CHAPTER 2

Separating mixtures

You will discover

The properties of different mixtures

How to separate mixtures

How sewage is treated

How mixtures are separated in industry and for medical purposes

Pure chocolate?

This mixture of chocolates can be easily separated into colours. We can make up piles of red ones, blue ones and so on. But each pile is not pure chocolate. Each sweet is a mixture of a chocolate centre and a sugary coating. If we separate the centre from the coating we still won't have pure substances. Chocolate is a mixture of ingredients: cocoa, butter, sugar, milk and flavours blended together to give a great taste. The sugary coating is a mixture too. Even the colouring can be a mixture of colours.

Most substances on Earth are not pure. They are mixtures, like these chocolates. Some mixtures, like the water in the ocean, can be separated into pure substances quite easily. Others, like different gases in the air, are very difficult to separate.

1 Are the ingredients in chocolate pure or are they mixtures too?
2 How can we separate the different colours in the sugary coatings?
3 Apart from chocolate, air and water, what other substances are mixtures?
4 Why is it important to know how to separate mixtures?

Which are my shoes?

You're at a party — but your host won't let you wear shoes inside the house. So you take off your shoes and throw them on the pile beside the door.

When it's time to leave, you have to find your own shoes again. How do you do it? You probably recognise your shoes by their colour, shape, size and maybe even odour! These features are all **properties** of shoes.

The key to being able to find your shoes is knowing the properties of your own shoes. If you don't know their properties, you can't tell the difference between your shoes and all of the others in the mixture of shoes.

Properties are worth knowing

Properties of this gold ingot that we can see include:

- *Colour is yellow or gold.*
- *Base is rectangular with a slightly smaller rectangular top surface.*
- *The surface looks shiny.*

Other properties that we can't observe just by looking at the photo include:

- *It is heavy for its size.*
- *It is hard.*
- *It feels smooth.*

Anything that we can observe with our five senses is a property.

Some properties, such as the ability to conduct electricity, or to dissolve in water, or melt at a particular temperature, can be observed and measured in a laboratory.

Knowing the properties of different substances enables us to separate them from other substances in mixtures. This process is known as **separation**.

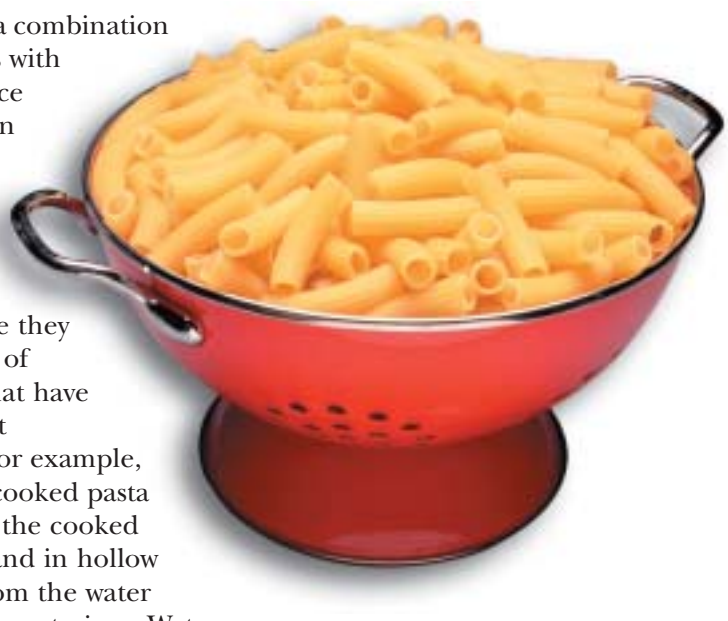
Big foot

The largest human foot belongs to an American, Matthew McGrory. His shoes are a size (US) 28.5. He wouldn't have too much trouble picking his shoes out of a pile!

Go to worksheet 6

Easy separating

A **mixture** is a combination of substances with each substance having its own properties. Some mixtures can be separated easily because they are made up of substances that have very different properties. For example, after you've cooked pasta you separate the cooked pasta (solid and in hollow cylinders) from the water (liquid) using a strainer. Water passes easily through the strainer, but the pasta gets caught.



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

Separating a mixture of iron and sand

You will need:
mixture of sand and iron filings (prepared by your teacher)
magnet
plastic wrap or small plastic bag.

- Cover the magnet with the plastic.
- Pass the magnet slowly over the mixture of sand and iron filings.
- Observe what happens as the magnet gets closer to the mixture.

1. Can you separate the two substances?
2. Why was the magnet covered with plastic?

Not-so-easy separating

Not all mixtures are as easy to separate as iron and sand, or pasta and water. If you dropped some fine sand in sawdust, it would be much harder to separate the mixture. The differences between the properties of sand and sawdust are not as easy to see as the differences between nails and sawdust.

It's a bit like trying to find your shoes in that giant pile. Imagine how hard that would be if all the shoes were the same colour and shape.

This chapter describes techniques used for separating other mixtures. All of the techniques make use of the different properties of the substances in the mixture.

Activities

REMEMBER

1. What is a mixture?
2. Why are some mixtures easier to separate than others?

THINK

3. List all the properties you can think of, for:
   (a) salt
   (b) sand
   (c) water.
4. How would you separate the parts of a mixture of salt, sand and water? Use your lists in the previous question to find a method.
5. Imagine you dropped nails in the sawdust at woodwork. Suggest two reliable ways of separating the nails from the sawdust.

INVESTIGATE

6. Design and carry out an experiment to separate a mixture of sand from salty water. Ask your teacher before you carry out the experiment. *Hint:* Separate one substance at a time.
7. How would you separate the sand from a mixture of sand and sawdust? Draw a flow chart to show the steps you would use. Check your method with your teacher before trying out your experiment.

BRAINSTORM

8. Make a list of the properties of shoes; for example, water resistance.

✓ checklist

I can:

- ☐ explain what mixtures are
- ☐ identify the properties of substances that allow simple mixtures to be separated.

Filtering at home

On a hot summer's day, the last thing you want is a dirty swimming pool. Even though the windows in your house are all open, you certainly don't want flies and mosquitoes inside. And when it's too hot to be outside, you wouldn't want to come inside to find the airconditioner blowing out dust.

Keeping things apart

When leaves land in a swimming pool, a **mixture** is formed. The flies, mosquitoes and dust in the air form another uncomfortable mixture. But the parts of each mixture can be separated using **filtration**.

Filters allow some substances through while blocking others out. Particles that are smaller than the holes in the filter will pass through. Bigger objects will be blocked.

Airconditioners filter air as well as cool it. They have very fine filters that are designed to stop small dust particles getting through. Air is drawn into the airconditioner and filtered before it is cooled.

Screens are placed on windows and doors to keep insects out. They filter the air that enters your home and prevent insects from entering.

A basket is used to filter leaves and other large objects from the water. The water is then pumped through sand or other fine filters to remove smaller particles from the water.

A dust bag in a vacuum cleaner has holes in it that allow air to pass through, but trap dust and dirt.

Go to worksheet 7

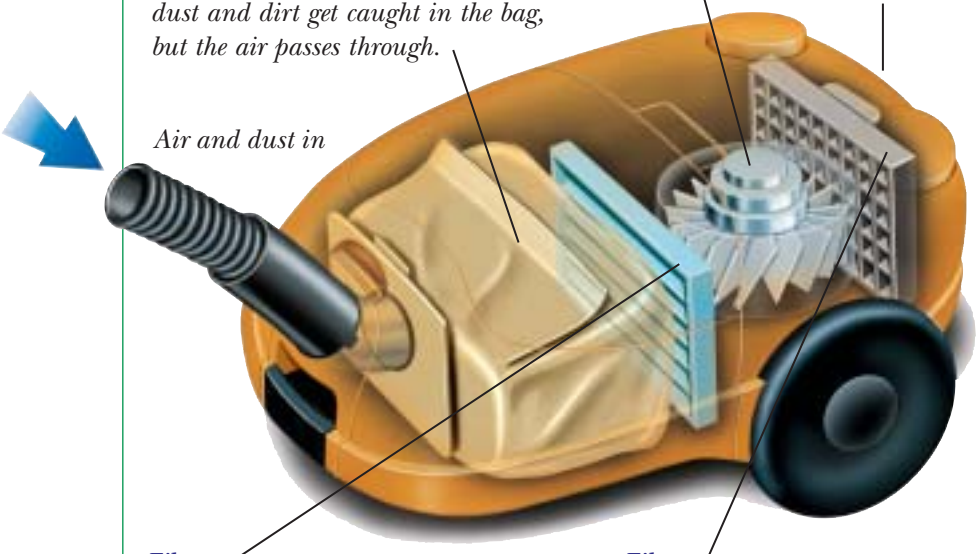
Cleaning up

Motor and fan
The motor turns a fan. The spinning fan creates the suction to draw in dirt, dust and air through the hose.

Dust bag
The dust bag in a vacuum cleaner is a filter. Dust particles, dirt and air are sucked into the dust bag. The bag has holes in it that are too small for dust and dirt to pass through. The dust and dirt get caught in the bag, but the air passes through.

Clean air out
Clean, dustless air leaves the vacuum cleaner.

Air and dust in



Filter
Some very small particles of dust may get through the dust bag. If dust passes through to the motor, the motor could be damaged. This filter catches small particles of dust that were not blocked by the dust bag.

Filter
Some vacuum cleaners have another filter to make sure that the air leaving the vacuum cleaner is clean.

Kitchen filters

The water that goes down our drains passes through many filters; the first is in the sink. The filter in the plughole stops food and scraps from the sink going down the drain.

The size of a filter depends on what needs to be blocked or stopped. The sink plughole filter has quite large holes. It is meant to stop only large food scraps getting through.

You wouldn't sift flour in a pasta strainer. The flour lumps would pass straight through. Tea strainers and coffee filters are much finer than pasta strainers. They need to stop small tea-leaves and ground coffee from flowing into the drink.

Activities

REMEMBER

1. What is the purpose of the dust bag in a vacuum cleaner?
2. Why does a sink have a plastic or metal insert in the plughole?
3. Why are holes in a pasta strainer bigger than the holes in a coffee filter?

THINK

4. Apart from insects, what else do screen doors keep out?
5. What property does filtration depend on?
6. The air that is drawn into a vacuum cleaner needs to pass through the dust bag before it leaves the vacuum cleaner at the other end. Why does a vacuum cleaner work better when the dust bag is empty?
7. Many kitchens have an exhaust fan. What mixtures would the filters above the stove separate?

BRAINSTORM

8. In groups of two or three, make a list of filters in each room of your home. What substances does each filter let through? What substances do they block?

INVESTIGATE

9. Find out what materials are used in fish-tank filters. Which ones are the best to use?

✓ checklist

I can:
- ☐ explain how filters work
- ☐ describe some uses for filters
- ☐ understand the need for differently sized filters.

Indonesia Review

28 August 2003 Weather: Sunny breaks, 18°C

Asia chokes

Every year a thick, hazy cloud moves over South East Asia. It's not a rain cloud. The dirty mix of smoke and fumes moves from Indonesia and Malaysia and spreads across to neighbouring countries.

The haze is the result of illegal forest fires lit by farmers, squatters and plantation companies. The fires pollute the air and threaten the survival of wildlife, including endangered species such as the Sumatran tiger and the orang-utan. Fires are a major cause of deforestation in South East Asia. In 1997 alone, over one million hectares of vegetation was destroyed by fire.

In 1997, *The Year of the Great Haze*, suffocating smoke affected 70 million people. The World Health Organisation has warned that haze-related deaths will increase. Although the fires have been less intense this year, officials have sent out health warnings to all residents on the Borneo and Sumatran islands. Hospitals are on alert, ready for an increase in breathing-related illnesses.

Residents are advised to:

- stay indoors as much as possible
- keep windows closed
- block all doorways and air vents with wet towels.

Those willing to risk going outside are buying face or gas masks to **filter** the air they breathe. Officials have warned that many of the masks are poor quality and do not protect the wearer's lungs.

Indonesian and neighbouring governments are trying to save the environment and protect people's health. Fire fighters have been sent to fight the fires instead of allowing the blazes to burn out. The Indonesian environment minister released the names of the plantation companies involved. But will tougher laws and stricter enforcement stop the illegal fires? Stan Ward, an Australian fire-fighting volunteer in Indonesia, doesn't think so. 'These guys will just light another fire across the road from where you are putting a fire out', he said.

Learning from Mexico City

High **pollution** figures released by Enviro Asia today revealed that of the 15 most polluted cities in the world, 12 are located in Asia. Much of the air pollution comes from cars, factories and power stations. As industries expand through Asia, governments are looking for help.

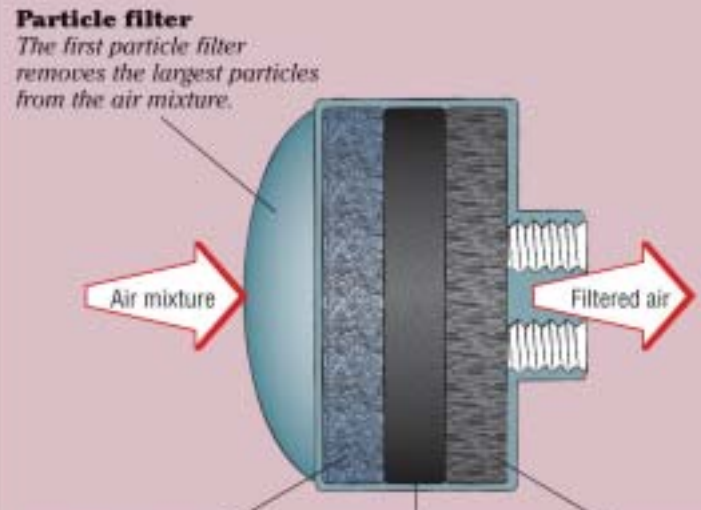
Mexico City has a long history of pollution and is still one of the most polluted cities in the world. Residents and governments of Mexico City are working together to create cleaner air and want to pass on what they have learned.

The government of Mexico City has set strict guidelines for industries and cars. All new cars in Mexico City are fitted with **catalytic converters**. These filters can be fitted to car exhaust systems. Harmful chemicals such as carbon monoxide and unburned hydrocarbons are released when fuel burns. As they pass through the catalytic converter, some of the harmful chemicals are trapped and others react to form less dangerous emissions.

Mexican officials will assess the situation in Asia. They have warned all industrial nations that without careful planning and strict guidelines, many more cities could become just like Mexico City, or even worse.

Gas mask sale!

Our gas masks are guaranteed to thoroughly purify air to meet strict standards.



Remember: Replace your filters on a regular basis.

Activities

REMEMBER

1. List three causes of air pollution.
2. List three filters mentioned in this newspaper article and advertisement.
3. Briefly describe a device used to **purify** the air we breathe.

THINK

4. Why are **concentrations** of gases like carbon monoxide greater in cities than in country areas?
5. Why do the filters from gas masks need to be replaced regularly?
6. Why were the residents of Borneo and Sumatra asked to block doorways and air vents with wet towels?
7. Suggest a reason why old cars have been banned from use in cities like Beijing and Mexico City.
8. The cloth masks that the people in the photograph are wearing do not filter many harmful chemicals from the air. Explain why the harmful chemicals can get through, but the dust particles cannot. Draw a diagram to help with your explanation.

BRAINSTORM

9. In groups of three or four, make a list of the ways in which we can reduce pollution from cars. In your list, include ways to reduce the number of cars on the road.

✓ checklist

I can:

- ☐ appreciate the problems caused by air pollution
- ☐ describe ways to purify air
- ☐ understand how a gas mask works.

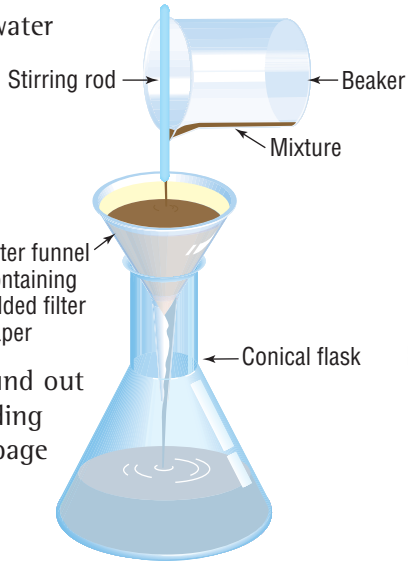
Going bush

After a long hike in the bush, a cup of billy tea would be delicious — except for the floating tea-leaves. A bottle of water collected from the creek would be thirst quenching — except for the muddy bits!

If you've ever been camping, you may have found yourself without the comforts of home. You probably didn't bring a tea strainer or a water purifier. How could you **filter** out the bits that you don't want?

Muddy water

You will need:
sample of muddy water
beaker
filter funnel
filter paper
stirring rod
conical flask.



- Fold the filter paper into quarters to form a cone. You can find out more about folding filter paper on page 244 of the Laboratory Toolbox.
- Place the filter paper in the filter funnel. Wet the paper a little to hold it in place.
- Set up the equipment as shown.
- Slowly pour the muddy **mixture** down the stirring rod and into the filter funnel.

!CAUTION: Do not allow the mixture to flow over the top of the filter paper.

1. Describe the sample of muddy water. For example, did the mud float on top of the water? Was it spread throughout the water?
2. The substance that passes through the filter, in this case the water, is called the **filtrate**. Describe the appearance of the water after it passes through the filter paper.
3. The parts left in the filter paper are called the **residue**. Describe the residue left on the filter paper.

Getting rid of mud

Muddy water is an example of a **suspension**. The dirt is suspended in the water, where it is still visible and doesn't **dissolve**. If you leave the muddy mixture to stand for a while, the dirt particles will sink to the bottom of the container. This important property helps us to separate dirt from water, even if we don't have a filter.

The muddy water can be **decanted** to separate the dirt from the water. Firstly, the mixture is left to settle. The dirt particles form a **sediment** on the bottom of the container. Secondly, the clean water from the top is poured off, or decanted carefully.

Decanting does not separate the muddy mixture as well as filtering. Some water is left in the residue. Some particles of dirt will be washed into the decanted water.

!CAUTION: Drinking creek water after filtering out the mud is only safe if you can be certain that no industrial wastes, harmful chemicals or germs have entered the water.

A camp cuppa

Billy tea is also a suspension. The tea-leaves are suspended in water. The tea-leaves are **insoluble**; that is, they won't dissolve in water. If left to stand, they will settle to form a sediment. To drink a cup of tea, the mixture could be decanted or filtered to remove the tea-leaves. Spinning the mixture very quickly also separates the leaves from the tea.

The method of spinning a mixture to separate its parts is called **centrifuging**. Solid suspensions are often separated from a liquid using a centrifuge. Two liquids can also be separated this way. The heavier parts of the mixture are forced to the outer edge of the centrifuge. The lighter parts can then be decanted off.

The tea is ready to drink after a few swings of the billy. The tea-leaves form a sediment on the bottom of the billy.

Making billy tea

No camping trip would be complete without billy tea. Billy tea was traditionally made in a metal can that was heated over a campfire.

Then a handful of dry tea-leaves was tossed into the boiling water and left to brew for a few minutes. For extra flavour, early settlers sometimes added gum leaves to the water as it boiled. To make the leaves settle to the bottom, the billy was swung in full circles at arm's length. Three anticlockwise spins and the tea was ready to drink. But they had to be careful. A timid swing or one ending in the wrong spot could result in a hot and painful soaking … and no billy tea!

Activities

REMEMBER

1. When **filtration** separates a mixture of muddy water:
   (a) which part is the filtrate?
   (b) which is the residue?
2. What happens to a suspension if it is left to stand for a long time?
3. Which method of separation uses spinning to separate the parts of the mixture?

THINK

4. What properties of water and dirt make them ideal to separate using filtration?
5. What properties of tea-leaves and water make them ideal to separate by centrifuging?
6. Early settlers would spin the billy three times in an anticlockwise direction before drinking their tea. Would it make any difference if the billy was spun in a clockwise direction? Explain your answer.
7. During filtration, why is it important that the mixture is poured carefully?

CREATE

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

checklist

I can:

- ☐ use filtration to separate the parts in a suspension
- ☐ explain how sedimentation, decanting and centrifuging can separate the parts in a suspension.

Mixtures to consume

Most of the food we eat and most of the liquids we drink are **mixtures**. Some, like fresh orange juice, form **sediments**. They are **suspensions**. But others are different types of mixture.

Drinking solutions

Most fizzy drinks are not suspensions. They are **solutions**. These solutions are made from carbon dioxide, sugar and flavours dissolved in water. Substances that **dissolve** are said to be **soluble**. Soluble substances do not settle to the bottom of a container. They spread evenly throughout the solution and can't even be seen.

Filtering cannot separate the substances in a solution. The dissolved substances pass straight through very fine **filters**. You can tell if a mixture is a solution by holding it up to the light. If it is a solution, you can see through it.

Cordial is a solution that you can easily make yourself. You can alter the flavour of cordial by changing the **concentration** of the solution. The more syrup you add, the more concentrated the solution becomes. If you add too much syrup, you can **dilute** it by adding more water.

Parts of a solution

Both cordial and fizzy drinks contain water. The water is a **solvent**. The sugars, flavours and carbon dioxide are all **solutes**. Solutes dissolve in solvents to form solutions.

Water is a good solvent, because many substances dissolve in it. Eucalyptus oil is a solvent for grease stains, because grease dissolves in it.

More edible mixtures

Another type of mixture is a **colloid**. Particles of one substance are spread evenly throughout another. Substances that form colloids can be solids, liquids or gases. These mixtures are not clear, like solutions, but do not settle to form sediment like suspensions.

An **emulsion** is a special type of colloid. Emulsions are formed when one liquid is spread evenly through another liquid and does not settle in a layer.

Fresh pumpkin soup is a colloid. Small bits of pumpkin are spread through water and do not settle in a layer.

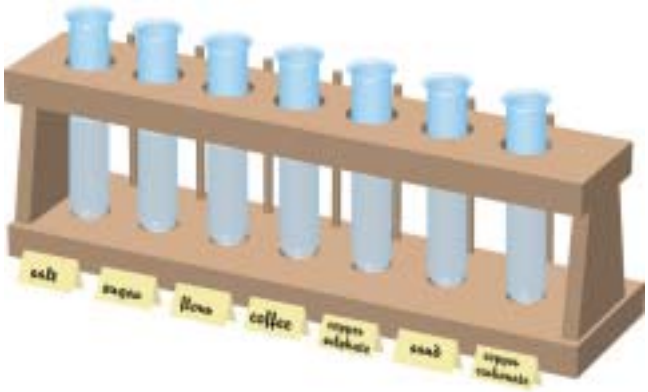
Marshmallows are colloids. They are mixtures of air spread through sugar and other ingredients.

***Homogenised* milk** *is an emulsion. It is made from butterfat (oil) spread through water. Both parts of this mixture are liquids.*

Go to worksheet 8

Soluble or insoluble?

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



- Half fill each of the test tubes with cold water.
- Label the test tubes salt, sugar, flour, coffee, and so on.
- Use a spatula to add a very small amount of each substance to its labelled test tube. Do not use more than a quarter of a spatula full.
- Shake each test tube. Refer to page 244 of the Laboratory Toolbox for instructions on how to do this.
- Draw up a table of your results like this incomplete one:

Substance mixed with water	Clear or cloudy?	Solution (soluble) or suspension (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 a solution or a suspension. Record this in the table.

1. Which of the substances dissolved in water?
2. How can you tell if a substance has dissolved?
3. Which of the mixtures could be separated by **filtration**?

Activities

REMEMBER

1. What solutes are present in fizzy drinks?
2. Which two types of substance mix to form emulsions?
3. Label the solvent, solute and solution in this photo:

THINK

4. Is fog a solution, suspension or colloid? Explain your answer.
5. Non-homogenised milk separates into two parts if it is left to stand. But homogenised milk does not settle. It is an emulsion.
   (a) What type of mixture is untreated milk?
   (b) Cream and butter are both made from milk. What types of mixture are cream and butter?

INVESTIGATE

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

CLASSIFY

7. In groups of three or four, decide whether the following substances are suspensions, solutions, colloids or combinations of these. Write down a reason for each decision. Share your results with the class.
   muddy water cup of coffee
   mayonnaise whipped cream
   hot chocolate
   cup of tea with tea-leaves in it

checklist

I can:
- ☐ describe how solutions are formed
- ☐ distinguish between suspensions, solutions and colloids
- ☐ explain how to dilute concentrated solutions.

Salty solutions

The oceans and seas hold most of the world's water. So, castaways stranded on an island in the ocean should have no trouble finding a drink. But sea water is far too salty to drink! So, how can pure water be **separated** from a salty-water **mixture**?

A solution to the problem

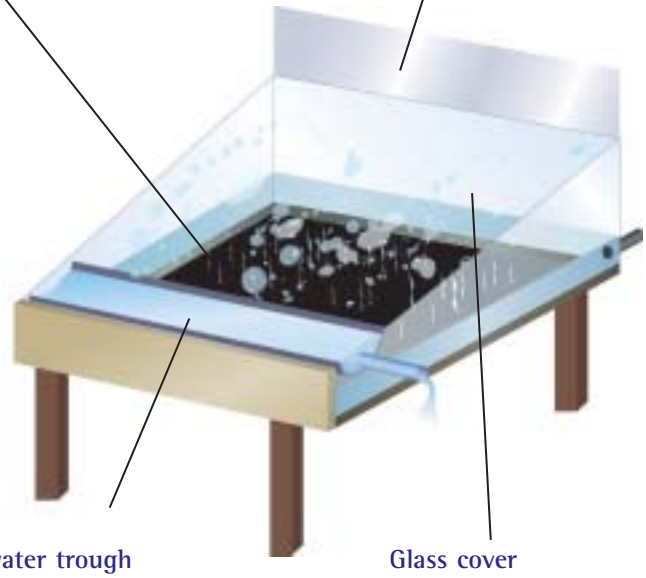
Sea water contains salt and many other substances. Larger objects, like seaweed and bits of shell, can be removed by filtering the mixture. But the filtered salty water is a solution. The salt will not separate from the water during the filtering process. Another method, called **distillation**, can be used to **purify** the water.

Solar distillation

Life-saving water stills have been built in many places where fresh water is scarce. Water stills heat water, evaporate vapour from the mixture and collect the pure 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.

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.

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.*

Water, water!

Nearly 98 per cent of the Earth's water is salt water! Most of it is stored in the seas and oceans. Much of the remaining water is stored in the ice caps of Antarctica and around Greenland. Only a small percentage of the Earth's water is available for our use because we do not currently purify sea water.

Why is it that we don't purify sea water?

Hint: Consider the costs and effects on the environment.

Go to worksheet 9

Crystallisation and distillation

You will need:

Bunsen burner, matches and a heatproof mat
tripod and gauze mat
evaporating dish
salt-water mixture
safety glasses and laboratory coat
distillation kit (such as Quickfit apparatus).

What is distillation?

Distillation separates substances by heating them and collecting the vapour that is boiled off.

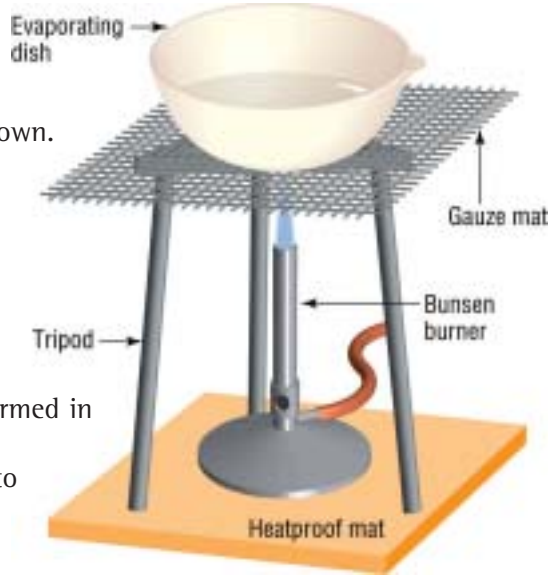
This method separates:

- solutions where a solid has been dissolved in a liquid
- two liquids that have different boiling points.

After distilling, the two substances in the mixture are separated into different containers. One remains in the original container. The other is collected as a vapour and cooled to become a liquid again.

Part A Crystallisation

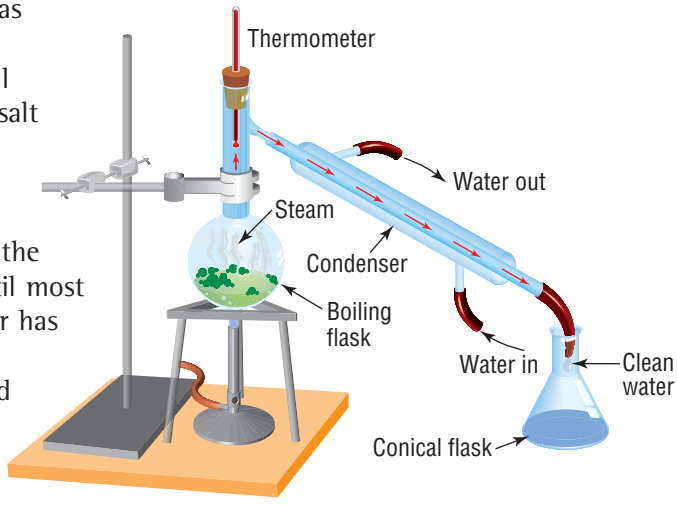
- Pour a small amount of salt water into the evaporating dish.
- Place the evaporating dish on the gauze mat as shown.
- Gently boil the salt water until most of the water has evaporated.
- Once the dish has cooled, observe its contents.



1. What **residue** has formed in the dish?
2. What has happened to the water?
3. This method of separation is called crystallisation. What could it be used for?

Part B (teacher demonstration) Distillation

- Set up the distillation equipment as shown.
- Pour a small amount of salt water into the boiling flask.
- Gently boil the mixture until most of the water has evaporated.



4. When would distillation be used instead of crystallisation?
5. What is the purpose of the water surrounding the condenser?

Activities

REMEMBER

1. Which methods of **separation** can be used to separate the parts of a solution?
2. What is the purpose of the glass cover of a solar water still?

THINK

3. What difference in properties does distillation rely on?
4. Why is crystallisation not suitable for purifying water?
5. Where does table salt come from?
6. Find out how distillation is used in industry.

CONNECT

7. Go to www.jaconline.com.au/science/weblinks and click on the Perfume link for this textbook to find instructions on how to distil perfume. Try using orange peel, flower petals or leaves.

checklist

I can:

- ☐ describe the processes involved in distillation and crystallisation of mixtures
- ☐ use crystallisation to separate the parts of a solution.

Separating colours

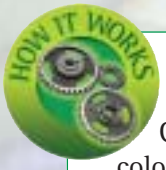
For thousands of years, people have added colours to food. The colours made food more appealing. Early civilisations used saffron and other spices to colour some foods yellow. Some of the colours added to the taste, but some were poisonous.

Today, colours are added to food for many reasons. Some colours protect vitamins that are affected by sunlight. Other colours replace colours lost during storage. Some fruits and vegetables are coloured to give them a more even appearance. Other foods, like lollies, are coloured just for fun!

Safe colours

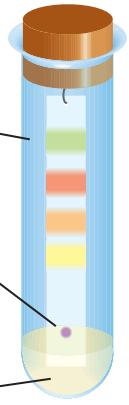
Because some colours added to food in the past were actually poisons, colours and other additives must pass strict tests before they can be used in foods. Foods with added colours can be tested at any time to identify the particular additives that have been used.

One method used for testing is called **chromatography**. Even foods that appear to be just one colour could be a mixture of colours. Chromatography separates out the different colours in the **mixture**.



Chromatography

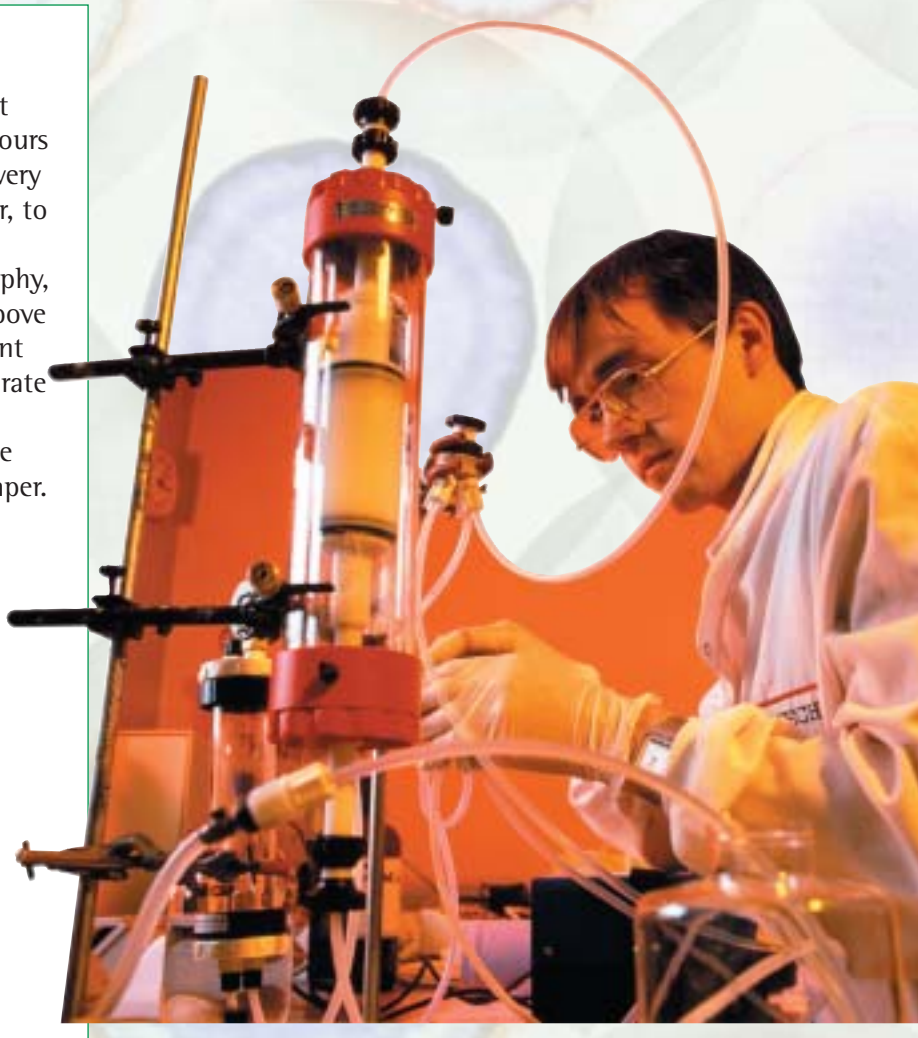
Chromatography works because different colours have different **solubilities**. Some colours **dissolve** more easily than others. Water is a very good **solvent** for many food colours. However, to **separate** the colours, they are not all placed straight into the water. For paper chromatography, the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



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

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

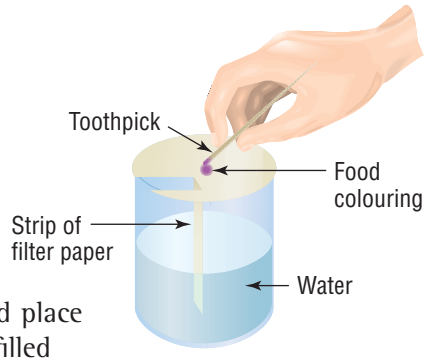
Solvent
The filter paper is hung so that it just dips into the solvent. The solvent soaks up the strip of filter paper, taking the food colours with it.



A chromatograph automatically separates mixtures by chromatography.

Separating colours with chromatography

You will need:
food colouring
filter paper
beaker
toothpick
scissors.



- Cut a strip into the filter paper and place it over a half-filled beaker of water. The strip should just dip into the water.
- Use the flat end of a toothpick to place a small amount of food colouring onto the centre of the filter paper.
- Wait for the water to soak up into the filter paper. Observe the mixture as it separates into different colours.
- Try this experiment with other food colourings.

1. Are the colours used in food colouring single colours or mixtures of colours? Explain your answer.
2. How many colours in total are needed to make each of the different food colourings that you tested?

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**.

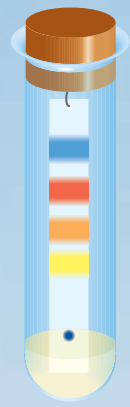
Forensic scientists use gas chromatography to detect a range of substances, including traces of illegal drugs. They can also use chromatography to compare mixtures found at crime scenes with those found on suspects. Many mixtures contain a unique combination of substances. For example, ink from different 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.

Activities

REMEMBER

1. Complete the sentence: Chromatography is a method used to separate parts of a mixture with different _____.
2. Why is water used as a solvent to separate food colours?
3. List the colours found in this ink, from:
   (a) the fastest moving to the slowest moving
   (b) the most soluble to the least soluble.
4. List three uses of chromatography in industry.



THINK

5. Why is the mixture placed above the level of the solvent in chromatography?
   Hint: What would happen if the mixture was placed in the solvent?
6. Zoe performs a chromatography experiment on waterproof markers using water as a solvent. Will her experiment work? Explain your answer.

CREATE

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

INVESTIGATE

8. Investigate different types of solvent that could be used to separate pen ink and waterproof markers. Before running the experiment, have your choice of solvents approved by your teacher. As a starting point, you may wish to use methylated spirits.
9. Does the colour of food affect whether or not people choose to buy and eat it? Design an experiment to test your answer.

checklist

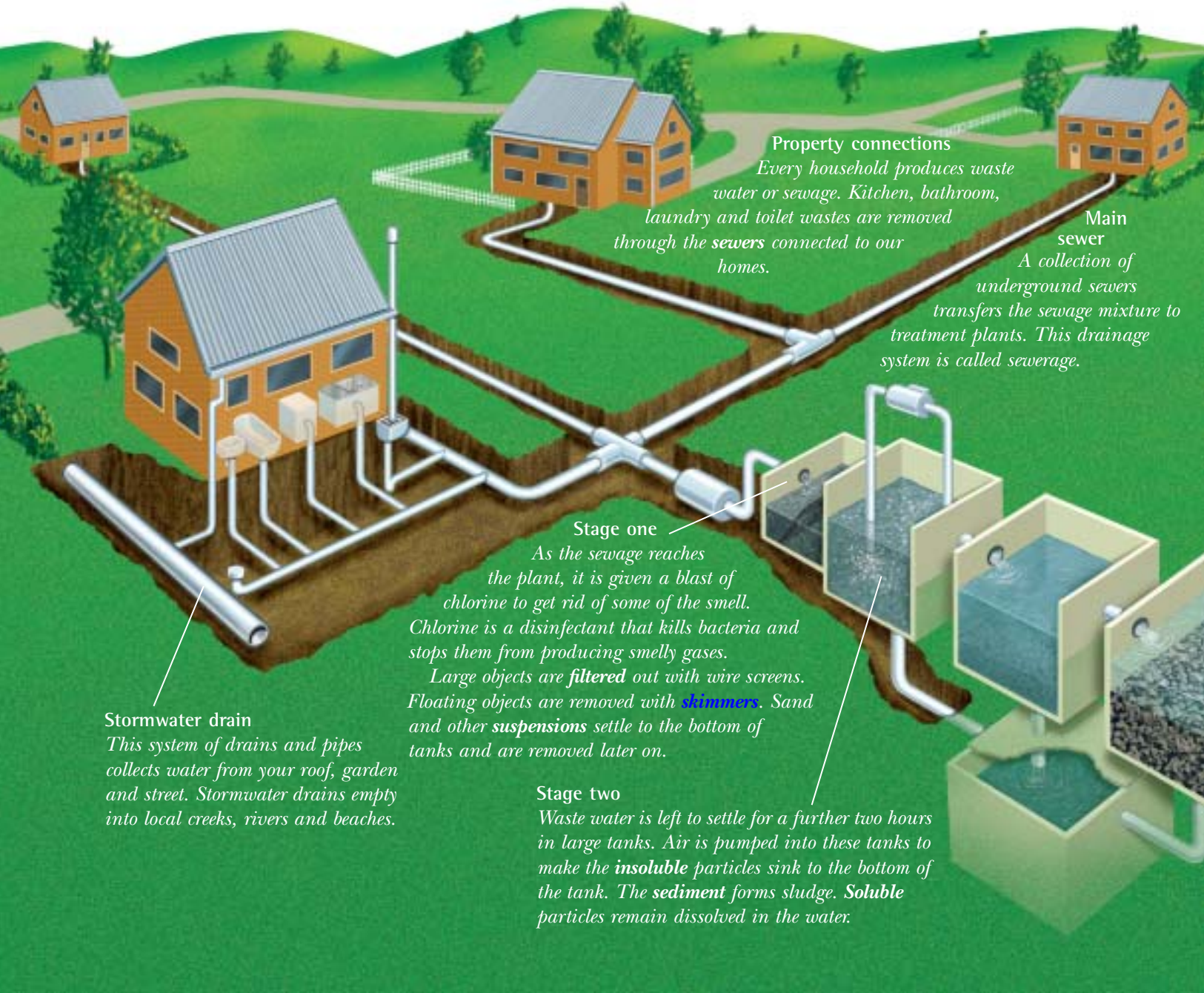
I can:
- ☐ explain, in basic terms, how chromatography works
- ☐ use chromatography to separate mixtures of colours
- ☐ describe examples of how chromatography is used in industry.

Flushing wastes

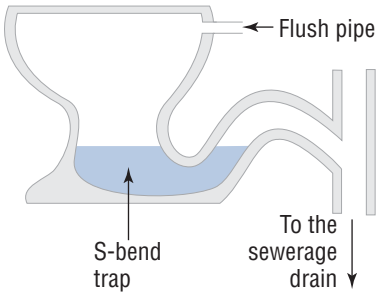
The waste water that flows from toilets, laundries, bathrooms and kitchens must be purified before the water is used again or released into the sea. **Bacteria**, which can cause diseases, also needs to be removed before the waste water is safe to reuse or release into the environment.

Separating and treating

The introduction of a **sewerage** system through Melbourne stopped the spread of diseases like typhoid. A system of drains now transports **sewage** to water-treatment plants. One water-treatment plant is in the suburb of Werribee, south-west of Melbourne. The plant separates the water from the other parts of the sewage mixture. Purified water from the sewage mixture can be released back into Port Phillip Bay and major rivers. It is also used for irrigation of crops. This important separating process keeps our waterways, beaches and drinking water clean and free from **contamination**.



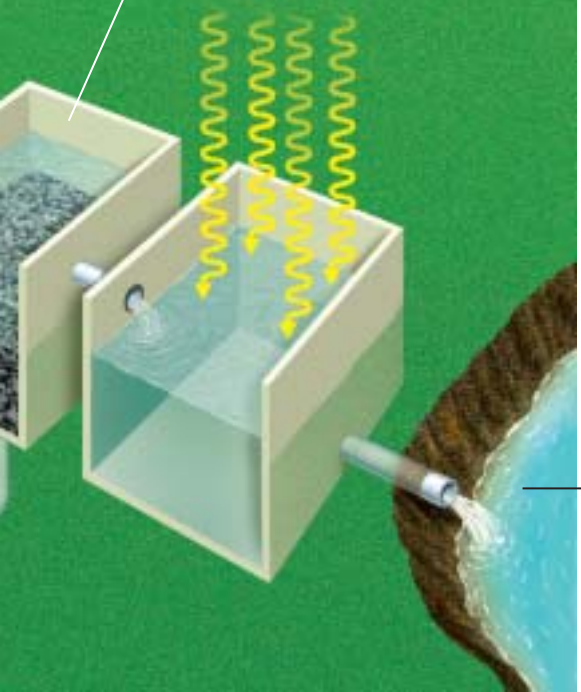
Filtering out bad smells



Bacteria and substances that are washed down with waste water can have a bad odour. The sewer pipes that remove waste water from your home fill up with smelly gases. A simple filter keeps the smells from entering your house.

The pipes that carry waste water from toilets and sinks have bends in them called S-bends. The bends fill with water, which acts as a filter. Gases cannot pass through the water back into the house, so our homes stay odour free!

Stage three
'Good' bacteria feed on materials that are still in the waste water. The water is trickled through layers of stone, where the bacteria remove the last traces of waste from the water.



Outlet to sea
The water is given one last dose of chlorine, to kill the bacteria. The water then passes through ponds, where sunlight ***disinfects*** *the water before it is released to Port Phillip Bay or used for irrigation.*

Smelly old Smellbourne

If you walked the streets of Melbourne in the 1880s you would understand how Melbourne earned the name 'Smellbourne'. Kitchen, bathroom and laundry waste water was poured into open drains along the streets. Even human toilet wastes floated along these drains. Industry and animals added to the murky mixture that flowed from the drains into the rivers and out into Port Phillip Bay. Clean drinking water wasn't easy to find, because the rivers and lakes were becoming contaminated. Bacteria which cause diseases, such as typhoid, were spread by these open drains.

Activities

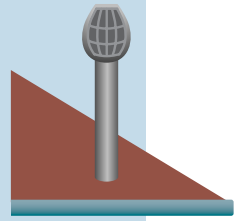
REMEMBER

1. How was clean drinking water being contaminated in Melbourne in the 1880s?
2. From which rooms of a house does the sewer remove waste water?
3. Which separating method removes large objects from sewage mixtures?

THINK

4. Explain the difference between sewage and sewerage.
5. How does the environment benefit from separating water from the other substances in sewage?
6. Why should harmful chemicals and rubbish never be poured down stormwater drains?

OBSERVE



7. Vent pipes and gully traps allow any smelly gases to escape from the sewer pipes.
   (a) Where are the vent pipes and gully traps in your home?
   (b) What would happen if the gully trap was covered?

CONNECT

8. Go to www.jaconline.com.au/science/weblinks and click on the Think Before You Flush link for this textbook. Make a list of items or substances that you should not pour down the kitchen sink or flush down the toilet. In a two-column table suggest why each item should not enter the sewerage system.

checklist

I can:

- ☐ explain how sewage travels from my home to the treatment plant
- ☐ understand the different separating methods used with sewage.

Recycling products

Most local councils have a **recycling program**. Items such as paper, some plastics, glass, aluminium and steel can be recycled and made into new products.

Recycling reduces the amount of rubbish created and saves precious resources such as trees and bushland. Many **manufacturing processes** pollute the environment. Recycling and reusing materials reduces the need for manufacturing processes.

Separating by sight

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

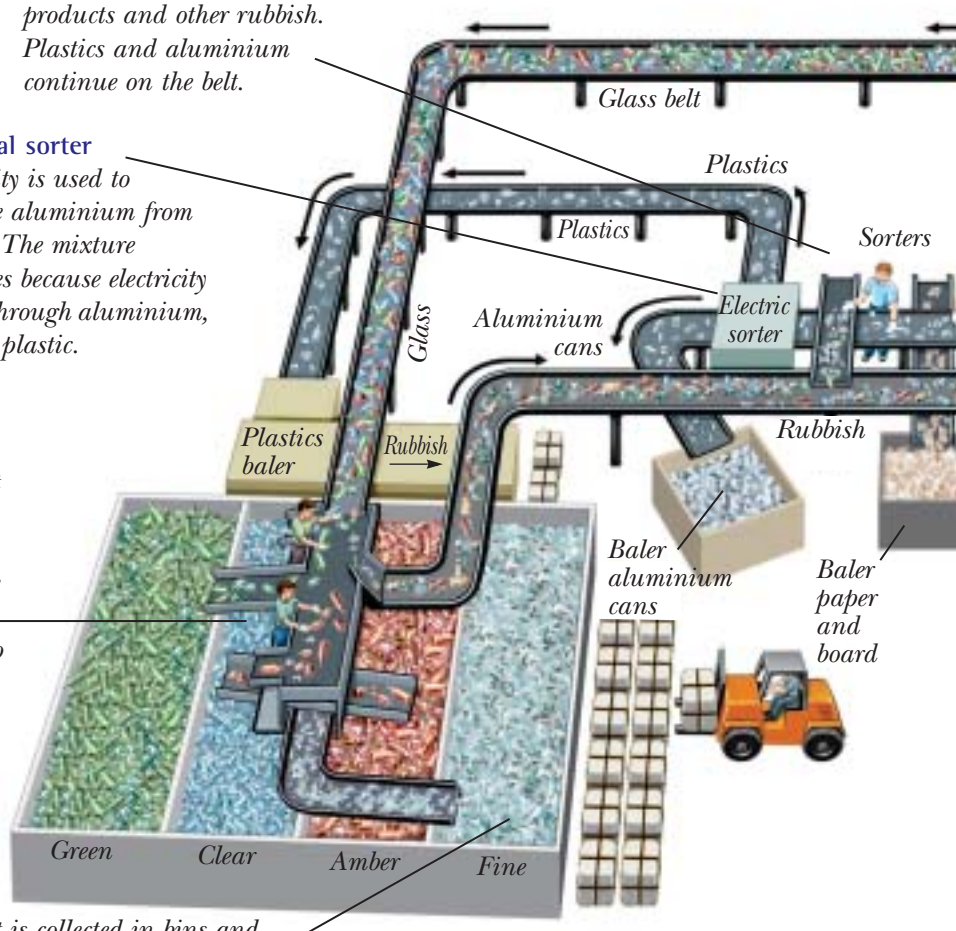
Magnet
Steel cans are separated using a magnet. The steel is collected in a separate container, ready to be sent to steel manufacturers. Material that is not attracted to a magnet continues along the conveyor belt.

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

Sorters
People sort out paper products and other rubbish. Plastics and aluminium continue on the belt.

Electrical sorter
Electricity is used to separate aluminium from plastic. The mixture separates because electricity passes through aluminium, but not plastic.

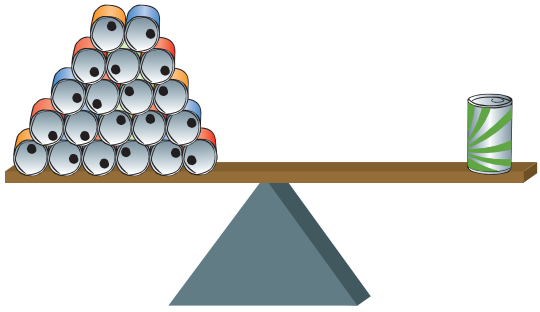
Sorters
People separate different coloured glass by hand. Any other rubbish that has made it through the conveyor belt is also removed. Glass is sent to processing plants where each separate colour is crushed, melted and mixed with raw materials to make new bottles and jars.



Fines bin
Finely broken glass cannot be separated by sight. It is collected in bins and sent to a glass processing plant. At the processing plant, lasers are used to separate very small pieces of differently coloured glass.

Saving energy

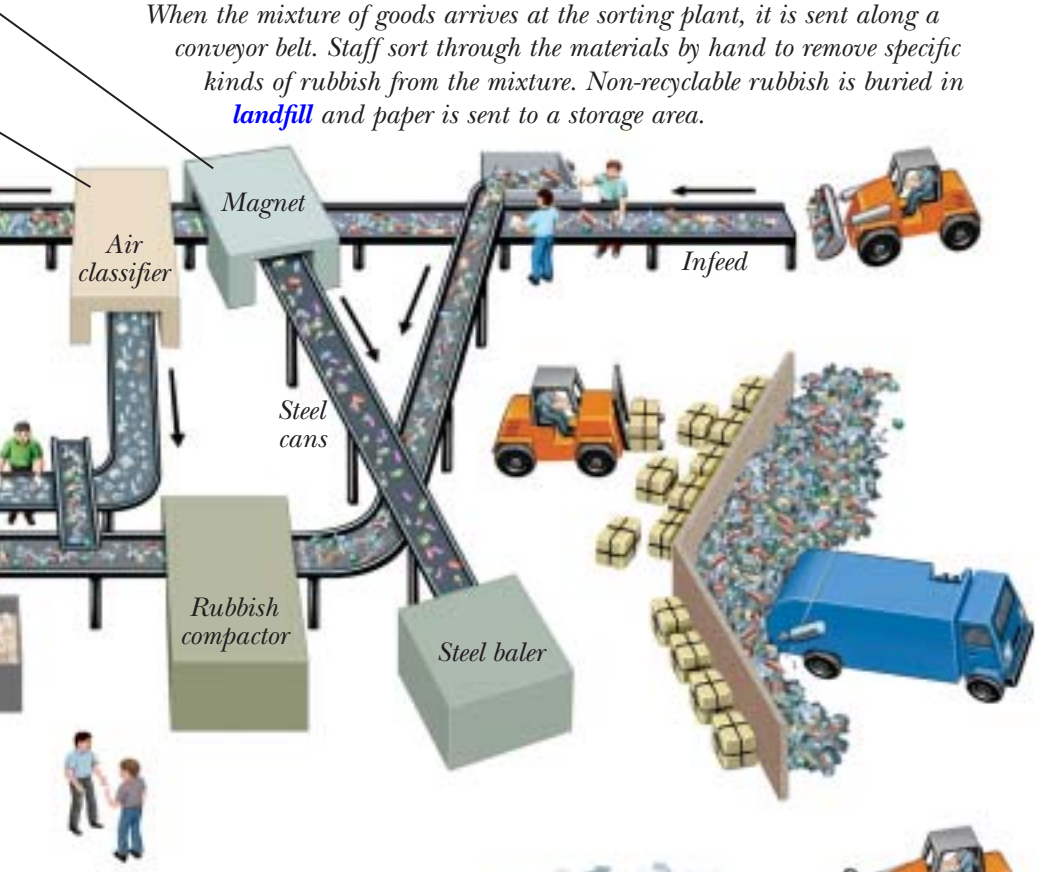
How does recycling bottles save oil, coal and gas? It takes energy from fossil fuels to run the equipment that mines and processes the materials that make new products. Recycling also reduces the amount of **raw materials** that need to be extracted from the ground and processed.



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

Pre-sort

When the mixture of goods arrives at the sorting plant, it is sent along a conveyor belt. Staff sort through the materials by hand to remove specific kinds of rubbish from the mixture. Non-recyclable rubbish is buried in ***landfill*** *and paper is sent to a storage area.*



Paper storage

Paper makes up a large part of our household rubbish and we usually sort it out at home. It is often collected separately from other recyclable materials. From the recycling plant it is sent to ***paper mills*** *for re-processing. At the mill, paper is shredded and mixed with water to make new paper products.*

Activities

REMEMBER

1. Give two reasons why recycling is good for the environment.
2. Why do recyclable materials need to be separated?

THINK

3. Prepare a table like the one below and fill it out with information on separating rubbish.
   (a) Record the methods used to separate different types of material in a recycling plant.
   (b) For each method, record which material is removed from the flow of rubbish.
   (c) What properties of this material allowed it to be separated from the mixture?

Method	What is removed?	Properties

4. Why aren't magnets used to separate out aluminium cans?
5. Explain why people, rather than machines, need to manually separate some of the recycling mixture.

CREATE

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

checklist

I can:

- ☐ understand how a recycling plant operates
- ☐ see how different separation techniques suit different materials.

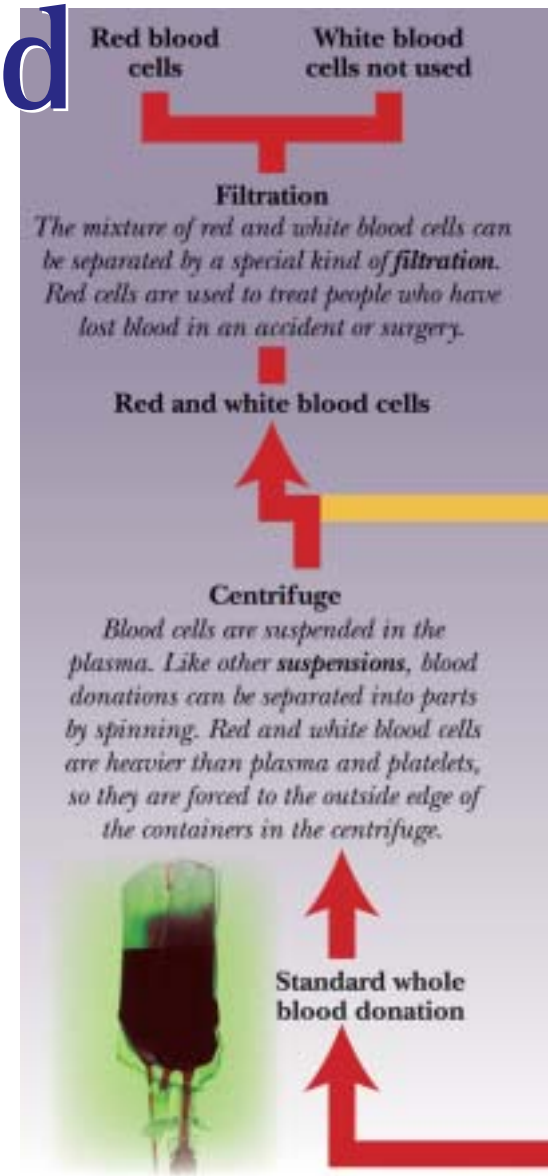
Separating blood

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**, to carry oxygen; **white blood cells**, to fight disease; and **platelets**, to 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.



HOW ABOUT THAT!

The average human body contains between 5 and 7 litres of blood. Each single drop of blood contains about 250 million red blood cells, 400 000 white blood cells and 15 million platelets. During exercise, each of these drops 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 to the circumference of the Earth which is about 40 000 km. How amazing is that!

HANDS ON SCIENCE

Using a centrifuge (teacher demonstration)

You will need:
centrifuge
mixture containing iron oxide, lead oxide (red lead) and water.

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

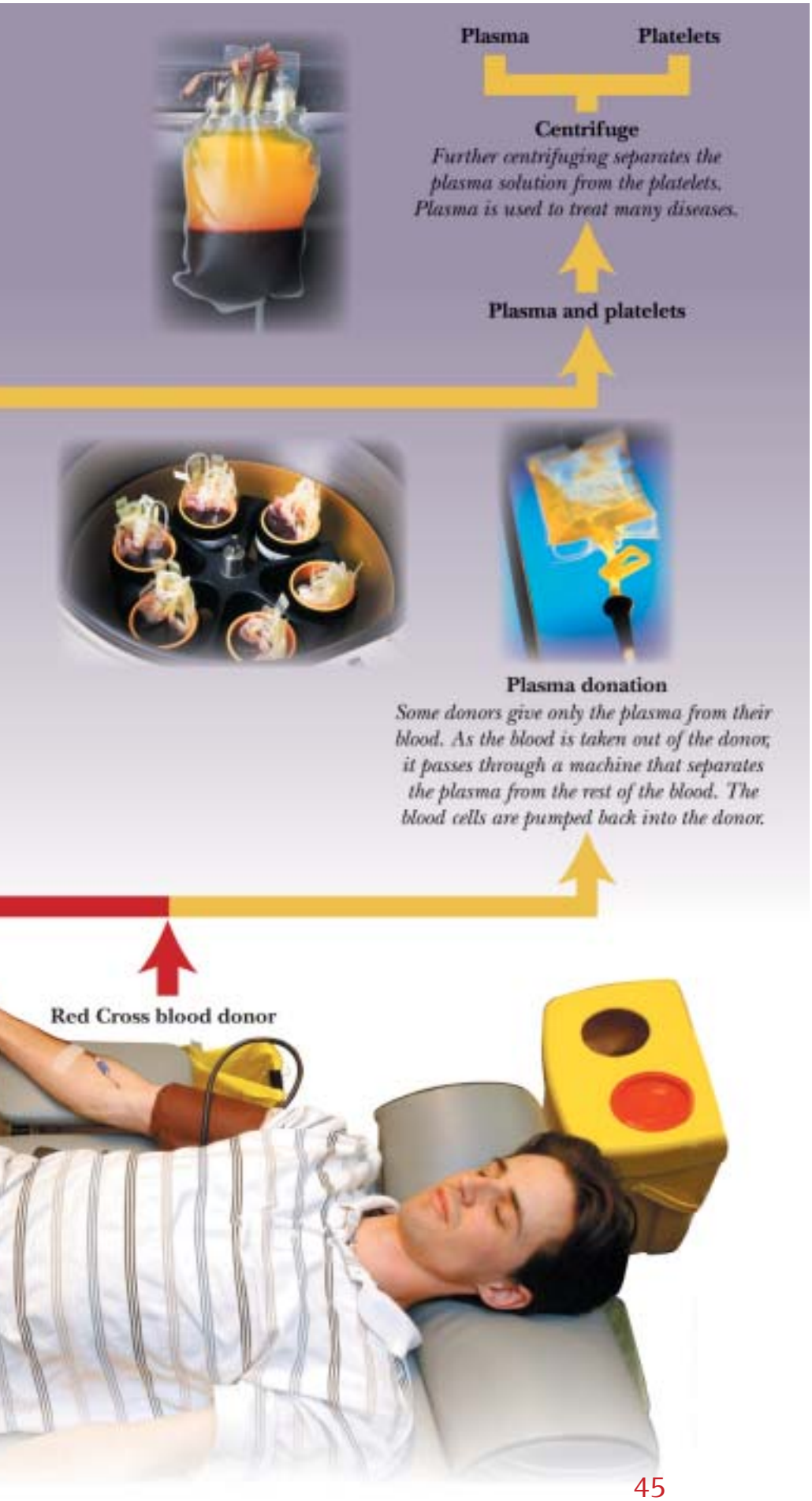
- Stir the mixture then pour equal amounts into two separate centrifuge test tubes.
- Place the test tubes on opposite sides of the centrifuge.
- Allow the centrifuge to spin for about a minute.
- Observe the mixture after centrifuging.

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?

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.)

Go to worksheet 10



Activities

REMEMBER

1. Why is blood separated into different parts?
2. Why do blood clots not form in a blood donation?
3. Which technique is used to separate the different parts of blood?
4. Turn to page 39 to answer this question. Which separation technique is used to detect traces of drugs in a patient's blood or urine?

THINK

5. Why is blood separated in a centrifuge rather than left to settle by itself?
6. What property of plasma and platelets allows them to be separated with a centrifuge?

CREATE

7. 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.

CONNECT

8. Go to www.jaconline.com.au/science/weblinks and click on the Australian Red Cross Blood Service link for this textbook.
   Find out:
   (a) how old you need to be to donate blood
   (b) the minimum weight blood donors must be.

✓ checklist

I can:

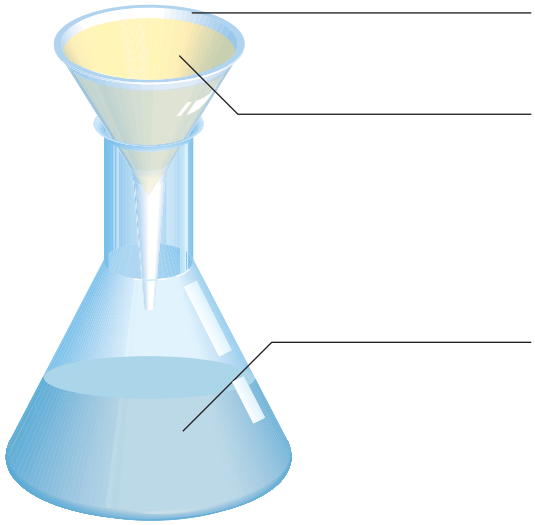
- ☐ describe medical applications of separating techniques
- ☐ understand that blood is made up of four different parts.

Check and challenge

Separating mixtures

Separating and concentrating techniques

1. Give an example of a mixture that could be separated using a filter.
2. Decide if the word in *italic* makes the statement true or false. If the statement is false, replace the *italic* word with the correct word.
   (a) To increase the concentration of a solution such as cordial, add more *solvent* to the solution.
   (b) *Chromatography* can be used to separate substances with different solubilities.
   (c) When a mixture of salt and water is heated, the water begins to evaporate. The salty solution becomes *diluted* in this process.
   (d) The *heavier* parts of a mixture are forced to the outer edge of a centrifuge when it spins.
3. (a) Label the following diagram:



   (b) Explain how this equipment separates mixtures.
4. (a) List the properties of iron filings, sugar and water.
   (b) Describe a method for separating a mixture containing iron, sugar and water. Each of the three substances needs to be collected into a separate container.
5. Some filters have smaller holes in them than others. Why are the holes in coffee filters smaller than the holes in pasta strainers?

Types of mixture

6. Complete this sentence:

   A mixture is a combination of _____, each having its own _____.
7. Decide if the word in *italic* makes the statement true or false. If the statement is false, replace the *italic* word with the correct word.
   (a) Suspensions contain *soluble* particles in a liquid.
   (b) A suspension can be separated in a *centrifuge*.
   (c) Milk is a *solution*.
   (d) Emulsions are a type of *colloid*.
8. Complete this sentence:

   Chromatography separates mixtures whose substances _____ at different rates.
9. Oil floats on water. When detergent is added, the oil forms droplets in the water that do not settle out. What type of mixture has been formed?

10. How are emulsions and colloids similar and how are they different?
11. Homogenised milk is a:
    A suspension?
    B emulsion?
    C colloid?
    D solution?
12. Make a list of some of the substances that would be present in a mixture that is usually separated with a catalytic converter.

Appropriate methods

13. Draw and label the equipment needed to separate a mixture of sugar and water if:
    (a) only the sugar needs to be kept
    (b) both the sugar and water need to be kept.
14. Pasta is placed in water to cook. The pasta sinks to the bottom when it is left to stand.
    (a) What type of mixture is the pasta and water?
    (b) Describe two techniques that can separate this type of mixture.
    (c) Which technique is best for pasta and water? Explain your answer.
15. Spin cycles of washing machines separate clothes and water. What techniques of separation do they use?

Separating in medicine and industry

16. Some medicines form suspensions. Why do they need to be shaken before taking?
17. Why does blood collected from the Red Cross Blood Service need to be separated before it is used?
18. What is the purpose of an S-bend in a kitchen sink pipe?
19. 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
20. List some of the substances that a gas mask separates from air to purify it.
21. What is the purpose of magnets in a recycling plant?

Concentrate

1. Many cleaning solutions can be bought in concentrated form. These concentrated solutions need to be diluted in water before they are used.
    (a) In this case, what is the solvent?
    (b) If the cleaning concentrate is a bright blue colour, how could you tell the difference between the diluted and concentrated solutions?
    (c) The concentrated cleaning solution needs to be diluted so that there is one part of concentrate to five parts water. How many litres of water need to be added to half a litre of concentrate?
    (d) If you wanted to make a concentrated solution, would you add large or small amounts of solute? Explain your answer.
2. Suggest two ways of making a solution of salt and water more concentrated.

Medical and industrial separation

3. Food workers are unsure of whether a particular artificial colour has been added to a new batch of lollies. The colour is believed to affect certain medical conditions. The new batch of lollies cannot be distinguished from other lollies by looking at them. How could the workers check for the presence of the colour in the lollies?
4. (a) What is the purpose of an oil filter in a car?
    (b) Why does this oil filter need to be changed regularly?
5. Could water be used as a solvent to find out which pigments are in a sample of oil paint? Explain your answer.
6. Why do surgeons wear masks and gloves during an operation? Explain your answer in terms of separating substances.

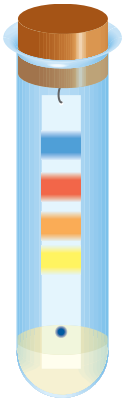
Summary of key terms

bacteria: the smallest life form found on Earth. Some types of bacteria are responsible for decay and disease.

catalytic converters: filters fitted to the exhaust systems of cars. Catalytic converters trap harmful chemicals released by cars to reduce the amount of harmful emissions entering the atmosphere.

centrifuging: a separation technique that spins heavier substances to the outside of the centrifuge

chromatography: a separation technique that separates small traces of substances using differences in solubility



circumference: the distance around the outside of a circle

colloid: a mixture in which the particles of one substance are spread evenly throughout another

concentration: the amount of solute compared to the amount of solvent in a solution

contaminated: a useful substance that contains another substance or substances that we don't want

crystallisation: a separation technique that uses evaporation to separate the parts of a solution. The solvent is evaporated and leaves behind the solute.

decanted: the liquid part of a suspension is carefully poured off, leaving the solid sediment behind

dilute: (*noun*) a solution that contains a small amount of solute compared to solvent; (*verb*) to make weaker by adding solvent

disinfect: to remove harmful bacteria

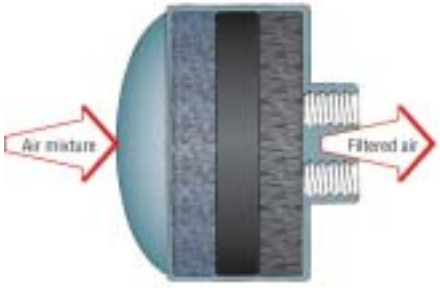
dissolve: to mix one substance (the solute) completely with another (the solvent) so that it is no longer visible

distillation: a separation technique that uses evaporation to separate substances. One substance is evaporated. The vapour is collected and then condensed back into a liquid.

emulsion: a colloid with droplets of one liquid spread evenly through another

evaporate: to change from a liquid to a gas; for example, from water to steam

filter: a device that allows some materials to pass through. It blocks those too large to fit through.



filtrate: the part of a mixture that passes through a filter

filtration: a separation technique that separates objects of different sizes

forensic scientists: scientists that collect, examine and compare evidence to solve mysteries and crimes

homogenised milk: processed milk. The butterfat (oil) is broken up into droplets and spreads evenly through the rest of the milk. This milk is an emulsion, so the butterfat will not settle out.

insoluble: unable to be dissolved

landfill: an area set aside for the dumping of rubbish

manufacturing process: process used to make products

mixture: a combination of substances, each with its own properties

paper mill: place where paper products are manufactured

plasma: the yellowish liquid part of blood that contains water, minerals, food and wastes from cells

platelets: living cell fragments found in blood. They are responsible for healing wounds. They do this by clumping together.

pollution: any substance that has an undesirable effect on the environment. For example, carbon monoxide is a pollutant produced by cars.

properties: characteristics or features of an object or substance

purify: to remove unwanted substances from a mixture

raw material: material in its natural form; such as minerals in the ground, forests, and materials found in water or in the air

recycling program: a program often run by local councils, to collect recyclable materials from people's homes

red blood cells: living cells that transport oxygen to all other living cells in the body

residue: the substance that does not pass through a filter. A residue is also left behind after evaporation.

sediment: the material that collects when suspensions are left to stand. Insoluble substances that collect at the bottom of a container are sediments.

separation: the process of dividing a mixture into its parts

sewage: a mixture of water and substances that flows from laundries, bathrooms, kitchens and toilets

sewer: pipes that remove sewage from a property

sewerage: the system of drains and pipes that takes the sewage away from a property

skimmer: a device that passes along the surface of a mixture and removes floating substances

solubility: a property of a substance that describes how it dissolves. Substances with different solubilities dissolve at different rates.

soluble: able to be dissolved

solute: substance that is dissolved in solvent to form a solution

solution: a mixture of a solute dissolved in a solvent. Solutions are clear, but can be coloured.

solvent: the substance in which a solute dissolves to form a solution

suspension: a mixture of a gas or liquid and an insoluble substance. The insoluble substance will settle out when the mixture is left to stand.

water still: a device used to distil water

water vapour: water in a gaseous state

white blood cells: living cells that fight bacteria and viruses. They are part of the human body's immune system.