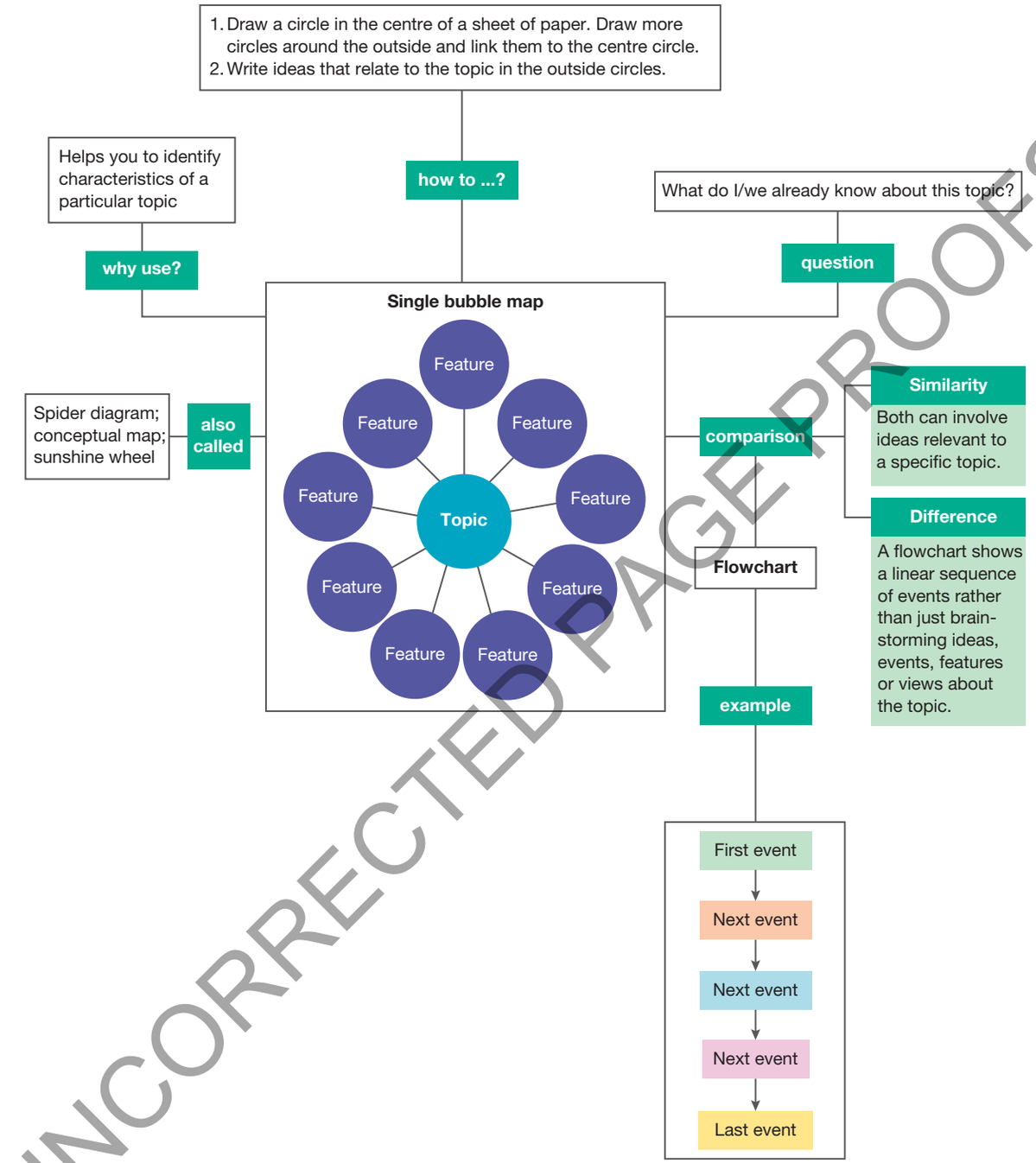
Method	What is removed?	Properties

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.

5.10 Single bubble maps and flowcharts

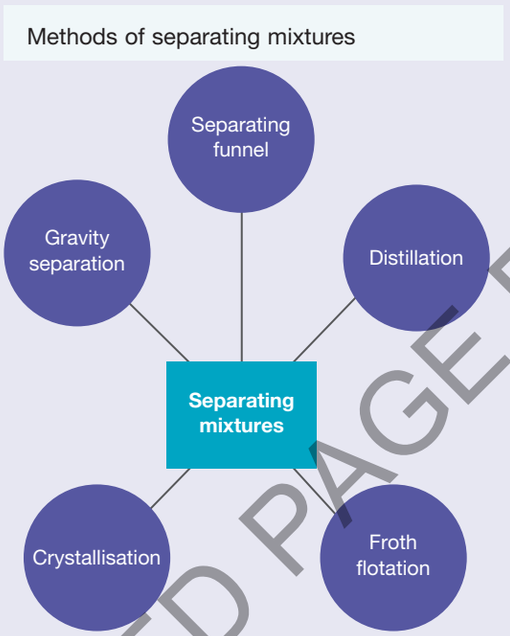


5.10 Exercises: Understanding and inquiring

To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. *Note:* Question numbers may vary slightly.

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:
   (a) salt from a mixture of sand, salt and water in a beaker
   (b) copper ore from the rocks dug out of a copper mine (see section 5.8).
4. Copy and complete the following flowchart to show how salt can be recovered from a mixture of salt and sand.

Step 1:	Add water to mixture and stir.
↓	
Step 2:	
↓	
Step 3:	Pour salty water into evaporating dish.

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

- Alum added to water
- Floc settles to bottom to form a sediment
- Water pumped to local water tower
- Water pumped from river or lake
- Water filtered through sand and gravel

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.

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Complete this digital doc: Worksheet 5.9: Single bubble maps and flowcharts
Searchlight ID: doc-19831

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5.11 Project: The diamond flush

5.11.1 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!

5.11.2 Your task

Choose one of these valuable items and determine the most likely place that the missing object would 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) would be subjected to as it undergoes treatment. You will then put together a PowerPoint presentation that explains the pathway along which the object would 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.

5.11.3 Process

Open the ProjectsPLUS application for this chapter located in your Resources section. Watch the introductory video lesson and then click the 'Start Project' button to set up your project group.

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Watch this 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

5.12 Review

5.12.1 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

5.12.2 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'

5.12.3 Separating mixtures

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

5.12.4 Science as a human endeavour

- explain how salt is separated from sea water in desalination plants and why the process is controversial
- 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

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5.12 Review 1: Looking back

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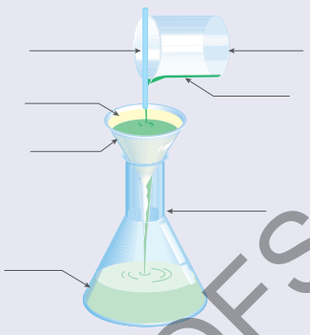
1. Construct a table with two columns with the headings 'Pure substance' and 'Mixture'. List the following substances under the appropriate heading: freshly made apple juice, tap water, soft drink, cake batter, sterling silver, distilled water, gold nugget, glass, cornflakes.
   You may have to research 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.
   (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 better 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. 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
15. Use a labelled diagram to illustrate the differences between the processes of osmosis and reverse osmosis used in desalination plants.
16. 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.
17. 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.
18. Muddy water is an example of a colloid. How is a colloid different from other suspensions?
19. Mayonnaise is an example of an emulsion, which is a type of colloid. How is an emulsion different from other colloids?
20. How does flocculation make the particles in a suspension settle out?
21. Explain why blood collected by the Red Cross Blood Service needs to be separated before it is used.
22. What is the purpose of the S-bend in the toilet?
23. Describe the two separating processes in a recycling plant that are done by sight.
24. 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

25. Explain why chlorine is added in small amounts to the water supplies of many cities.
26. Read the story below 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' and 'salt evaporation'.

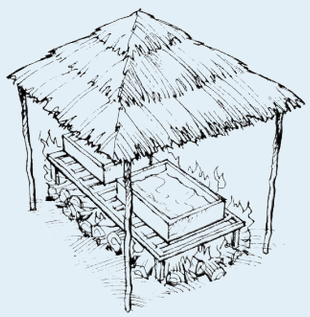
An ocean of salt

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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Complete this digital doc: Worksheet 5.9: Single bubble maps and flowcharts
Searchlight ID: doc-19831

Complete this digital doc: Worksheet 5.10: Summing up
Searchlight ID: doc-19832

Complete this digital doc: Worksheet 5.11: Looking back: Separating mixtures
Searchlight ID: doc-19833

Complete this digital doc: Worksheet 5.12: Science literacy
Searchlight ID: doc-19834