Vocabulary

- matter
- particle theory of matter
- pure substance
- mixture

Lesson 1

Pure Substances and Mixtures (Heterogeneous and Homogeneous)

Learning Outcomes

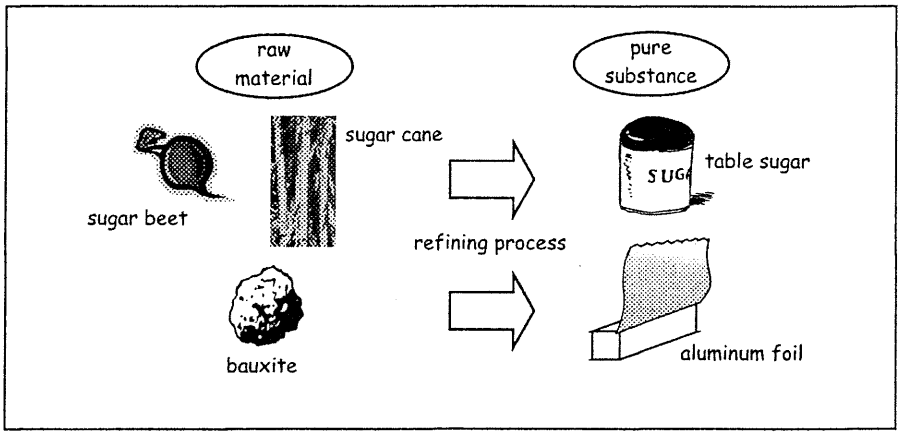
After completing this lesson you will be able to

- ❑ identify the difference between a pure substance and a mixture, according to the particle theory of matter

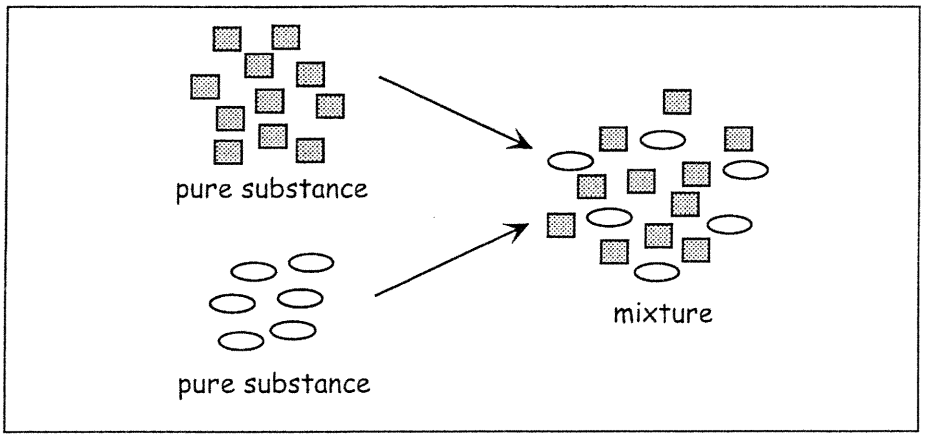
What is the Difference Between a Pure Substance and a Mixture?

Matter is anything that takes up space and has mass. As discussed in Module 1, the **particle theory of matter** states that all matter is made up of tiny particles.

A **pure substance** contains only one type of particle. Substances don't usually occur in their pure form in nature, so in order to obtain pure substances, people must refine raw materials. Some examples of pure substances are gold, aluminum, and sugar.



Raw materials, and many substances around us, are actually examples of mixtures. **Mixtures** are substances that consist of combinations of two or more pure substances, or different particles. Mixtures can be in the form of solids, liquids, and/or gases, in any combination.



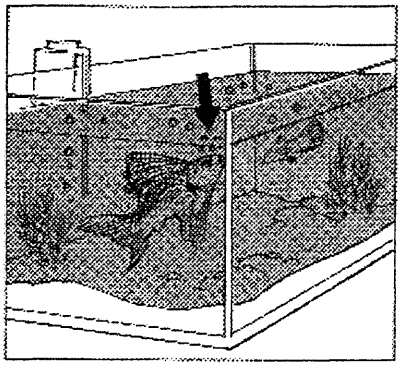
Practice

Six of the possible kinds of mixtures are:

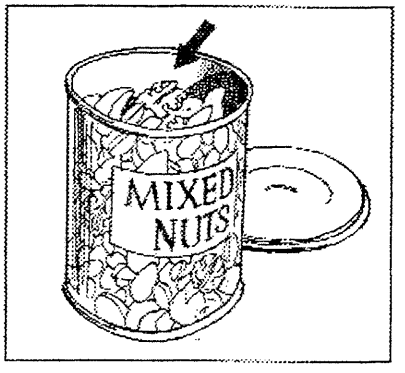
a) a mixture of gases
b) a mixture of liquids
c) a mixture of solids
d) a mixture of gases in a liquid
e) a mixture of solids in a liquid
f) a mixture of solids and gases

In each picture on the following page, there is an arrow that points to a mixture described in the list above. Write the letter that shows what kind of mixture it is below each picture.

1. _____



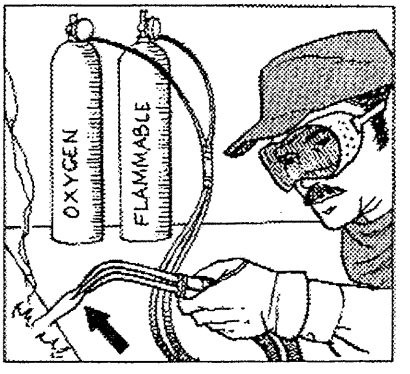
2. _____



3. _____

4. _____

5. _____

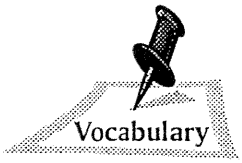


6. _____

Questions: True or False?

Are the following statements true or false?

	True	False
1. Air is a mixture.		
2. Gold is a pure substance.		
3. Water from a lake is a pure substance.		
4. A pure substance contains particles that are all alike.		
5. Two different gases together make up a mixture.		



- mechanical mixture
- heterogeneous mixture
- solution
- homogenous mixture
- solute
- soluble
- solvent

Lesson 2

Solutions, Solutes, and Solvents

Learning Outcomes

After completing this lesson you will be able to

- ❑ explain the difference between a solution and a mechanical mixture
- ❑ recognize that solutions are homogenous mixtures and mechanical mixtures are heterogeneous mixtures
- ❑ describe solutions by using the particle theory of matter
- ❑ identify the solute and solvent in a solution
- ❑ identify common substances that are examples of pure substances, solutions, and mechanical mixtures

What is a Mechanical Mixture?

Mechanical mixtures are mixtures composed of two or more substances that remain visible even after they are mixed. Think of how granola cereal or trail mix looks — the individual ingredients such as raisins, nuts, and dried fruit remain visible even after mixing. Concrete is another example of a mechanical mixture — the components of the sand, lime, and water used to create it often remain visible.

Mechanical mixtures are also known as **heterogeneous mixtures** (uneven mixtures). A salad dressing made of oil and vinegar is considered a heterogeneous mixture because its components — oil and vinegar — remain separate and distinct.

Think about a chocolate chip cookie. Would it be considered a mechanical mixture? Why or why not? Explain your answer.

_____

_____

_____

The Magic of Solutions

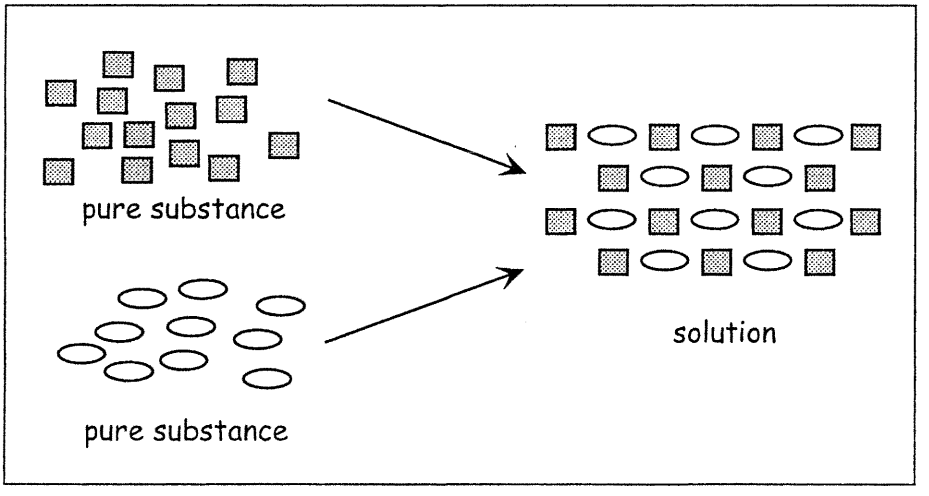
Solutions are a type of mixture in which the pure substances within the solution mix together so well that they give the appearance of only one substance.

When sugar is mixed with water, for example, the sugar seems to "disappear." Yet, if you were to taste the mixture, you would know the sugar was still there. Also, if you were to place the solution in a shallow dish and allow the water to evaporate, the sugar would reappear.

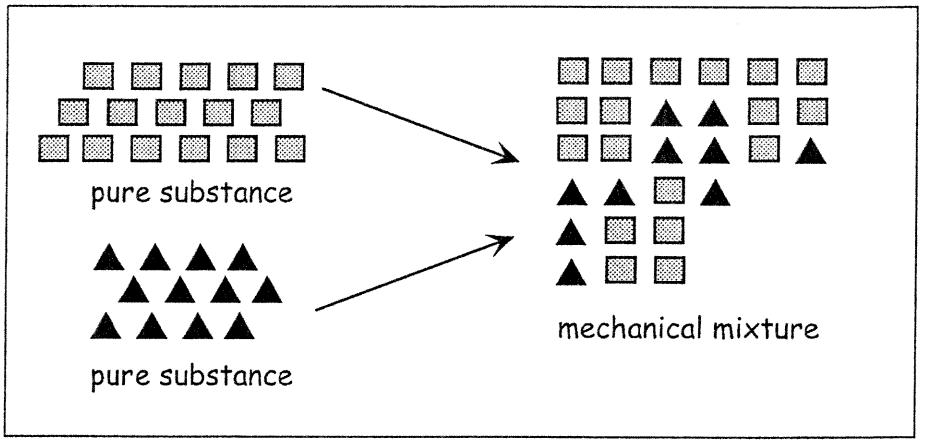
Air is an example of a solution you can obtain by dissolving carbon dioxide, oxygen, and argon into nitrogen gas. Brass is also a solution, made up of copper and zinc. Remember, solutions can be any combination of the three states of matter — solid, liquid, and gas.

When vinegar and water are combined, it appears as if the substance is the same throughout. These types of mixtures are called **homogenous mixtures**. In these mixtures, the particles in a solution spread out evenly and do not settle upon standing.

We can use the particle theory of matter to illustrate the concept of solutions and mechanical mixtures. Here is an example of a solution, which is evenly mixed:



Here is an example of a mechanical mixture, which appears uneven after mixing:



Solutions have two parts: a solute and a solvent. A **solute** is the substance that dissolves. (With the sugar water example, the sugar is the solute. Because sugar dissolves in the water, sugar is described as "**soluble**.") A **solvent** is the substance in which the solute is dissolved. (In the case of the sugar water example, the water would be the solvent.)

According to the particle theory of matter, it is the attraction between the particles of a solute and solvent that keeps them in solution.

Questions

Part 1: Liquid Solutions and the States of Matter

All the examples in Figures A, B, and C are liquid solutions. Remember, there are three states of matter — solid, liquid, and gas.

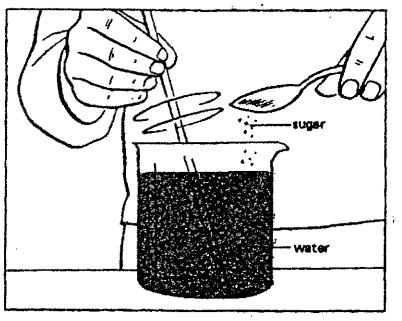


Figure A

1. Name the states of matter of the substances in this liquid solution (Figure A).

   _____ and _____

2. The solute is the

   _____

   solid, liquid

3. The solvent is the

   _____

   solid, liquid

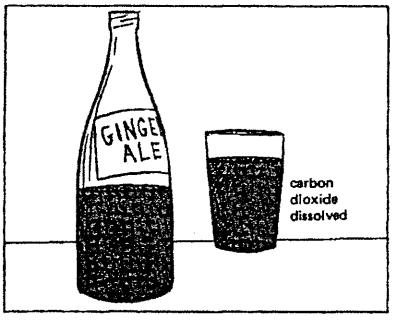


Figure B

4. Name the states of matter of the substances in this liquid solution (Figure B).

   _____ and _____

5. The solute is the

   _____

   gas, liquid

6. The solvent is the

   _____

   gas, liquid

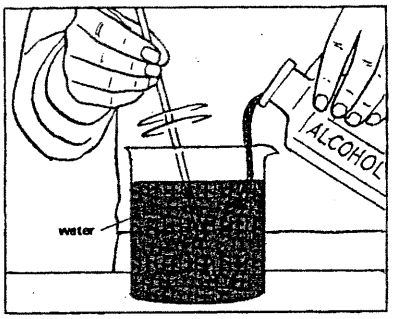


Figure C

7. Name the states of matter of the substances in this liquid solution (Figure C).

   _____ and _____

Note: In solutions where all the parts are liquid, we usually do not name the solute and solvent.

Part 2: Completing Sentences

Choose the correct word or term for each statement. Write your choice in the spaces provided.

1. A liquid solution has at least one _____ .
   solid, liquid, gas

2. The solute in a liquid solution _____

   _____ .
   must be a gas, must be a solid, can be any state of matter

3. In solutions of liquids and solids or of liquids and gases, the solvent is always the _____ .
   solid, liquid, gas

4. In solutions of all liquids, we usually _____ name the solute and solvent.
   do, do not

Part 3: Which Are Liquid Solutions?

Ten mixtures are listed below. Some are liquid solutions, some are not. Think about each mixture, then fill in the boxes.

	Mixture	Do the substances dissolve? (Write YES or NO.)	If the substances dissolved,	
			name the solute (or solutes).	name the solvent.
1.	sugar water			
2.	muddy water			
3.	salty water			
4.	pebbles in water			
5.	instant coffee drink			
6.	orange juice			
7.	oil and water			
8.	instant tea drink			
9.	ocean water			
10.	vegetable soup			

Part 4: Fill in the Blanks

Complete each statement using a term or terms from the list below. Write your answers in the spaces provided. Some words may be used more than once.

mixture	liquid solution	sugar water
two	liquid	solvent
solid	gas	solute
soluble	water	

1. Different things close together make up a _____ .
2. A _____ is a special kind of mixture.
3. An example of a liquid solution is _____ .

4. A liquid solution has _____ main parts.
5. One part of a liquid solution is always a _____ .
6. The liquid part of a liquid solution is called the _____ .
7. The other part of a liquid solution can be a _____ , or a _____, or a _____ .
8. The part of a liquid solution that mixes into the solvent is called the _____ .
9. A solute that dissolves in a solvent is said to be _____ .
10. Sugar is soluble in _____ .

Part 5: Matching

Match each term in Column A with its description in Column B. Write the correct letter in the space provided.

	Column A	Column B
_____	1. mixture	a) means "able to dissolve"
_____	2. solute	b) liquid part of a liquid solution
_____	3. solvent	c) different things close together
_____	4. liquid solution	d) a special kind of mixture
_____	5. soluble	e) part of a solution that is dissolved

Part 6: Reaching Out

Be a detective! How can you tell if a mixture is a liquid solution? See if you can figure out the clues.

Figure D

- This is a mixture of sugar and water.
- Sugar and water is a liquid solution.

Figure E

- This is a mixture of muddy water.
- Muddy water is not a liquid solution.

		Muddy Water	Sugar Water
1.	Are the parts evenly mixed?		
2.	Can you see the separate parts?		
3.	Do particles fall to the bottom?		
4.	Can you see clearly through this mixture?		

How can you tell if a mixture is a liquid solution? In your own words, list the clues.

_____

_____

_____

_____

_____

Why are Some Substances Soluble and Others Not?

As you just learned, an oil and vinegar salad dressing is a heterogeneous mixture, whereas a vinegar and water mixture is a homogeneous mixture (one part dissolves into the other).

To understand why this is, think back to the particle theory of matter. This theory states that particles are attracted to each other. In the oil and vinegar salad dressing, oil particles have a strong attraction for only oil particles; therefore they do not spread evenly through the vinegar. However, in the vinegar and water solution, the particles of each of the substances do not hold a strong attraction for their own particles. This allows the particles of both substances to move between each other evenly.

Learning Activity: Combining Substances

To complete the following learning activity, you'll need two jars, some marbles, and some sand.

- Fill two jars half full, one with marbles and one with sand. Predict how full the jar would be when the two substances combine.
- Pour the sand into the jar of marbles. Observe what happens.
- Would you consider this a model of what happened when

  a) oil and vinegar mix, or

  b) when vinegar and water mix?

  Explain your answer.

_____

_____

_____

_____

_____

_____

Notes

Vocabulary

- properties
- magnetism
- filtration
- sifting
- evaporation
- distillation
- chromatography

Lesson 3

Separation Techniques and Industry

Learning Outcomes

After completing this lesson you will be able to

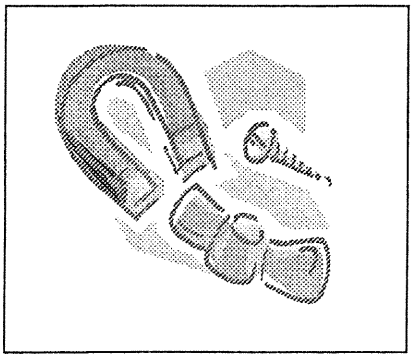
- ❑ identify different methods of separating mixtures
- ❑ determine which method of separation would be best for a particular circumstance

Separation Techniques

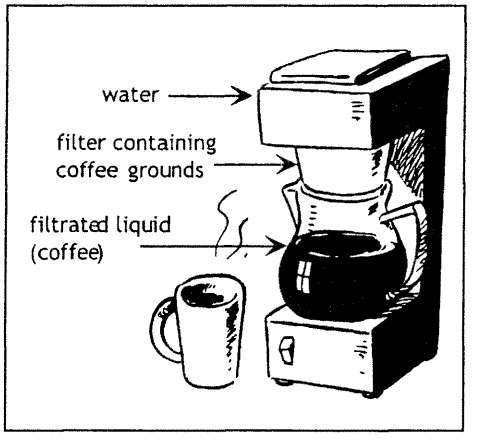
As discussed in Lesson 1, people sometimes want to separate pure substances from raw materials or other mixtures. In turn, these pure substances can be mixed with other substances to create new products or mixtures.

There are a variety of ways to separate substances in mixtures. Knowing the **properties** — key characteristics of substances — helps to determine which method is best when separating mixtures. Here are some options:

- The property of **magnetism** can be used to separate mixtures. For example, iron filings are attracted to magnets. If you had a mixture of iron filings and sand, you could drag a magnet through the mixture to separate the two substances. The iron filings would become attached to the magnet, while the sand would not.



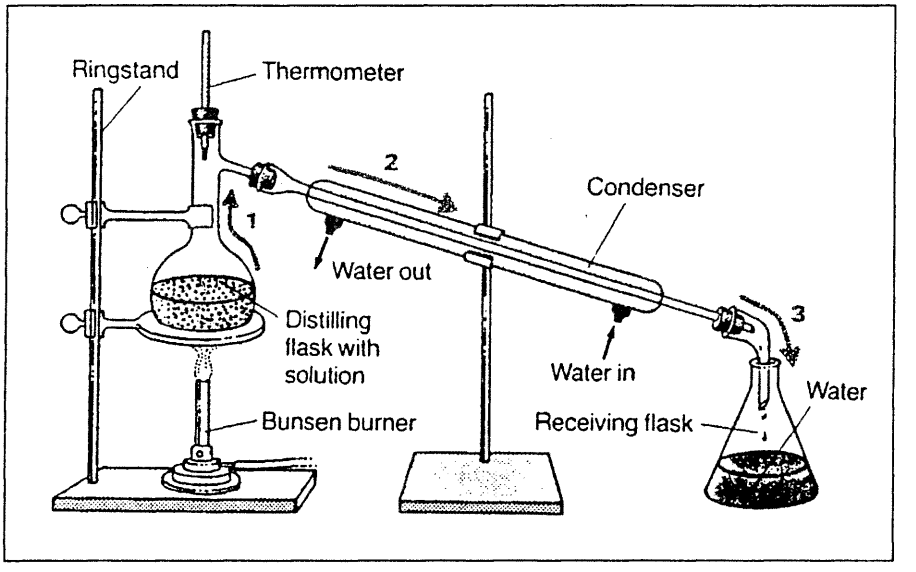
- **Filtration** or **sifting** is a method in which you use the property of size to separate mixtures. If the particles within a mixture are two different sizes, you could use a sieve or strainer to separate the two components. This would allow the small pieces to fall through the sieve, while the larger pieces would be caught in the basket part. If one of the substances in a mixture was made up of small pieces and the other was a liquid, you could use filter paper to separate the two substances. (This occurs in the process of making coffee — the coffee grounds are placed in filters and water is poured through the filter, letting only the dissolved coffee and water through but not the bitter, larger-sized coffee grounds.)



- **Evaporation** is a method that you studied earlier when you thought about whether sugar would remain in a sugar-water solution after the water had evaporated. With evaporation, the liquid portion of the solution is allowed to evaporate, leaving the solute behind. To speed up the process of evaporation, heat can be added.
- **Distillation** is a method that uses the property of the boiling point to separate two components of a solution. If the components do not share the same boiling point (meaning, one begins to boil at a different temperature than the other), you can separate the two by reaching the boiling point of one substance and having it change to a gas. Unlike straight evaporation, with distillation you can collect this gas by cooling it and having it condense into another container. This method can be used to separate the components of muddy water, for example, to obtain clean drinking water.

A Distillation Unit

Here is an illustration of a distillation unit.



How a Distillation Unit Works

1. A solution is heated in a flask and the water turns to steam. Solids or liquids that have not reached their evaporation point remain in the flask.

2. The steam enters the condenser and is cooled. As it cools, it changes back to a liquid.

3. The condensed liquid comes out of the condenser and enters the receiving flask.

What Happens in Distillation?

Check with the illustration on the previous page as you read.

1. The liquid solution is boiled in the boiler. The solvent evaporates. The solvent changes from a _____ to a gas (water vapor).
2. The vapor moves out of the boiler. It goes into the inner tube of the cooling section.
3. The cold water in the outer tube cools the vapor. This makes the vapor condense. The vapor changes from a _____ to a liquid.
4. The liquid drips into a container. It is pure. It has been distilled. It has no solute dissolved in it.
5. What happens to the solute? The solid solute stays behind in the boiler. It is now dried up. It is in solid form.

- **Chromatography** is a method that uses the property of the absorption rate to separate different-coloured substances from a solution. Chromatography is sometimes used to identify solutions. Comparisons are made to the known chromatographs of substances.

  For example, inks are solutions, and each type of ink has its own characteristic chromatograph. The liquid portion of ink allows the ink to spread so that letters or drawings can be made. When the solvent dries, you see the coloured solute left behind. To create a chromatograph of ink, water is allowed to absorb and place solutes back into the solution for a brief period of time.

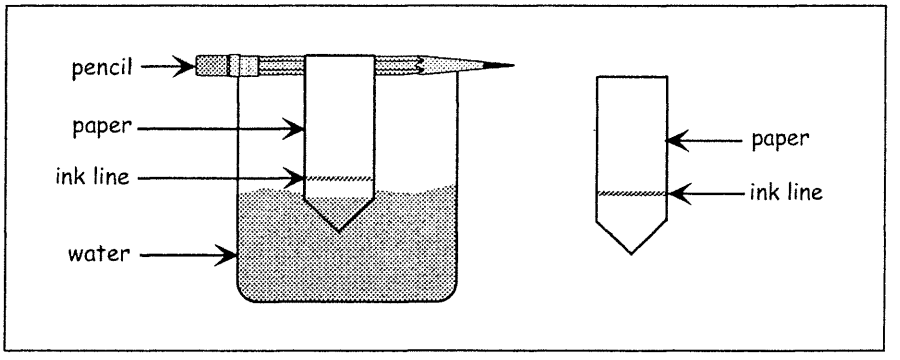
Check This Out
Crude petroleum is a fossil fuel. It is found underground, and pumped up from oil wells in Canada. The crude petroleum is then separated into several different substances, such as gasoline, diesel, propane, and oil lubricant. To find out more about the process that is used to separate each of the components of crude petroleum, visit: <http://www.howstuffworks.com/oil-refining4.htm>.

Learning Activity: Chromatography

Follow the steps below to find out what colour of pigments are in the ink of a felt pen. Make a prediction of what colours you will see. Once you have completed the learning activity, try it again with a different-coloured felt pen.

To conduct this learning activity you'll need a clear container, a coffee filter, a pencil, tape, and two different-coloured felt ink pens.

1. Cut a piece of coffee filter paper into the shape indicated on the following diagram (like a rectangle, but with a pointed end). Your shape should be at least 11 cm long and 5 cm wide.



2. Using a felt ink pen, draw a line 4 cm from the triangular end of the paper (see above).
3. Attach the square end of the paper to a pencil with a piece of tape. Roll the excess filter paper onto the pencil.
4. Place the tip of the paper into a container filled with 3 cm of water. Make sure the ink line stays above the water level.
5. Observe.

6. Draw a diagram illustrating your results.

7. Repeat with a different-coloured felt pen.

8. Compare the two results.

Questions: Separation Anxiety

Which separation method — magnetism, filtration or sifting, evaporation, distillation, or chromatography — would you recommend to divide the components of mixtures in the following examples?

1. A landscaping business receives a dump truck full of an unsorted mixture of sand and stones from a gravel pit. The business wishes to sort it so that bags of sand can be sold for use in sandboxes and the small stones can be sold for landscaping projects. What type of separation method would you suggest? _____

2. A chef is preparing stew and finds it is too watery. Without adding anything, how can the chef separate some of the water from the mixture? _____

3. A person is allergic to the yellow dying agent used in manufacturing certain candy coatings. Although the coatings appear as one colour, the colours are often made from a combination of dyes. What separation method can be used to determine if a yellow dying agent was used?

_____

Learning Activity: Matching

Match the following terms to the appropriate descriptions below.

properties	chromatography
evaporation	magnetism
distillation	sifting
filtration	dissolving

a) ability to be attracted to a magnet: _____

b) a solute going into solution when a solvent is added:

_____

c) distinguishing characteristics of substances:

_____

d) separating parts of a mechanical mixture according to size:

_____

e) removing the solvent by exposing it to air for over a period of time: _____

f) technique used separate small-sized materials from a liquid:

_____

g) separating different coloured substances from a dried ink:

_____

h) method of separating a solute from a solvent that is based on the boiling point of a substance: _____

Notes