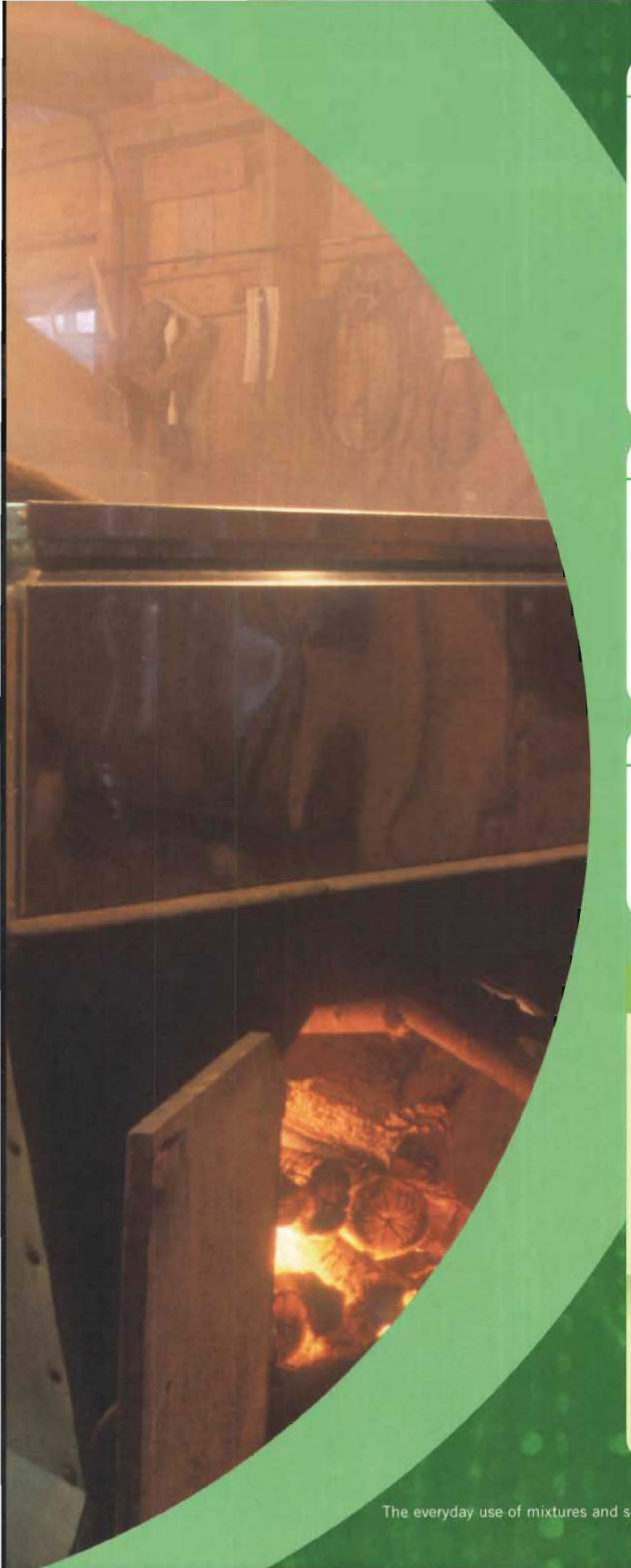
9.0 The everyday use of mixtures and solutions has an impact on society and the environment.

The commercial process of making maple syrup has an impact on society and the environment.



What You Will Learn

In this chapter, you will:

- identify industrial applications of the processes used to separate mixtures or solutions
- assess the impact on society and the environment of different industrial methods of separating mixtures and solutions
- assess positive and negative environmental impacts related to the disposal of pure substances and mixtures

Skills You Will Use

In this chapter, you will:

- investigate processes used for separating different mixtures
- use a variety of forms to communicate with different audiences and for a variety of purposes

Why This Is Important

Industrial methods used to separate and dispose of mixtures and solutions can have dramatic effects on where and how we live and may have lasting environmental effects.

Before Writing

Thinking Literacy

Procedural/Sequential Pattern

Some types of writing give step-by-step instructions (procedural pattern), or present a series of events in order (sequential pattern). Scan this chapter for examples of writing that follow a procedural/sequential pattern. When might you use this pattern in your writing?

Key Terms

- aeration
- herbicide
- insecticide
- landfill
- overburden
- radioactive
- salt pan
- surface mining

9.0 Getting Started

Figure 9.1 The use of pesticides can produce spotless fruits and vegetables, but at a price.

If you walk past your grocery store's fresh produce section, you may see fruits and vegetables that look healthy and delicious, and practically shine with freshness (Figure 9.1). However, some of these products may have been treated with pesticides. **Pesticides** are chemical mixtures used to destroy pests that can harm crops. **Herbicides** are pesticdes that kill competing plants during the planting and growing process. **Insecticides** kill insects and pests that may spoil or damage the appearance of the crops. Even if the use of these chemical mixtures does not affect the immediate quality of the foods you eat, other side effects, such as contamination of rivers, lakes, and ground water, could result from the use and disposal of these chemicals.

Examples of the dangers to the environment of improper disposal of pure substances and mixtures are, unfortunately, too common (Figure 9.2 on the next page). One way to lessen the chance of this happening is to learn more about methods used by industries to dispose of pure substances and mixtures safely.

In this chapter, you will learn about some industrial methods used to separate mixtures. You will learn about the impact of those methods on society and the environment. You will also consider the effects of use and disposal of pure substances and mixtures on the environment. As you read through this chapter, think about your personal use of consumer products and consider how you influence the environment.

Figure 9.2 Industrial seepage from oil processing plants has created algae blooms, which deplete oxygen in the water and suffocate local fish populations. The green areas in this photo are algae.

C32 *Quick Lab*

Sifting for Precious Metals

Commercial mining often involves separating material known as ore (which contains precious metals, such as gold or silver) from rock. You can simulate this process in your classroom.

Purpose

To separate pennies, nickels, and quarters from a mixture of coins, sand, and stones

Materials & Equipment

- several pieces of paper
- sand
- small stones
- scissors
- plate
- various coins

Procedure

1. Obtain scissors, paper, coins, and quantities of sand and stones from your teacher.
2. Use scissors to cut holes in the paper. The holes should be small enough that the coins will not fit through the holes but large enough that the sand and stones will fit through the holes.
3. You may wish to measure the size of each coin to ensure that the size of holes cut in the paper is slightly less than the size of a coin. This may mean that you use more than one piece of paper and that you perform the sifting more than once.
4. Carefully sift the mixture above a plate, allowing the sand and stones to pass through the holes in the paper but not the coins.

Questions

5. How big were the holes you cut in the paper to allow passage of the sand and stone mixture but not the coins?
6. Were you able to complete the sifting process in one try, or were multiple siftings needed to separate each type of coin?
7. Provide some examples to explain how mining companies might improve upon the efficiency of sifting to separate a mixture.

9.1 Industrial Methods of Separating Components of Mixtures

Here is a summary of what you will learn in this section:

- There are different methods of separating components from mixtures.
- There are many industrial applications of the different methods of separating solutions and mechanical mixtures.

Figure 9.3 Many common products are produced from metals separated from rocks mined from the ground.

There are many different types of substances and consumer products manufactured every day that involve industrial methods of separating pure substances and mixtures into different components. Bicycles, computers, and even cellphones are produced from materials that are created by separating metals from rocks mined from the ground (Figure 9.3). Crude petroleum is refined to produce fuels, plastics, and edible oil-based products, such as synthetic whipping cream. Many foods and drinks that you consume every day, from maple syrup to diet cola, are made using processes that involve separating mixtures.

C33 *Starting Point*

Skills A C

Distillation of Antifreeze

Antifreeze helps to protect an automobile's engine from damage. It is used to prevent water in the radiator from freezing or boiling. Table 9.1 shows the boiling points of three components of antifreeze.

1. Work with a partner and use the information in the table to predict what would happen if the antifreeze solution were gradually heated until it began to boil.
2. Antifreeze boils at 188°C. When it starts to evaporate, would the gas (vapour) contain more methanol or more water? Explain your answer.
3. Why might one substance have a higher boiling point than another substance? **Hint:** Use the particle theory of matter to help explain your answers.

Table 9.1 The Boiling Points of Some Common Components of Antifreeze

Substance	Boiling Point (°C)
water	100
methanol	65
ethylene glycol	197

Separation Using Distillation

Fractional distillation is used to separate different substances or fractions that make up crude petroleum oil based on differences in their boiling points (Figure 9.4). Crude petroleum oil in liquid form is pumped through pipes into a furnace where it is heated and changed into gaseous form. The resulting mixture of very hot gases is passed into a fractionation or distillation tower. As the gases rise in the tower away from the heat, the gas mixture cools. Substances with higher boiling points, like paraffin wax, condense and are captured near the bottom of the tower where the temperature is greater. Substances with lower boiling points, like gasoline, remain as gases as they move up the tower until they condense and are captured at higher levels.

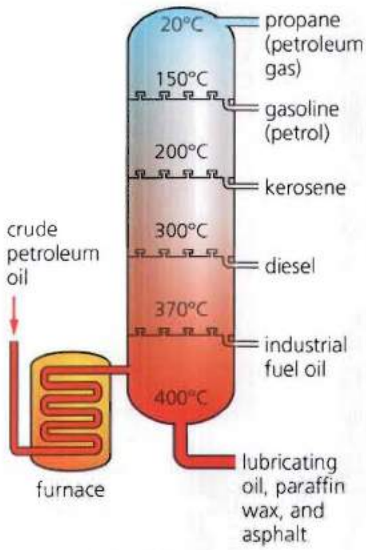


Figure 9.4 Crude petroleum is separated into different parts.

Separation Using Evaporation

Every spring, millions of litres of maple sap are collected in eastern Canada to make maple syrup. The sap is boiled to evaporate most of the water (Figure 9.5). What remains is a sweet mixture of sugar, water, and substances from the tree that give maple syrup its distinctive flavour.

For thousands of years, people living near oceans have used the heat from sunlight to evaporate seawater and obtain salt. Seawater flows into a large, low-lying area called a **salt pan**, which is surrounded by dikes. When the water has evaporated, the remaining solid is about 96 percent salt (sea salt).

Figure 9.5 It takes about 40 L of maple sap to make 1 L of maple syrup.

C34 *Learning Checkpoint*

Fractional Distillation

1. Crude petroleum is a mixture of different substances. Some are liquids and some are solids. Is crude petroleum a solution or a mechanical mixture? Explain your answer.
2. Explain how gasoline, kerosene, and crude petroleum are related.
3. Explain why substances with a lower boiling point are removed near the top of a petroleum fractional distillation tower.

Figure 9.6 This water filter removes particles of dirt and some bacteria.

Separation Using Filtering

Water purification uses very fine filters to separate dirt and some bacteria from water. Water filters can be used to improve the taste and purity of tap water (Figure 9.6). Commercial water filters are often used to remove impurities from the water during the production of different food products.

Air filters are often used in building ventilation systems and industrial clean rooms to ensure that the air is free of dust and other substances. Fans force air through microfilters, which have tiny pores that trap dust particles, pollen, and tiny particulate matter.

Figure 9.7 This industrial magnet removes steel and iron from other metals at a metal-recycling plant.

Separation Using Magnetism

Recyclers of solid waste often use magnets to separate metals (e.g., iron, steel) from other waste products. Figure 9.7 shows that iron and steel are attracted to the magnet and can be removed from non-magnetic substances, such as wood and plastics. Steel and iron recovered by this process can be melted down and remanufactured into other useful products. Bits of iron and steel (e.g., paper clips, staples) can be removed with magnets from waste paper and corrugated board, which can then be reprocessed into recycled paper products.

Separation Using Sifting

Rocks containing metals (ore) are sifted before metal is extracted from ore by melting. This sifting process separates the denser metal-containing rocks from lighter rock material (which has very little metal content) to make it easier to remove the metals from the rocks.

Sifting flour is also an important process in baking. Most flour bought from grocery stores is pre-sifted. Sifting flour breaks up lumps to ensure that the flour can be measured properly. In addition, when flour is sifted, air is added so that when flour is mixed with liquid ingredients (e.g., eggs, water), the dry flour can be fully and evenly moistened, which results in light, fluffy baked goods.

Take It **Further**

Panning for gold is a separation process developed by early prospectors. They needed to separate gold from sand and gravel in streams. To do this, they would shake a pan containing water and a small amount of sand and gravel so the gold would sink to the bottom. Learn more about panning for gold and other mining techniques. Begin your search at ScienceSource.

C35 *Quick Lab*

Using Magnetism to Separate Recycled Metals

Aluminum soft drink cans have a very high value for recycling. Unfortunately, the value of this resource is often reduced because of contamination from metallic cans that contain iron and steel. Recycling centres use large magnets that attract iron and steel to remove the contaminant metals and increase the value of the recycled aluminum. In this activity, you will learn to use a magnet to separate different magnetic and non-magnetic materials.

Purpose

To separate the steel and iron cans in your recycling box from aluminum cans

Materials & Equipment

- clean metal containers for recycling
- permanent magnet (larger is better)

Procedure

1. Make a table in your notebook like the one shown below.

Table 9.2 Magnetic Properties of Cans for Recycling

Type of Container	Attracted to Magnet (Yes or No)
soft drink	

2. Select a number of metal containers (i.e., 4 to 6 different types of cans) from your recycling box.
3. Hold the magnet close to each container.
4. Make a note in the table about whether or not the container is attracted to the magnet.

Questions

5. What types of containers were attracted to the magnet?
6. Why are these types of metals attracted to the magnet?
7. Describe a process that would enable the large-scale separation of metallic cans from aluminum cans.
8. Why do you think it is necessary to separate certain types of metals from other metals before heating them?
   Hint: Think about what happens to a metal's magnetic properties when it is heated.

9.1 CHECK and REFLECT

Key Concept Review

1. Identify two industrial uses of distillation and what components of mixtures are separated in each use.
2. List three commercial products that could have been separated using sifting.
3. List at least three uses of filters to separate components of mixtures.
4. Explain how a magnet could be used to separate different types of metals at a recycling centre.

Connect Your Understanding

5. Use the particle theory of matter to explain why evaporation of seawater can be used to obtain salt.
6. Use the particle theory of matter to explain why air filters used in automobiles and furnaces must be changed regularly.
7. Explain why gasoline and propane are removed near the top of a distillation tower, whereas diesel fuel and industrial fuel oil are removed nearer the bottom of a distillation tower.

Practise Your Skills

8. Devise a procedure to separate a mixture of iron nails, salt crystals, and wood chips from a mixture that also contains copper pennies. Write down your procedure as a set of instructions.

For more questions, go to ScienceSource.

C36 *Thinking about Science, Technology, Society, and the Environment*

STSE

Separating Industrial Mixtures

Industries like mining focus on separating metals from rock mixtures. The resulting metals are used in everything from automobiles to airplanes. Most industries use technology to increase efficiency of metal extraction and to minimize costs and environmental impacts.

With a partner, consider some costs and benefits of mining by answering the following questions.

1. How does mining directly benefit you and your school?
2. What are some costs to the economy and environment that result from mining?

9.2 Impact of Industrial Methods of Separating Mixtures and Solutions

Here is a summary of what you will learn in this section:

- Some methods of separating mixtures often have a negative impact on the environment.
- Some methods of separating mixtures, such as filtering, can be positive for the environment.

Many commonly used commercial products, including gasoline and plastics, are produced in refineries. A **refinery** is an industrial plant that purifies crude substances, such as petroleum or sugar. As you learned in the previous section, mixtures such as crude petroleum are separated into different substances at refineries (Figure 9.8). These refineries are often built at a considerable distance from cities and towns. The production process often produces offensive odours and may also create by-products that can contaminate air and ground water. Many industrial separation processes have requirements and consequences that influence where they are located.

Figure 9.8 Oil refineries separate crude petroleum into different substances.

C37 *Starting Point*

Skills A C

Industrial Methods of Separating Pure Substances and Mixtures

Mining, metal extraction, oil refinement, and many other industrial processes separate useful pure substances and mixtures from other mixtures and solutions. Each method or process contributes some benefit to society or the economy. Work with a partner to determine what you already know about these processes and what you would like to learn by answering the questions that follow.

1. Identify two or more industrial processes that operate in your community.
2. What consumer products are produced by each process?
3. What waste products are produced by each process?
4. Where are the industrial plants located with respect to water bodies and houses?

Mining

Surface mining involves removing a large amount of soil and rock on the surface in order to access the valuable material underneath. This surface material is called the **overburden**. Surface mining can result in vast destruction of the environment if steps are not taken to replace the overburden and rehabilitate the disturbed area.

Open pit mining involves the removal of all materials in a large pit. This mining process is used when the material being mined is uniformly scattered in overburden that is also relatively consistent in texture. It can be used to obtain metals located near the surface (Figure 9.9). **Strip mining** involves removal of long strips of overburden in areas where the material being mined is concentrated in veins. It can also be used when the overburden is found on the sides of hills and in valleys, much like the oil that is trapped in the soil of the tar sands in Alberta.

Figure 9.9 This is an open pit mine from which iron ore was extracted.

Coal Mining

Coal is often found in large, flat deposits at or near Earth's surface. Mining can occur at or below the surface. In the Appalachian Mountains of the eastern United States, coal is found in layers beneath the tops of mountains. A method of mining called mountaintop removal has been adopted by coal mining companies and has had a large influence on this environment (Figure 9.10).

Figure 9.10 This type of coal mining is called mountaintop removal.

The **mountaintop removal** process starts with clearcutting and removal of the mountaintop forest, as none of the vegetation can survive this coal extraction process. Next, all soil on top of the mountain is removed and set aside for possible reclamation. Explosives are used to blast away the land and rock above the coal. This overburden is then pushed into a nearby valley to fill the hollow. Large trucks or draglines are used to transport coal to washing and processing plants.

During this process, millions of litres of waste water are stored in nearby pools created by the construction of earthen dams. After the coal is removed, the stored topsoil may be deposited on the exposed surface, and steps can be taken to replant trees to ensure revegetation.

C38 During Writing

Thinking Literacy

Elements of Procedural/Sequential Writing

Writers sometimes use the procedural/sequential pattern when describing information in paragraphs. Reread the information on the mountaintop removal process in the last two paragraphs on the previous page. What signal words did the author use that tell you this is an example of procedural/sequential writing?

Can you think of other signal words a writer using this pattern might use?

How could you visually display the steps in the mountaintop removal process? Develop a graphic organizer to do this. Think about how you will organize the boxes and the kind of lines you will use to connect the boxes. Share your ideas with a partner.

Extracting Metals from Ore

Most metals found in Earth's crust are combined with other substances and must be separated by chemical means. For example, gold is extracted from ore by combining it with cyanide, which makes the gold able to dissolve in water. Cyanide is a very toxic chemical. However, cyanide loses its toxicity when exposed to sunlight.

As a result, many gold extraction plants have **tailing ponds** (Figure 9.11). These are large pools where the cyanide compounds (mixed in with crushed rock) break down in sunlight. However, during periods of heavy snow, rain, or floods, the ponds may overflow. Harmful chemicals can escape these ponds and enter ground water, which may lead to environmental damage.

Figure 9.11 Refining gold involves cyanide, which can poison aquatic habitats.

Refining Oil

When oil is refined, very large amounts of gases are released into the atmosphere, along with a noticeable smell. As a result, refineries are usually located far from populated areas. Waste gases produced by the refining process, such as methane or natural gas, are released and sometimes set aflame in a process known as **gas flaring** (Figure 9.12). Waste methane is a significant greenhouse gas. It has 25 times the ability to trap heat in the atmosphere that carbon dioxide has. Some refineries have attempted to recapture and recycle this gas for use as fuel.

Figure 9.12 Waste gases are burned off during "flaring."

Figure 9.13 Large amounts of fuel are consumed to evaporate water to produce maple syrup.

Figure 9.14 Water filters are used to purify drinking water.

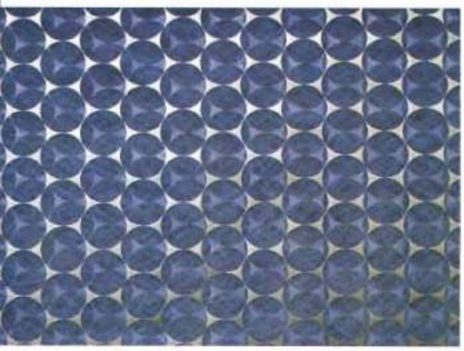


Figure 9.15 Filters in your furnace can remove dust and pollen from the air.

Take It **Further**

An automobile air filter allows the engine to "breathe." Find out how the air filter works. Begin your search at ScienceSource.

Evaporation and the Environment

Nearly every industrial separation process that relies on evaporation (such as the production of certain fuels, distilled spirits, and many types of plastics) uses heat from fuel combustion to speed up the process. For example, to produce 1 L of maple syrup, 40 L of water must be separated by evaporation (Figure 9.13). This may involve burning of fuel wood from maple trees or some other fuel. This process produces a considerable amount of carbon dioxide, which can have a negative impact on the environment.

Filters and the Environment

Some methods of separating mixtures can have a positive impact on the environment. Filtering is an example of a separation method with positive consequences. Air and water filters are the two most common types of filters.

Filtering Liquids

Waste water treatment involves the use of filters that separate impurities from water. This process helps to make it possible for municipalities to provide large amounts of pure treated water for domestic use. Where treated water is not available or when you want the additional assurance of purity, water filters can be used to obtain pure water for home use (Figure 9.14). In this case, an industrial process of separating mixtures (water filtration) has a positive impact on society and the environment.

Filtering Air

Many people suffer from asthma or allergies that are made worse by breathing air contaminated with dust, pollen, and other matter produced by combustion of fuels. Smog can make it impossible for some people to leave their house. Filters can greatly improve the quality of air both inside and outside the home, making it healthier for people to breathe. For example, air filters are used in furnaces and air purification devices to help clean the air inside the home (Figure 9.15). This is another industrial process (air filtration) that has a positive impact on society and the environment.

C39 *Quick Lab*

Benefits of an Air Filter on Indoor Air Quality

Air filters are beneficial to the environment, as they can improve the air quality in the surrounding area. They are used to separate impurities, such as dust, pollen, and by-products of combustion, from the air you breathe. Like most filtering processes, larger particles are blocked by the filter while smaller particles are allowed to pass through tiny openings in the filter.

Purpose

To demonstrate the benefits of an air filter on indoor air quality

Materials & Equipment

- 2 plastic drinking straws
- facial tissue
- cellulose tape
- eraser
- cheesecloth (optional)

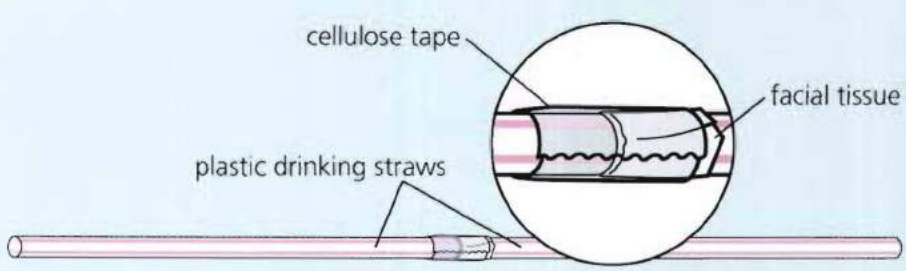
Procedure

1. Cut a small piece of facial tissue. The piece should be just large enough to cover the end of a straw.
2. Place the tissue between the ends of two straws. Tape the two straws together, end to end, with the tissue between the straws.
3. Breathe in through the straws to test if air passes through the tissue filter and the straw-and-tissue apparatus. Adjust the tissue filter and straws to allow the passage of air.
4. Use the eraser to make rubber crumbs by rubbing the eraser on your desk or a sheet of paper.
5. Attempt to suck up the rubber crumbs by drawing air through the straw-and-tissue apparatus. Be careful not to inhale the rubber crumbs.
6. After several attempts, remove the tissue filter from its location between the two straws. Examine the tissue for evidence of trapped particles.
7. (Optional) Repeat steps 1 to 6 using cheesecloth instead of tissue.

Questions

With a classmate or as a whole class, discuss the following questions.

8. Why was air able to pass through the straw-and-tissue apparatus?
9. Why were other particles not able to pass through the tissue?
10. What modifications could you make to the straw-and-tissue apparatus to make this more effective for use with smaller particles?
11. What did this experiment tell you about the effectiveness of air filters in improving indoor air quality?



Toolkit 2

SKILLS YOU WILL USE

- Asking questions
- Recording and organizing data

Removing Carbon Dioxide from Air

When you breathe, you take in air, which is a mixture of gases. Limewater is a solution of the solid chemical calcium hydroxide in distilled water. It can be used to detect carbon dioxide.

Materials & Equipment

- 50 mL limewater solution
- 100-mL beaker or jar
- plastic drinking straw
- dark piece of paper

CAUTION: Do not eat or drink anything during this activity.

Question

How can carbon dioxide be removed from air?

Procedure

1. Obtain 50 mL of limewater solution from your teacher and place it in a 100-mL beaker.
2. Observe the colour and clarity of the limewater solution and make note of it in your notebook.
3. Place the limewater solution on top of a dark piece of paper.
4. Blow air through a straw to make bubbles in the limewater solution. Observe and make note of any changes that you observe.
5. Wash your hands thoroughly after completing this investigation.

Analyzing and Interpreting

6. Describe the changes that occurred in the limewater as you bubbled your breath through it.
7. What substances are present in the air that you exhale?
8. How do you know that something in the air that you exhaled through the straw was responsible for changing the appearance of the limewater solution?
9. Suggest a way to modify the experiment to decide whether breathing adds carbon dioxide to air or carbon dioxide is already present in the air before you breathe it.

Skill Builder

10. How could you organize the observations that you made during this activity to present your findings clearly?

Forming Conclusions

11. What is the answer to the question at the beginning of this activity?
12. What normally happens to the carbon dioxide that you exhale?

9.2 CHECK and REFLECT

Key Concept Review

1. (a) Distinguish between the terms "open pit mining" and "strip mining."
   (b) Why are open pit mining and strip mining both considered to be surface mining?

2. Oil refining separates crude petroleum into different pure substances and mixtures by the method of fractional distillation.
   (a) List two ways in which oil refining benefits society and the environment.
   (b) List two ways in which oil refining negatively affects society and the environment.
   (c) List two strategies followed by oil refineries that minimize their harmful influence on society and the environment.

Connect Your Understanding

3. Filtering technologies involve the use of something that blocks some particles, but leaves most particles able to pass through the filter. List three ways in which filters affect you or one of your family members.

Practise Your Skills

4. Air purifiers, like the one shown below, dramatically reduce the concentration of indoor pollutants. Draw a simple diagram of an air purifier to show how it might work. Be sure to include the following labels: unfiltered air, filtered air, filter, and fan.

For more questions, go to ScienceSource.

C41 *Thinking about Science, Technology, Society, and the Environment*

STSE

Air Purifiers

Many people heat their home with forced-air furnaces that come equipped with air filters to trap dust, pollen, and other air-borne pollutants. However, many homes are heated by other means. For example, other heating solutions include use of wood stoves, electric space heaters, or hot water radiators, none of which come with air filters. Should people using this heating technology be required to use air purifiers? With a partner, decide whether or not you would support some type of law or by-law requiring air purification technology in every home. Be prepared to report your thinking to the class.

9.3 Effects of Use and Disposal of Pure Substances and Mixtures on the Environment

Here is a summary of what you will learn in this section:

- Careless use and disposal of pesticides has a harmful effect on the environment.
- The release of raw sewage has a negative effect on waterways.
- Disposal of industrial substances and mixtures, as well as by-products of industrial processes, has a negative impact on the environment.

The headlines screamed, "Raw sewage streams into Toronto creeks." Of course, everyone was concerned and wondered how this could happen. Raw sewage can make people sick and it can also damage the environment. Upon further investigation, it was revealed that cities across Canada treat their sewage differently. Partially treated sewage is regularly discharged into the waterways around many large urban centres in Canada.

C42 Starting Point

Skills A C

Dilution versus Pollution

Many pure substances and mixtures have very little impact when they occur at very low levels. For example, chlorine can be diluted to allow people to swim safely in a pool. However, other substances retain the ability to harm even in very small concentrations.

Starting with blue food colouring that is 87 percent blue dye by volume, do the following:

- Add 1 mL of blue food colouring to 99 mL of tap water (Figure 9.16).
- Collect 1 mL of the resulting solution and add it to another 99 mL of tap water.
- Repeat the process until you can no longer see the blue colour.

Consider This

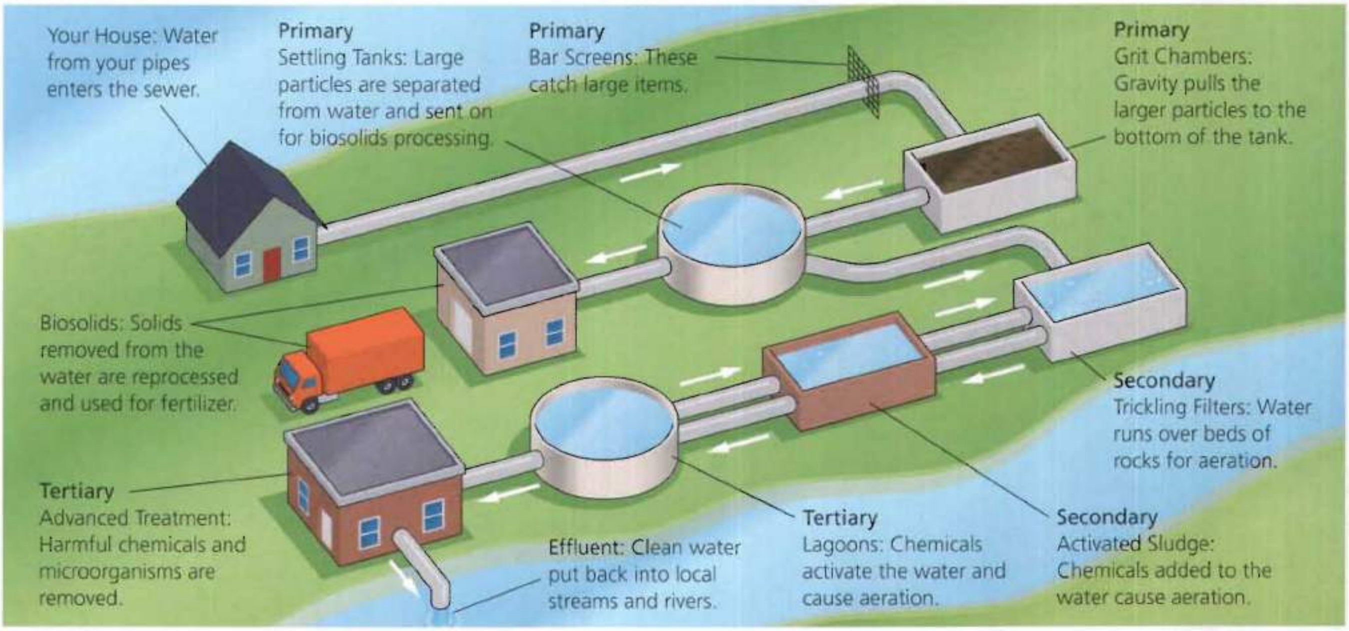
1. After how many dilutions can you no longer see the blue colour?
2. Some substances are toxic at levels of less than one part per million. If the blue dye were toxic, do you think dilution with water would be an effective treatment method?

Figure 9.16 The blue food colouring represents a toxic substance.

Sewage and Waste Water Treatment

Sewage is the liquid waste water from toilets, baths, showers, and sinks. The water may also contain run-off from roofs, urban green spaces, and roadways, and liquid waste from industries. It is treated at a waste water treatment plant, and the treated water is eventually returned to the environment. Figure 9.17 illustrates that waste water treatment usually involves a three-stage process that includes mechanical, biological, and chemical treatments.

Figure 9.17 Waste water usually goes through three levels of treatment: mechanical, biological, and chemical.



Primary, Secondary, and Tertiary Treatment

Water flowing into the treatment plant is full of solids that must be removed before further processing. **Primary treatment** involves separation of a mechanical mixture, including removal of suspended solids, rocks, sand, and grit. It allows heavy matter in the mixture to settle to the bottom of a sedimentation tank before moving on to secondary treatment. The solid matter that settles at the bottom of the tank is called **sludge**.

Secondary treatment is a biological process involving **aeration**, which mixes waste water and sludge with large volumes of air. Living organisms, such as bacteria and protozoa, help to break apart larger clumps. This finer material then drops to the bottom of retention tanks and is removed.

Suggested Activity •
C44 Decision-Making Analysis on page 260

Tertiary treatment involves application of chemicals, such as chlorine, to disinfect and kill remaining germs, and to remove phosphates. Other treatments include exposure to high-intensity ultraviolet (UV) light and treatment with ozone gas, which also kill germs.

Any sludge remaining at the end of the process must be disposed of. This can involve bacterial action, burial, or incineration (burning).

Environmental Impact

In Canada, completely treated waste water is usually safe to return to the environment. However, during periods of heavy use or very rainy weather, water treatment plants become overwhelmed and waste water is not retained long enough to ensure purity. This commonly leads to the release of contaminated water. Recent upgrades to waste water treatment plants in Ontario have greatly increased the capacity to store and treat waste water effectively.

Pesticides


Figure 9.18 Insecticides and herbicides are used to control harmful pests and weeds.

As you learned at the beginning of this chapter, farmers use pesticides, such as insecticides and herbicides, to protect their crops. Home-owners often use insecticides to maintain their lawns and gardens. Farmers use herbicides to control weeds to enable the maximum growth of crops (Figure 9.18). However, the widespread use of pesticides has had a significant impact on the environment.

Residues

According to environmental studies, almost every lake, river, and stream in the more populated areas of North America contains varying levels of pesticide **residues**. These are chemicals that come from pesticides.

Residue levels are very low in some areas, but in waterways that flow into the Great Lakes, the level of pesticide contamination is significant. The Ontario Ministry of the Environment recommends that, "Women of childbearing age and children under 15 should restrict their consumption of most sport fish caught in Ontario waters and some freshwater fish should not be consumed at all."

It is difficult to prevent pesticides from entering our water supply. Figure 9.19 shows ways that pesticides can move into water supplies. For example, some chemicals are introduced through **percolation** where they seep into the ground and later enter a water supply. As the liquid chemicals move through the ground, leaching may occur. **Leaching** is a process in which soluble parts of a substance are separated out. Another example is pesticide drift. When pesticides are sprayed over an area, the wind can carry the chemical particles out over water. When they settle in the water, they may build up in harmful concentrations that can damage the environment for years.

Figure 9.19 Pesticides and their residues can enter waterways in different ways.

Environmental Impact

The effects of pesticide use have been noted in farmers, in the environment, and in residues found in foods. Farmers have reported headaches, dizziness, and vomiting as a result of using pesticides that are considered safe. Long-term health problems include respiratory and digestive problems, memory disorders, and skin and eye problems.

Environmental contamination from pesticides has led to fewer kinds of living things in soil and waterways. This means that plants and animals that were native to an area are now either completely gone or greatly reduced in numbers. Also, many fruits (e.g., apples, oranges) and vegetables (e.g., lettuce, spinach) may contain pesticide residues or have residues present on their surfaces.

C43 *During Writing* Thinking Literacy

Using a Procedural/Sequential Pattern

List, in sequential order, all the pure substances and mixtures you have used since you woke up this morning. Much of what we use in a day produces some form of waste product, such as paper waste or water waste. Re-examine your list and think about ways you could reduce the amount of waste you produce. Use your ideas to write a procedural paragraph outlining an action plan that could reduce the waste products created at your school. Remember to include signal words appropriate to this type of writing.

Figure 9.20 Burlington Bay is one of the main locations for steel production in Canada.

Figure 9.21 Industrial processes sometimes result in chemicals being released into the air.

Figure 9.22 Household solid waste is buried under soil and stored in landfills.

Disposal of Pure Substances and Mixtures

Burlington Bay, located in the extreme west of Lake Ontario, is an example of the influence of industry on the landscape (Figure 9.20). The water, air, and environment have been polluted by steel manufacturers for years. An unknown amount of industrial waste material has been released into the environment by the steel industry since it began in Hamilton nearly 100 years ago. The amount of waste is surely very large, but we are still just learning about its effect on the environment and human health.

Sudbury is another example of an area damaged by the disposal of industrial waste mixtures. Much of the land has been damaged by acid rain, which is caused by sulphur released into the air (Figure 9.21). In addition, a by-product of nickel and copper smelting is **slag** (a mixture of waste rock), which was discarded over a large area of land in the greater Sudbury area. This damaged the natural environment.

Landfills

Household solid waste, including garbage and waste from lawns and gardens, is usually disposed of in large landfills (Figure 9.22). A **landfill** is an area where garbage is disposed of and buried under layers of soil. Many items pose no hazard with this type of storage. However, many hazardous liquids are not suitable for landfill and must be treated in another manner. For example, some oil-based paints contain lead, which is a very toxic pure substance. Latex paint does not contain lead and is safe for disposal in a regular landfill.

Hazardous chemicals must be stored in special sites for the disposal of hazardous wastes. Examples include mercury, a pure substance found in fluorescent light bulbs, and cadmium, a pure substance found in rechargeable batteries. Disposal sites for hazardous wastes are specially constructed to contain dangerous solid and liquid substances. These sites are sealed to prevent the movement of ground water, which could carry harmful liquids into wells and other drinking water sources.

Nuclear Energy and Uranium

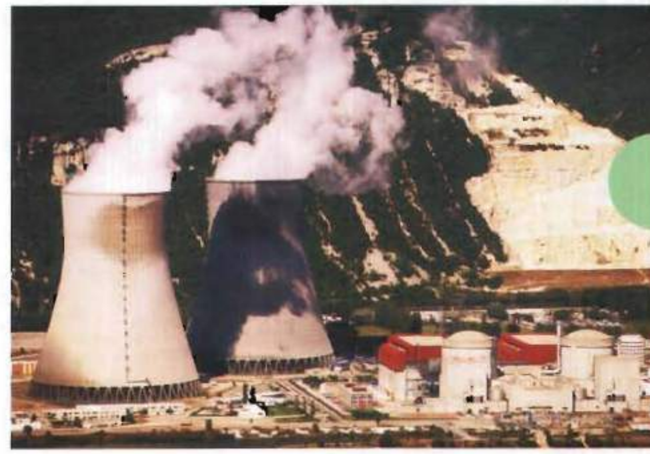


Figure 9.23 Nuclear power plants generate electricity using uranium as fuel.

Uranium is the fuel source most commonly used in generating electricity from nuclear power (Figure 9.23). The uranium is not burned like fossil fuels, so there is no release of air pollution or carbon dioxide. Instead, energy is released in a controlled nuclear reaction. However, the use of uranium as a fuel source for nuclear power has some significant social and environmental implications.

Uranium is not uncommon in Earth's crust. In fact, it can be found in small amounts in most rocks, dirt, and in the oceans. However, to be used as a fuel source, uranium must be concentrated and purified. Uranium is radioactive. A **radioactive** substance releases energy in the form of radiation. This radiation can be harmful. Uranium fuel must be produced carefully to avoid harming workers and the environment.

Storage and Disposal

Typically, the uranium used as a fuel source can last for a period of about six years. The spent fuel must be stored temporarily in a large pool of water, where it cools and loses some of its radioactivity. After about five years in a spent fuel pool, the uranium is cool and stable enough for transportation to a reprocessing site. About 95 percent of the uranium can be reprocessed and used again as fuel. Unfortunately, the remaining 5 percent remains dangerously radioactive and must be prepared carefully for long-term storage.

Waste uranium material from nuclear power generation remains dangerously radioactive for a very long time. Some estimates suggest that spent nuclear fuel will pose a hazard for at least 10 000 years. Given that an average nuclear power plant produces up to 30 tonnes of waste fuel per year, the safe disposal of nuclear fuel is a very large problem. Some radiation and environmental experts recommend storage of spent nuclear fuel in deep underground deposits that can be monitored for leakage. The actual uranium fuel would first be sealed in dry storage casks made of steel and further encased in concrete containers, which would be moved to a final storage location, possibly kilometres underground.

Take It **Further**

Canadian technology is behind a type of nuclear reactor used in Ontario. CANDU stands for **CAN**ada **D**euterium **U**ranium. This type of nuclear reactor has a very impressive safety record. Learn more about CANDU reactors. Begin your search at ScienceSource.

C44 *Decision-Making Analysis*

Toolkit 4

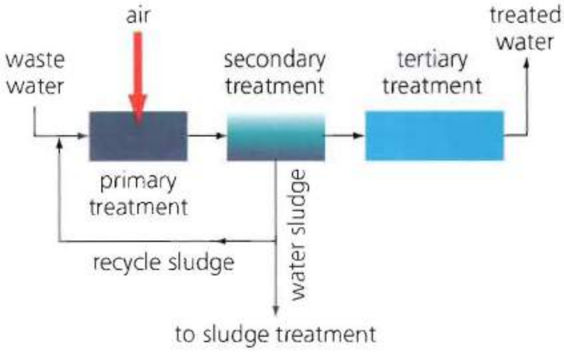
SKILLS YOU WILL USE
- Gathering information
- Organizing information

Community Treatment of Waste Water

Issue

How is waste water treated in your community?

Background Information



Municipalities across Ontario have established locations to treat waste water. Find out where your local waste water treatment plant is located and how it operates. In this activity, you will have a chance to learn more about waste water and its treatment in your community.

Before Field Trip

1. Find out the current population of your community.
2. Bring with you the materials requested by your teacher.

After Field Trip

3. Determine the volume of water treated daily at your local waste water treatment facility.
4. Calculate the per capita volume of water treated (the total amount of waste water treated divided by the population of the municipality).
5. Drawing on what you learned at the waste water treatment plant, list two or three problems that complicate the process of waste water treatment.

Analyze and Evaluate

6. What are some ways that people could reduce the amount of water that they discharge from their homes?
7. Explain how severe storm activity can affect the capacity of a waste water treatment facility.
8. List three ways to reduce the amount of water consumed and the amount of waste water produced at your school.
9. Use information collected during your field trip to answer the following questions. Be prepared to present your information to the class in a form determined by your teacher.
   (a) Explain how waste water is treated in your community.
   (b) Identify the major source or sources of raw water, the volume of water treated, and the average time required for water to pass through the water treatment facility.
   (c) Identify the major physical components and chemicals used in primary, secondary, and tertiary treatments of waste water.

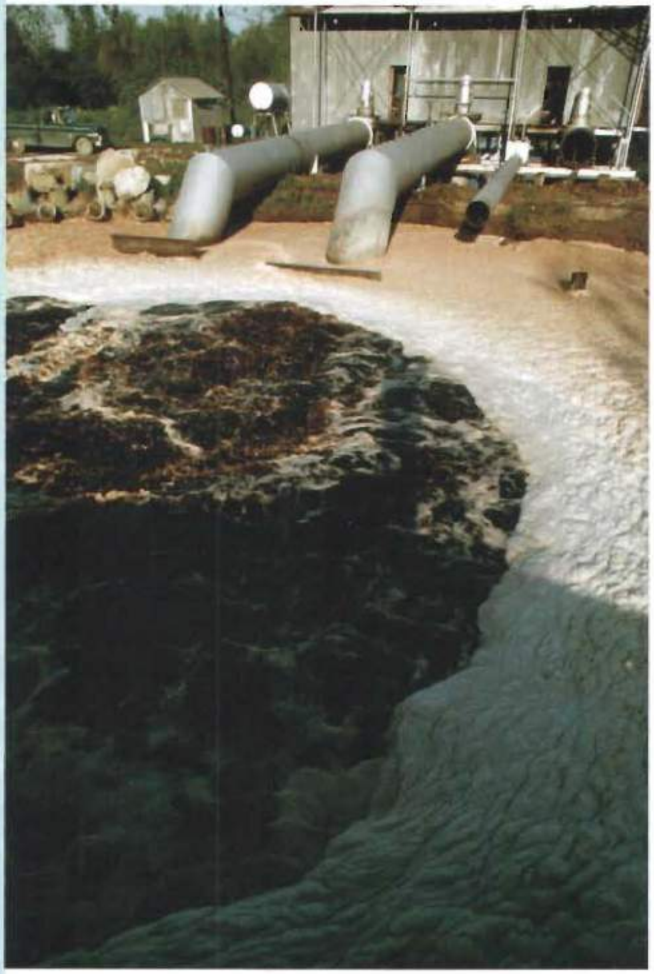
C45 *Decision-Making Analysis*

Toolkit 4

SKILLS YOU WILL USE

- Gathering information
- Determining bias

Dealing with Dangerous Disposal Practices



Issue

How can you determine whether or not a mixture of cellulose is hazardous waste or a soil conditioner that can benefit agriculture?

Background Information

A by-product of paper production is a **slurry**, or mixture of cellulose, chemicals, heavy metals, and other unknown solutions. Paper manufacturers must be able to dispose of this mixture safely. Otherwise, it could be hazardous for the soil and the environment. Some environmental experts claim that the slurry is good for soils if it is applied under certain conditions in a limited amount.

Analyze and Evaluate

1. Use information from the Internet to learn about other uses of waste cellulose.
2. Identify alternatives to spreading cellulose on agricultural fields.
3. Try to determine the exact contents of the waste cellulose mixture.
4. Determine the potential benefits of spreading cellulose or other waste paper on agricultural fields.
5. Use the information you have developed to make a plan for the safe use and disposal of waste cellulose.
6. Prepare a list of precautions that must be exercised to ensure the safe and proper working of your plan.
7. Could you make an informed decision about safe disposal practices based on the information you collected? If so, how did you know your information was true and complete? If not, what steps could you take to ensure that the information you obtain is complete and reliable?
8. Share the results of your inquiry with the class as directed by your teacher.

9.3 CHECK and REFLECT

Key Concept Review

1. What is a pesticide, and why would a farmer want to use pesticides?

2. Identify and explain three ways in which pesticides find their way into waterways.

3. Explain the difference between primary and secondary treatment of waste water.

4. Identify two chemicals added to treated waste water to kill germs and disinfect.

5. Explain why emissions from an industrial smokestack are mixtures and not solutions.

Connect Your Understanding

6. Use the particle theory of matter to explain how sedimentation tanks help to remove solid wastes in the treatment of waste water.

7. Identify at least two ways in which heavy rain can affect the efficiency of waste water treatment facilities.

8. Use the particle theory of matter to explain the connection between air pollution and the disposal of industrial wastes.

Practise Your Skills

9. Suppose you represent a citizens group in a community where a mining company has applied to build a refinery that will have a large smokestack. Write a list of questions that you can present to the company to find out whether the refinery will damage the environment.

For more questions, go to ScienceSource.

C46 *Thinking about Science, Technology, Society, and the Environment*

STSE

The Cost of Generating Electricity

In 2007, the government of Ontario pledged to shut down all coal-fired electricity generating stations by 2014. They were concerned about pollutants, such as mercury, entering the environment and large amounts of carbon dioxide contributing to climate change. Critics suggested upgrading the plants to remove pollutants from the exhaust. Supporters wanted a switch to non-polluting power sources. Both options are expensive. What do you think is the best approach? Discuss your opinion with a partner and be prepared to share it with the class.

Making Connections

Jay Ingram

Jay Ingram is an experienced science journalist and is the host of *Daily Planet* on Discovery Channel Canada.

The Brazil Nut Effect

The next time you open a can of mixed nuts, take a careful look before you start munching. Which ones are sitting on top? The big ones! But the big ones are heavier, and gravity should have pulled them to the bottom. You are looking at a strange phenomenon called The Brazil Nut Effect.

Amidst all the peanuts, cashews, and walnuts, the Brazil nuts are the biggest and the most impressive demonstration of this gravity-defying effect. How do they get to the top? Believe it or not, physicists have been trying to figure this out since the 1930s.

First of all, the container has likely been shaken a lot from the time it was sealed in the factory until you opened it. That is the key to the effect. As a result, smaller nuts (or pieces of nuts) are jostled, slip down, and fill in the tiny spaces under the big ones, and with time, the big ones end up on top. But that's not the whole answer.

That shaking also triggers a flow inside the container, with nuts moving in a slow stream up the middle, across the top, and down the sides. Small nuts just keep going around and around like that, but big ones get stuck at the sides of the can. They were able to push smaller nuts out of the way on their way up, but they can't squeeze them aside on the way down – the downward stream is just too thin. So they stay on top.

And even that isn't the whole story. Scientists at the University of Chicago have discovered the weirdest thing: the density of the nut is crucial. If you have three large nuts, all the same size but different weights, the lightest and heaviest move up the fastest; the one in the middle is slowest. Even stranger is their discovery that the air in the can must be responsible for that: if the can is put in a vacuum, these nuts of different densities all move at the same speed. They aren't yet able to explain all this.

Try a Brazil Nut Experiment yourself: open a can, take out all the nuts, mix them up, put them back in, and shake the can. I bet you'll see the big ones on top. But imagine: scientists aren't really sure exactly why that happens.

9.0 Chapter Review

Assess Your Learning

After Reading — Thinking Literacy

Reflect and Evaluate

Reflect on the processes involved in writing a procedural paragraph. When would a writer choose to use this organizational pattern? What special features do writers include when they write in this way? Are there other words you have encountered in your own reading and life that mean the same thing as "procedure"? How does the ability to recognize procedural writing help you as a reader? Write a summary of 35 words or less describing procedural writing.

Key Concept Review

1. In the manufacture of maple syrup, what substance is separated from the mixture? What is left behind in the mixture? K

2. List five methods of industrial separation of mixtures. K

3. (a) Which of the following products has the lowest boiling point: kerosene, propane, or gasoline? K

(b) How does boiling point affect the location at which a substance is removed during the process of fractional distillation? K

4. List the methods of separation used in water purification. K

5. Filters are used to separate components of mixtures. Identify examples of filters, the substances separated, and the mixtures from which they are separated in the following items. K

(a) car

(b) furnace

(c) kitchen tap

Connect Your Understanding

6. In some communities, the quality of water may not always be the same. Especially in times of heavy rain, surface run-off may cause bits of soil and bacteria to enter a community's water supply. What advice would you give these communities about treatment methods for drinking water? C

7. Evaporation is used commonly in tropical regions to collect salt from seawater. Why is this process not used extensively in North America? A

ACHIEVEMENT CHART CATEGORIES

K Knowledge and understanding — T Thinking and investigation — C Communication — A Application

Practise Your Skills

8. Hydrogen peroxide solution is a cleanser that can be applied directly to skin to help kill bacteria that cause acne. To be safe, the solutions must be no more than 3% hydrogen peroxide in water, although it can be less concentrated. Which of the following solutions of hydrogen peroxide are safe for application to skin?

   (a) 6 g in 200 mL

   (b) 5 g in 100 mL

   (c) 20 g in 200 mL

   (d) 3 g in 50 mL

Unit Task Link

In your unit task, you will investigate water samples taken from a number of sources. You have just examined some consequences of industrial methods of separating mixtures and disposing of mixtures and pure substances. As you continue to work on your unit task, consider how local industrial and commercial processes might affect water quality near you.

C47 Thinking about Science, Technology, Society, and the Environment

STSE

Bottled Water

Many school boards in Ontario have discouraged the use, and some have banned the sale, of bottled water in schools and school board buildings.

There are many reasons for this decision. First, the amount of oil needed to produce the plastic mixture necessary to manufacture the bottles is considered an unnecessary and wasteful use of resources. Second, a great deal of waste is generated when empty plastic bottles are later disposed of. Some sources suggest that up to 90 percent of plastic water bottles eventually end up in landfills. Third, there is concern about who owns the water that is eventually put in bottles, and the price that bottling companies pay for the water, and whether or not that price is fair. Others say that the quality of water in bottled water, which may be treated by filtering alone, is no better, and possibly worse, than regular tap water.

Work with a partner to make a list of the benefits that can be obtained from the use of bottled water. Include in the list examples from your own experience that support your opinion. Make another list of the costs associated with the use of bottled water. These costs should include examples from your own experience and also opinions that you may hold.

Use these lists to help as you discuss the following questions. Be prepared to discuss your findings with your class.

1. Do you think your school or school board should ban the sale of bottled water?
2. If so, what alternatives are possible to provide clean, fresh drinking water for students and school staff?
3. If not, what steps can you take to address the previously mentioned concerns?

UNIT C Summary

7.0 The particle theory of matter can be used to explain pure substances and mixtures.

KEY CONCEPTS

- A mixture can be classified as either a solution or a mechanical mixture.
- There are six points of the particle theory of matter (e.g., all matter is made of particles, there are spaces between particles).

CHAPTER SUMMARY

- Everything that we see is made up of matter.
- Matter can be classifed as a pure substance or a mixture.
- Mixtures can be classified as solutions or mechanical mixtures.
- The particle theory of matter describes the characteristics of matter.

8.0 Mixtures and solutions can be analyzed through concentration, solubility, and separation.

KEY CONCEPTS

- Solutions consist of solutes and solvents.
- Solutions can be dilute or concentrated, and saturated, unsaturated, or supersaturated.
- The concentration of a solution is the amount of solute dissolved in a specific amount of solvent.

CHAPTER SUMMARY

- The concentration of a solution can be described in qualitative and quantitative terms.
- Solutes and solvents can be identified in various kinds of solutions.
- Solubility is affected by temperature, type of solute, and type of solvent.
- Rate of dissolving in a particular solution is affected by temperature, particle size, and stirring.
- Solutions and mechanical mixtures are separated in different ways.
- Water is sometimes known as the universal solvent.

9.0 The everyday use of mixtures and solutions has an impact on society and the environment.

KEY CONCEPTS

- Commercial products consisting of solutions and mechanical mixtures can be separated in different ways.
- The improper use and disposal of pure substances and mixtures can have a harmful effect on society and the environment.

CHAPTER SUMMARY

- There are many industrial applications of the methods used to separate components from mechanical mixtures and solutions.
- Many industrial methods of separating mixtures have a negative impact on the environment.
- Some methods of separating mixtures, such as filtering, can be positive for the environment.
- Improper disposal of industrial substances and mixtures, as well as by-products of industrial processes, has a negative impact on society and the environment.

UNIT C Task

"Clearly" You Can Drink This Water

Getting Started

It was not that long ago that people could safely drink water directly from springs, streams, and creeks. Today, we would not think about doing this! Pollution, in many forms, has entered nearly all surface water bodies.

In this unit, you have developed many skills of investigation that are used to maintain supplies of clean water. These skills include differentiating between pure substances and mixtures as well as techniques to separate them. Most consumer goods are made from pure substances and mixtures. When the goods are no longer needed, there is a risk that the components will find their way back into our environment if they are not recovered properly.

These streams may look safe to drink from, but one is definitely not.

Your Goal

You will investigate water samples taken from a number of surface water sources. In each case, you will use your skills of observation and investigation to purify the water as thoroughly as possible. As well, you will match the recovered components of the sample to a "creek profile" that will allow you to determine the source of each of the samples.

What You Need

- equipment that was used throughout this unit for separating mixtures
- water samples from each of the creeks
- profile cards for each of the creeks

Steps to Sucess

1. As a class, review techniques for separating pure substances and mixtures.
2. As a group, review the properties of solutions and mechanical mixtures.
3. Create an observations table that will allow you to record your results.
4. With each of the water samples, separate all of the impurities that form the mixture with the water. Set them aside for identification.
5. Using what you have learned about the particle theory of matter, make a hypothesis as to the identity of the impurities.
6. When your analysis is complete, match it to a "profile card" that identifies the creek from which the sample was taken.

How Did It Go?

7. How pure were you able to make the samples? What was the final test that you used before deciding that you were finished?
8. Was there any equipment or materials that you know would have improved your investigation?
9. Were you able to determine which creeks your samples came from?
10. Create a brief report of the requirements for water treatment before water reaches your tap.

UNIT C Review

Key Terms Review

1. Create a mind map that illustrates your understanding of the following terms. (K)

- aeration
- concentrated
- distillation
- evaporation
- filtration
- heat
- herbicide
- insecticide
- kinetic energy
- landfill
- mechanical mixture
- mixture
- overburden
- particle
- pure substance
- radioactive
- salt pan
- saturated
- solubility
- solute
- solution
- solvent
- surface mining
- temperature

Key Concept Review

7.0

2. Explain the difference between a mechanical mixture and a solution. (A)

3. List all six points of the particle theory of matter. (K)

4. If all matter is made up of particles, what is between them? (K)

5. How does heat affect the speed of particles and distance between particles? (K)

6. How does an increase in temperature account for the fact that substances change state? (A)

7. Use the particle theory of matter to explain the difference between a pure substance and a mixture. (K)

8. Explain how heat is involved in the sublimation of carbon dioxide (dry ice) when it changes from a solid to a gas. (K)

9. Describe the changes in the state of matter when you light a wax candle on a birthday cake and later blow it out. (K)

10. People are composed of at least 70 percent water. Explain why people can be described as mechanical mixtures. (T)

8.0

11. Use the terms "solute" and "solvent" to explain the difference between a dilute and a concentrated solution. (K)

12. Use the particle theory of matter to explain the difference between a saturated and an unsaturated solution. (K)

13. Explain why solute particles must be attracted to solvent particles to enable formation of a solution. (K)

14. Does water dissolve all solutes? Explain your answer using examples. (K)

15. Steel is an alloy made up of iron and carbon. Explain why iron is considered the solvent and carbon is the solute. (A)

16. Use the particle theory of matter to explain why stirring speeds up dissolving. (K)

17. Use the particle theory of matter to explain why latex paint dissolves in water. (A)

ACHIEVEMENT CHART CATEGORIES
(K) Knowledge and understanding (T) Thinking and investigation (C) Communication (A) Application

9.0

18. Describe a method to separate aluminum cans from steel cans.

19. Explain the difference between distillation and evaporation.

20. Explain how air filters work to remove dust particles.

21. Ore is sifted before it is heated and melted to extract metal. Explain how sifting makes this process more efficient.

22. Why are oil refineries located at a large distance from populated areas?

23. Strip mining and open pit mining are both types of surface mining. Identify at least one negative environmental consequence of surface mining.

24. Explain why strip mining is suitable for obtaining oil from tar sands in Alberta.

25. Explain why mountaintop removal is potentially so destructive to the local environment.

26. Use the particle theory of matter to explain why gold becomes soluble in water when combined with cyanide.

27. Evaluate the use of cyanide as a means to extract gold from ore. Provide reasons to support your opinion.

28. Tailing ponds are built to prevent environmental contamination but may lead to release of contaminants into streams and rivers. Explain how mining companies could minimize this risk.

Connect Your Understanding

29. Explain why liquid laundry detergent is particularly useful for washing in cold water.

30. Some paint can be dissolved in water, while other paints must be dissolved using oil-based solvents. How could you determine which solvent to use? Explain at least two ways.

31. Water treatment facilities require the use of sedimentation tanks. Use the particle theory of matter to explain how these tanks help to separate materials in the waste water mixture.

32. Explain how filters placed on faucets in your home could actually result in water that is more pure than bottled water.

33. Pesticides tend to kill all types of insects, including those that actually feed on pest species. Describe two methods that you could use around your lawn and garden to reduce the need for pesticides.

34. Explain why cautions about consumption of fish are generally stronger for women of childbearing age and for children under the age of 15.

35. Most people do not apply pesticides and herbicides directly to or spill these chemicals in waterways. Yet, these mixtures are found in many lakes and streams. Explain how this happens.

36. Many lakes and rivers experience sharp increases in contamination from bacteria after summer thunderstorms. Explain why this happens. T

37. Balloons filled with air tend to remain inflated for a much longer time than balloons filled with helium do. Use the particle theory of matter to explain the difference. **Hint:** The particles of helium are smaller than most particles that make up air. T

38. Salad dressings made with oil and vinegar tend to separate and must be shaken before use. Use the particle theory of matter to explain why oil does not dissolve in water. C

39. Tennis racket technology has changed in the past five years. Rackets made from composite materials have made weaker players more competitive. Use the particle theory of matter to explain your classification of the composition of the materials that make up new rackets. T

40. Use the particle theory of matter to explain why a pizza is classified as a mixture but salt is a pure substance. C

41. Use the particle theory of matter to explain why steam, ice, and water are all considered to be the same substance. C

42. On a hot summer day, a glass of cold water warms rapidly. However, if an ice cube is added, the same amount of water will not warm up until the ice cube is melted. Explain why this is so using the particle theory of matter. C

43. Use the particle theory of matter to explain why 5 g of water occupies the space of 5 mL in the liquid state but completely fills a room when it evaporates. C

44. Describe one situation where you observed the contributions of science and technology to the understanding of pure substances and mixtures. C

Practise Your Skills

45. Draw a concept map that connects together the words solution, solute, solvent, evaporation, and distillation. K

46. Draw a tree diagram with the title "Separating Mixtures" to show the different methods by which mechanical mixtures and solutions can have their components separated. K

47. DDT is a pesticide that can cause harm when 1 mL of DDT is present in 1 000 000 L of water. If 1 mL of DDT has a mass of 1 g, what is the concentration of such a solution of DDT in g/1000 mL? C

48. Construct a comparison matrix titled "Surface Mining" that compares "open pit mining," "strip mining," and "mountaintop removal" with characteristics of "destruction of habitat," "large use of water," "minerals concentrated in the ground in veins." C

ACHIEVEMENT CHART CATEGORIES
K Knowledge and understanding T Thinking and investigation C Communication A Application

Revisit the Big Ideas

49. Select five items that can be found in your refrigerator at home. Classify the items as either pure substances or mixtures.

50. Write a short paragraph that shows clearly how these three words are related to one another: solute, solvent, and solution.

51. Explain the meaning of these terms in your own words: distillation, filtration, and evaporation.

52. Use the particle theory of matter to explain the differences between pure substances and mixtures. Provide examples of each.

53. Explain how temperature is involved in the process of changing between different states of matter. Use the particle theory of matter in your explanation.

54. Write a five-sentence paragraph focusing on the mining industry that supports or refutes this statement: "Mining is all about collecting and separating pure substances from mixtures."

55. A supersaturated solution contains more dissolved solute than could be dissolved by the solvent under normal circumstances. Use the particle theory of matter to explain how this occurs.

56. Some municipalities have banned the use of pesticides on lawns and gardens. Write a five-sentence paragraph to either support or refute this universal ban. Be sure to support your opinion with examples.

57. Ketchup appears to be uniformly red in colour and consistent in texture, but it is classified as a mechanical mixture rather than a solution. Use the particle theory of matter to explain why this is so.

C48 *Thinking about Science, Technology, Society, and the Environment*

STSE

Changing Your Consumption Habits

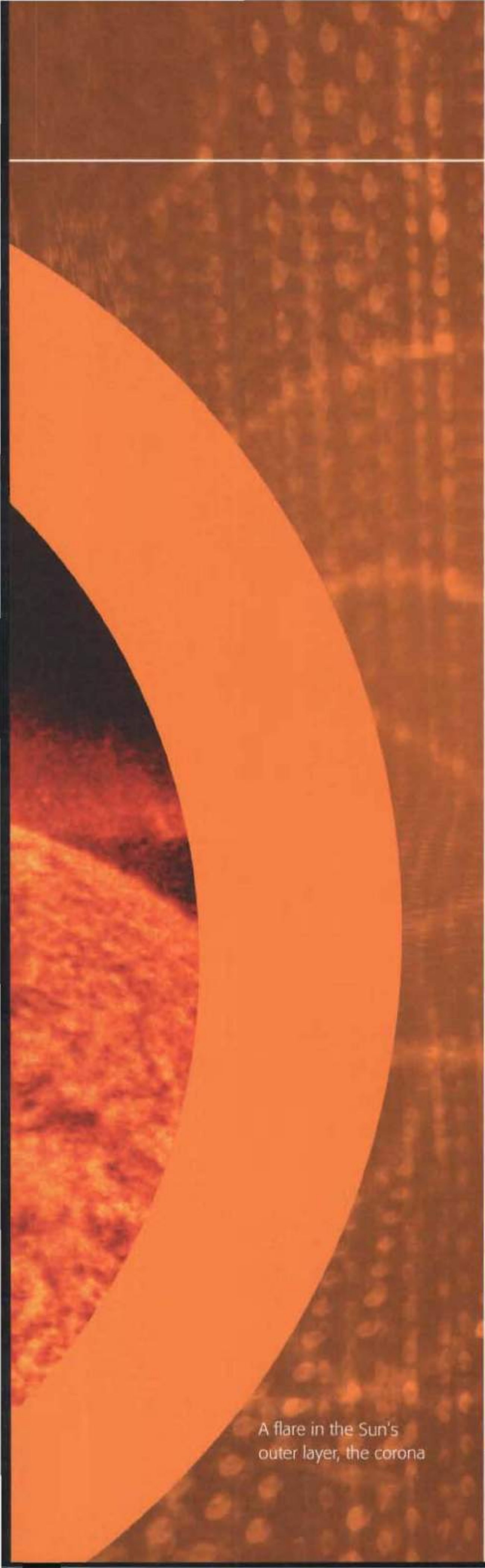
We use pure substances and mixtures every day. Think about what you have eaten today, the content of the air that you have breathed, and the substances produced by your use (e.g., carbon dioxide, waste products). Now, multiply this by about six billion, and you will have an estimate of the impact of humans on the environment.

If you could change anything you wanted, what would you do to change your consumption and production of pure substances and mixtures at school, in your home, in your community, or in Canada? Brainstorm some ideas with a partner, and then share them with your class.

UNIT D

Heat in the Environment

Unit Overview



A flare in the Sun's outer layer, the corona

Fundamental Concepts

In Science and Technology for grades 7 and 8, six fundamental concepts occur throughout. This unit addresses the following three:

- Energy
- Sustainability and Stewardship
- Systems and Interactions

Big Ideas

As you work through this unit, you will develop a deeper understanding of the following big ideas:

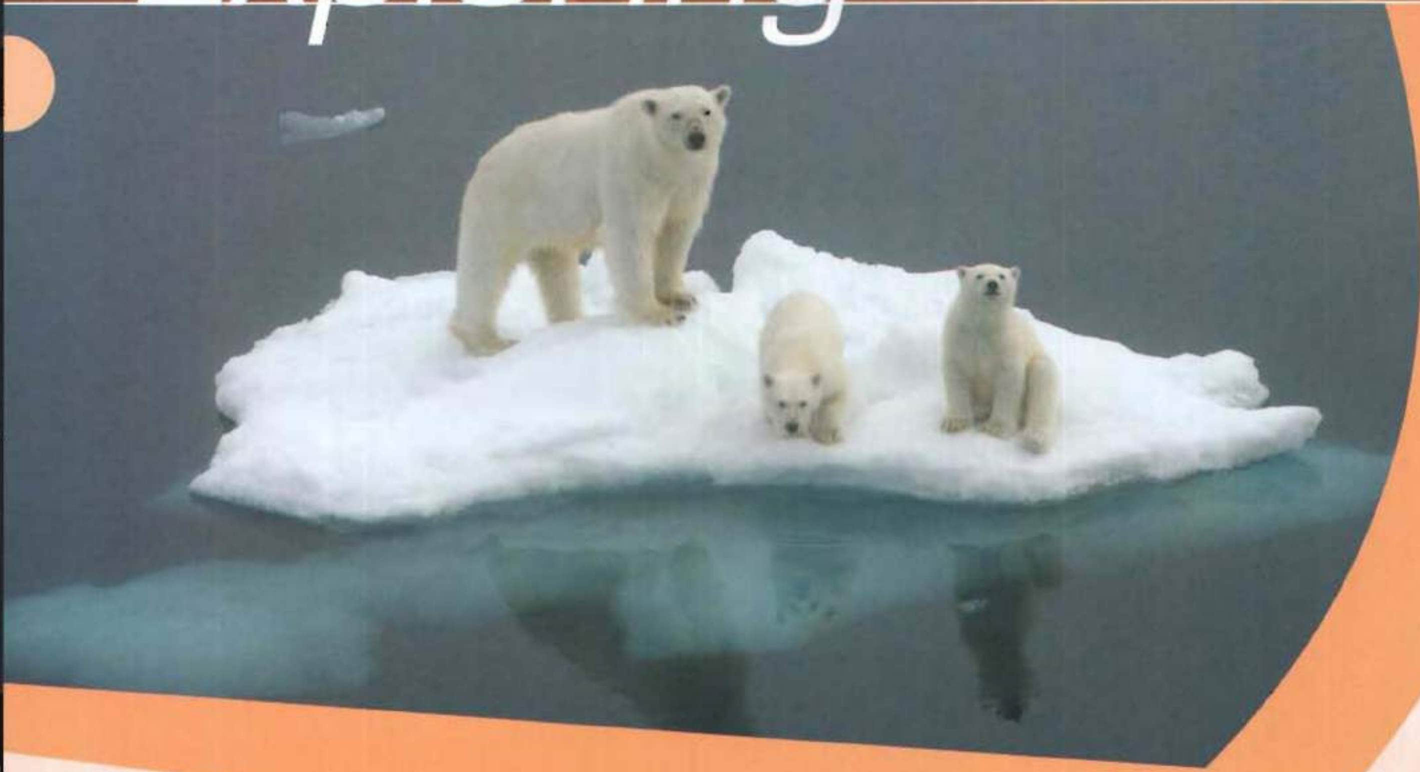
- Heat is a form of energy that can be transformed and transferred. These processes can be explained using the particle theory of matter.
- There are many sources of heat.
- Heat has both positive and negative effects on the environment.

Overall Expectations

By the end of this unit, you will be expected to:

1. assess the costs and benefits of technologies that reduce heat loss or heat-related impacts on the environment
2. investigate ways in which heat changes substances, and describe how heat is transferred
3. demonstrate an understanding of heat as a form of energy that is associated with the movement of particles and is essential to many processes within Earth's systems

Exploring



Increasing temperatures affect polar bears in Canada's Arctic.

The polar bears in the picture above are living with rapid changes in their habitat. The ice in Canada's Arctic is melting faster than expected because of increasing temperatures. This warmer climate is making it harder for polar bears to hunt and live where they usually do.

The news is full of stories like these about environmental problems such as pollution and climate change. What can we do about them? Environmentalists have a saying that can help us find a way to make a difference: Think Globally, Act Locally. It means thinking about the big, worldwide problems but finding ways locally to help solve them. Acting locally means making changes in your activities, your home, and your school.

In this unit, you will learn about heat and about global environmental concerns related to heat and climate change. For example, you will learn why we have to reduce our use of certain types of fuel for heating and electricity.

Energy-Saving Buildings

One way to do this is through constructing buildings that use less energy for heating and cooling. The Earth Rangers Centre in Woodbridge, Ontario, is an example of how different types of building materials and technologies can save energy. This building is not special just because of its energy use. It is both an environmental education centre for students like you and a hospital for wild animals. The building was designed to use very little energy and still be comfortable for both humans and animals.

The extra-thick concrete walls trap and hold heat during the warmth of the day. Then, as the air temperature drops at night, the walls release heat. The Sun's energy heats water for washing. Skylights let in both light and warmth from the Sun.

Hailey the striped skunk and Scarlett the red-tailed hawk are Animal Ambassadors at the Earth Rangers Centre. The Earth Rangers building is a comfortable environment for animals and humans.

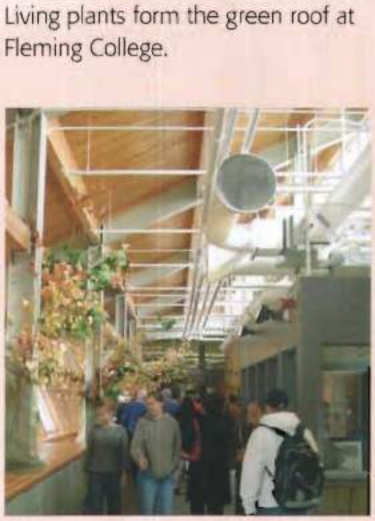
A Green Roof

The Earth Rangers building is unusual because of who uses it. But ordinary buildings, like school buildings, can also conserve energy. Fleming College in Lindsay, Ontario, has a new environmental technology wing that includes a green roof. The roof is green because it actually has plants growing on it! A green roof helps to keep a building warmer in winter and cooler in summer. To heat the new wing, the college uses heat from below Earth's surface — 122 m below. Wells bring water naturally heated from deep within Earth. Pumps circulate the water through pipes to heat the school building.

Living plants form the green roof at Fleming College.

Saving Energy at Home

New technologies are important for today and into the future, but we can reduce our need to burn fuel for heat even without them. Turn down the thermostat in the house at night or when no one is home. In the summertime, keep the temperature higher so that the air conditioning system does not have to work so hard. Doing what you can to save energy locally — in your own home — helps everyone globally.



Light coming through skylights makes a bright student area at Fleming College.

MORE TO EXPLORE

D1 *Quick Lab*

Heat in Your Home

Heat produced in people's homes contributes to the warming of the environment.

Purpose

To collect information about heat produced and used in your home

Materials & Equipment

- pen and/or pencil
- paper
- ruler

Procedure

1. Imagine that you are sitting at home in your kitchen. Think about the household items in your kitchen that produce or use heat.
2. Design and label a chart to record the name of the room and these items. Be specific.
3. In your head, take a tour of your home. For each room, identify the household items that produce or use heat.
4. Add your items, room by room, to your chart. You could also draw a floor plan that includes each room and the items you have identified.

Questions

5. Which room contains the most household items that produce or use heat?
6. Categorize the items in your chart. For example, one category could be "items used for cooking or reheating foods." Below your chart, record the names of your categories. Select a symbol (icon) or letter for each category. Then complete your chart by placing a symbol or letter beside each item.

D2 *Thinking about Science, Technology, Society, and the Environment*

STSE

The Environment in the News

What are you doing to think globally and act locally? In this unit, you will read about and discuss issues related to heat in the environment.

What to Do

1. Locate several newspaper, magazine, or Internet articles that refer to thinking globally and acting locally, sustainability, or stewardship, or use the article(s) supplied by your teacher.
2. Select one of the articles. In your own words, summarize the details of the article.

Consider This

3. Share your article and summary with your classmates. Ask them to provide comments about the article. Below your summary, describe their comments.

UNIT D

Contents

Unit Task

Insulation materials help prevent heat loss from homes and reduce the amount of energy needed to keep the house warm. In this Unit Task, you will use a variety of materials as insulation blankets to test how well the materials prevent heat loss from a plastic bottle containing hot water. You will then list the materials in order, from best heat insulator to worst heat insulator.

Essential Question

What materials help keep a house warm in winter?

Getting Ready to Read

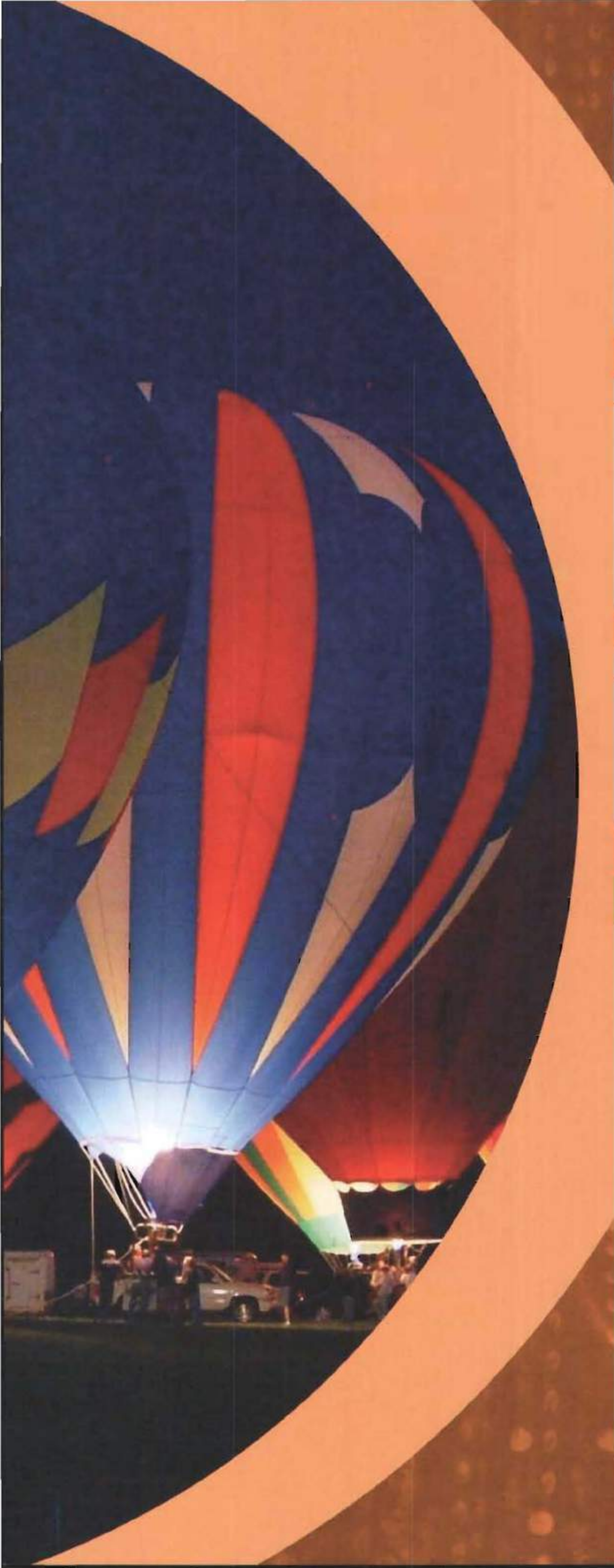
Thinking Literacy

Activating Prior Knowledge

Read the contents list. Without looking through the unit, record several facts that you know about each of these topics. In a separate paragraph, indicate which topics are new to you.

10.0 Heat causes changes in solids, liquids, and gases.

Colourful balloons expanding against an early morning sky



What You Will Learn

In this chapter, you will:

- use the particle theory to compare how heat affects solids, liquids, and gases
- identify ways in which heat is produced
- explain how heat is transmitted through conduction, convection, and radiation

Skills You Will Use

In this chapter, you will:

- follow appropriate safety procedures
- investigate the effects of heating and cooling
- investigate heat transfer by conduction, convection, and radiation

Why This Is Important

Heating and cooling cause many of the changes you encounter every day. By understanding these changes, you can predict how they will affect your life and the environment.

Before Reading

Thinking Literacy

Determining Importance

Readers often have to decide what is interesting information and what is important information. This textbook includes features to help you do this. Scan the top of this page and the summary boxes starting each section in this chapter. Look for patterns that help you determine what is important. Create a mind map for the main concepts in this chapter; the particle theory, heat production, and heat transfer.

Key Terms

- thermal energy
- heat
- particle theory of matter
- conduction
- convection
- radiation

10.0 Getting Started

Figure 10.1 Astronaut Dr. Dave Williams holds the Canadian record for hours spent outside the International Space Station.

Your environment includes the atmosphere — a thick layer of air that protects you from the strong energy of the Sun and other objects in space. To work in space, outside the space shuttle, Canadian astronaut Dr. Dave Williams needed to take his environment with him (Figure 10.1).

An astronaut's spacesuit provides protection from the extreme heat and cold of space. The side of the suit facing the Sun may be heated to a temperature as high as 120 °C. The other side, exposed to the darkness of deep space, may get as cold as −160 °C.

These extreme temperatures never occur on Earth, where the temperature ranges from about −89 °C to about 57 °C. The coldest temperature ever recorded in Canada was −63 °C in Snag, in Yukon Territory, on February 3, 1947. The hottest day on record in Canada was in Saskatchewan on July 5, 1937; the temperature reached a scorching 45 °C.

Figure 10.2 Cold temperatures are useful for some outdoor activities.

Canadians often talk about how hot or how cold it is outside, and heat plays many roles in our daily activities (Figures 10.2 and 10.3). At school, at home, in a car, or out shopping, you need to know how to control heat so that you can feel comfortable.

Producing, using, and controlling heat helps people survive around the world. People also use heat in manufacturing and other industries. However, some of the methods used to produce heat can harm plants, animals, and other living things in the environment.

Canadians are working to reduce the harmful effects of heat in the environment. To play your part, you need to understand what heat is and its impact on our planet. In this chapter, you will learn about heat, thermal energy, and temperature.

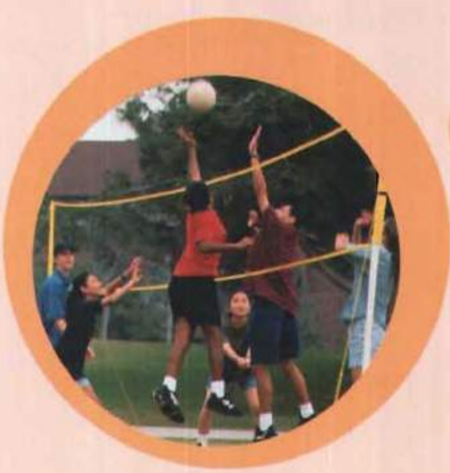


Figure 10.3 A warm, sunny day is a great time to be outside.

D3 *Quick Lab*

What Is Hot? What Is Not?

Purpose

To compare sensations of hot and cold under different conditions

Materials & Equipment

- 3 buckets or other containers
- stopwatch or clock
- water: cold, warm, and room temperature

Procedure

1. At the same time, stick one hand into a container of cold water and the other into a container of warm water (Figure 10.4(a)).
2. Keep your hands submerged for 1 min.
3. During the minute, predict what your hands might feel like when you place them into a third container of water at room temperature. Have a classmate record your prediction.
4. After 1 min, place both hands into a third container of water at room temperature (Figure 10.4(b)).

Figure 10.4

(a)

(b)

Question

5. Was your prediction in step 3 correct? Try to explain what happened and record your explanation.

10.1 Energy Transformations

Here is a summary of what you will learn in this section:

- There are many forms of energy.
- Energy can be changed from one form to another. This is called an energy transformation.
- Thermal energy is the total energy of the moving particles in a solid, a liquid, or a gas.

You get off your bicycle and park it next to your home. Entering your home, you immediately head for the refrigerator. You take a snack from the refrigerator. You see a note under a fridge magnet that reminds you to take tonight's dinner out of the freezer so that it can thaw. You open the freezer compartment of the fridge and remove the package. All the while, you are listening to great music on your MP3 player.

In this brief time, you have participated in several changes in energy. In fact, energy is changing from one form to another in each of the examples described above and around you as you read this paragraph! What are the different forms of energy? What is an energy transformation? To learn the answers to these and other questions, read on.

D4 *Starting Point*

Skills P C

Talking about Forms of Energy

An apple and a slice of pizza are delicious foods full of energy. The energy in food is in the form of chemical energy. In other grades, you learned about many different forms of energy.

Look at Figure 10.5. Name as many different forms of energy as you think are represented there. Share your list with a classmate. Check your answers after reading the next section.

Figure 10.5 There are several forms of energy represented in this scene.

Forms of Energy

Energy is the ability to make objects move. For example, the energy stored in fuels like gasoline can be used to make a car move. The energy in gasoline is a form of energy called chemical energy. There are 10 forms of energy, as shown in Figure 10.6.

Take It Further

Choose one of the types of energy shown below. Research ways in which people use this type of energy in everyday life. Begin your search at ScienceSource.

Figure 10.6 (a) Thermal energy is the total energy of the moving particles in a solid, a liquid, or a gas.

Figure 10.6 (b) Chemical energy is the energy stored in matter such as food, fuels, and clothing.

Figure 10.6 (c) Magnetic energy (magnetism) is the energy that causes some types of metal, such as iron, to attract or push away from certain other metals.

Figure 10.6 (d) Light energy is the form of energy that our eyes can detect.

Figure 10.6 (e) Gravitational energy is the stored energy an object has when it is above Earth's surface.

Figure 10.6 (f) Nuclear energy is the stored energy at the centre of particles of matter. Nuclear power plants produce electricity from nuclear energy.

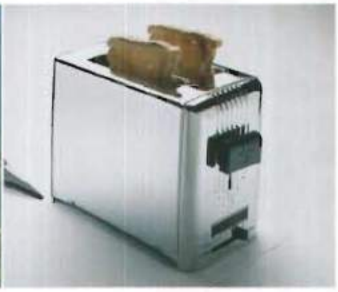


Figure 10.6 (g) Electrical energy (electricity) is the energy of particles moving through a wire or through an electrical device.

Figure 10.6 (h) Elastic energy is the energy stored in objects that are stretched, compressed, bent, or twisted.

Figure 10.6 (i) Sound energy is the form of energy that we can hear.

Figure 10.6 (j) Mechanical energy is the energy of objects in motion.

D5 Learning Checkpoint

Ten Terrific Forms of Energy

1. Name all 10 forms of energy.
2. Which forms of energy are used and produced when you:
   (a) listen to your MP3 player?
   (b) surf the Internet?
   (c) prepare dinner using a kitchen stove that burns natural gas?
3. Identify the form(s) of energy that are described in the following situations. You may need to list more than one form of energy for some of these.
   (a) playing a violin
   (b) throwing a baseball
   (c) stretching an elastic band

Figure 10.7 Every appliance in this kitchen can transform electrical energy into other forms of energy.

Energy Transformations

An **energy transformation** is a change from one form of energy to another. When you eat a banana, your body breaks down the chemicals in the food. This process releases the stored chemical energy. Your body can transform the chemical energy into thermal energy that keeps you warm and comfortable.

Energy is being transformed around you continuously. The ceiling lights transform electrical energy (electricity) into light. Moving automobiles transform the chemical energy of gasoline into mechanical energy. All of the appliances in Figure 10.7 transform one form of energy into another.

Suggested Activity
D6 Inquiry Activity on page 285

Hidden Energy

Consider the energy transformations inside a laptop or desktop computer (Figure 10.8). The spinning hard drive transforms electricity into mechanical energy. Some of the mechanical energy produces thermal energy. This is one of the reasons why the outer case of your computer feels warm. The hard drive also transforms electricity into magnetic energy to store your important data. You can hear the whirring of the computer's fan converting electrical energy into mechanical energy and sound. The DVD or CD drive uses the light energy of a small laser to read or burn information. All of these are examples of energy transformations that are hidden.

Figure 10.8 The devices inside a computer transform electrical energy into mechanical energy, light energy, magnetic energy, sound energy, and thermal energy.

D6 *Inquiry Activity*

Toolkit 2

SKILLS YOU WILL USE
- Asking questions
- Using appropriate equipment and tools

Amazing Transformations

Question

What energy transformations can you observe in this activity?

Materials & Equipment

- wooden block with 6 nails
- 3 elastic bands
- 1 commercial heat packet
- 1 battery
- 3 wires
- 1 switch
- 1 light bulb

Procedure

1. Visit each station and carry out the steps described below.

Station 1 Bouncing Sounds

2. This station has three elastic bands and a piece of wood with six nails (Figure 10.9). Stretch each of the elastic bands across two of the nails. Draw your own arrangement of the elastic bands.
3. Gently pluck each of the elastic bands. Describe what you hear as you pluck each elastic band. Identify the energy transformations you observe.
4. Place the rubber bands and wooden block with nails back where you found them when you arrived at this station.

Station 2 Warming Up

5. This station has one heat packet. Your teacher will have activated the packet. Describe what you feel on your hand when you hold the packet.
6. Identify the energy transformation you observe while holding the heat packet. Place the heat packet back where you found it when you arrived at this station.

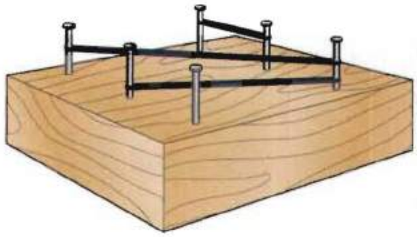


Figure 10.9 Set-up for Station 1

Station 3 A Bright Idea

7. This station has a battery, a switch, three wires, and a light bulb. Turn on the switch. Draw and label the equipment set-up. Describe what happens when the switch is turned to the "on" position.
8. Identify the energy transformations you observe while the light is on. Move the switch to the "off" position and make sure the light bulb is off before you leave this station.

Analyzing and Interpreting

9. List the different energy transformations you observed.
10. Which energy transformations produced heat?

Skill Builder

11. Think of an energy transformation that you have not discussed in class but could observe at a station like the three in the activity. Write a procedure your classmates could follow to observe the energy transformation.

Forming Conclusions

12. Using a table or other graphic organizer, summarize what you observed at each station. Your summary should include the name of the station, a description of what you observed, and a description of the energy transformations that occurred.

10.1 CHECK and REFLECT

Key Concept Review

1. Which forms of energy are used when:

(a) you ride in an automobile?

(b) you bounce a basketball?

(c) you boil water to make hot chocolate?

Connect Your Understanding

2. A student suggests that he could easily live without electrical energy. Write a paragraph to describe what his life would be like in that situation.

Practise Your Skills

3. Examine the typical street scene on the right. Draw and fill in the table. In column A, name five activities shown in which there is an energy transformation. In column B, name the *starting* form of energy that is being transformed. In column C, name the form of energy that is being *produced* in that activity.

For more questions, go to ScienceSource.

A: Activity in Street Scene	B: Starting Energy	C: Energy Produced
1		
2		
3		
4		
5		

D7 *Thinking about Science and Technology*

Exciting Energy

Imagine your daily activities from waking up until going to bed at night. Brainstorm the activities that involve an energy transformation. In your notebook, record as many of these activities as you can in three minutes. Group the activities in your list into categories of your choice. Give a name to each category. For each activity, identify the form of energy at the start and end of the transformation. Consider adding a drawing or image to represent each category. Share your list with your classmates.

What technologies do you use related to these activities? What are their sources of energy?

10.2 What Is Hot? What Is Cold?

Here is a summary of what you will learn in this section:

- Temperature is a measurement of the average energy of the moving particles of a solid, a liquid, or a gas.
- Heat is the thermal energy transferred from an area of higher temperature to an area of lower temperature.
- We use a thermometer to measure the temperature of solids, liquids, and gases.
- Heat transfer can raise the temperature of a solid, a liquid, or a gas.

We need to produce a huge amount of heat to keep buildings warm and comfortable, cook food, and make all the consumer products that we use. We obtain this heat from the Sun and many different kinds of fuels, such as wood, coal, oil, and natural gas. As you read about heat in this section, think about how important heat is in your life.

D8 *Starting Point*

Skills A C

Heating Things Up and Cooling Things Down

Examine the photographs in Figure 10.10. Decide which ones show a solid, a liquid, or a gas heating up. Record your answers under the title "Heating Things Up." Write a sentence for each photograph to explain how you know this.

Next, decide which photographs show a solid, a liquid, or a gas cooling down. Record your answers under the title "Cooling Things Down." Describe how you know this.

When you have finished, you should have described all four photographs.

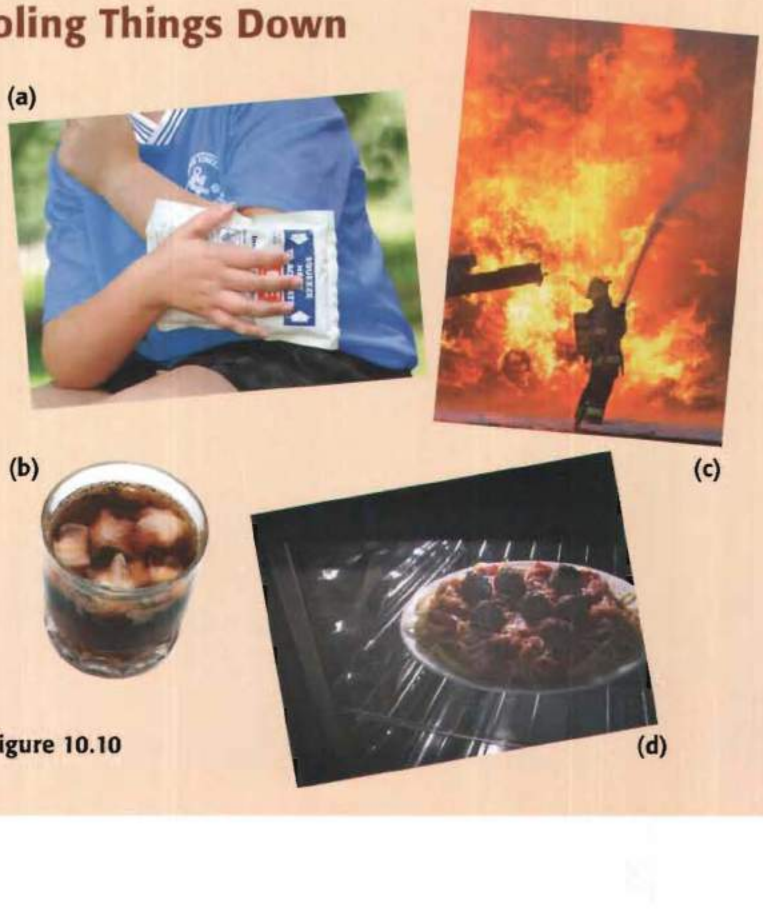


Figure 10.10

Figure 10.11 Extreme physical activity produces large amounts of body heat.

Heat Production

You are waiting for a bus on a cold day, so you try to keep warm by moving around. The more you move, the warmer you become. As you learned in section 10.1, your body produces heat. It transforms the chemical energy in the food you eat into mechanical energy of motion and heat (Figure 10.11). But your body heat and clothing are not enough to keep you warm all the time. We need a variety of heat sources to keep our homes and other buildings warm. Sources of heat are also needed for cooking, manufacturing, and other uses.

Fossil Fuels

Our main source of heat is the burning of **fossil fuels** — oil, natural gas, or coal. You may have an oil furnace or natural gas furnace in your home. If your home is heated with electricity, the electricity may have come from a process that involves burning coal, oil, or natural gas. These fossil fuels come from underground. They formed millions of years ago from the remains of plants and animals. Once we use these fuels, we cannot replace them; for this reason, they are called **non-renewable** energy sources.

Renewable Energy Sources

A **renewable** source of energy is one that can be re-used or replaced. That is what "renew" means — we can use it again and again or replace it. The Sun's energy, the wind, and flowing water are all forms of renewable energy. Heat from the Sun can be used for some of the heating in our homes and for heating greenhouses and swimming pools. Wind energy and flowing water can be used to generate electricity for heating buildings and for other uses, such as cooking and manufacturing (Figure 10.12).

Figure 10.12 Energy in the wind can be converted into electricity by wind turbines like these.

"Waste" Heat

Not all the heat around us is produced on purpose. For example, you turn on a lamp so that you have enough light to read by at night. But if you put your hand close to the bulb, you can feel the heat coming from it (Figure 10.13). A light bulb transforms electrical energy into light and heat. The heat from the bulb is considered "waste" heat because we do not need it.

Heat is produced in all energy transformations, whether it is wanted or not. Whenever energy is converted from one form to another, some heat is produced. In Chapter 12, you will learn how the different ways we produce heat affect our global environment.

Figure 10.13 A light bulb produces more heat than useful light energy.

D9 *During Reading*

Thinking Literacy

Important vs. Interesting Information

Reading large amounts of information can be overwhelming, but there are strategies to help you. As you read the next few pages, you will find information about temperature, thermal energy, and heat. Make a Heat InfoBox as shown in Figure 10.14. In each section of the InfoBox, draw a T-chart with the headings "Important Information" and "Interesting Information." As you read, add information to the appropriate T-chart in the appropriate column. When you are finished reading, compare your T-chart with a partner's. Did you record the same information in the "Important" columns? How is this an effective way to determine what is important information?

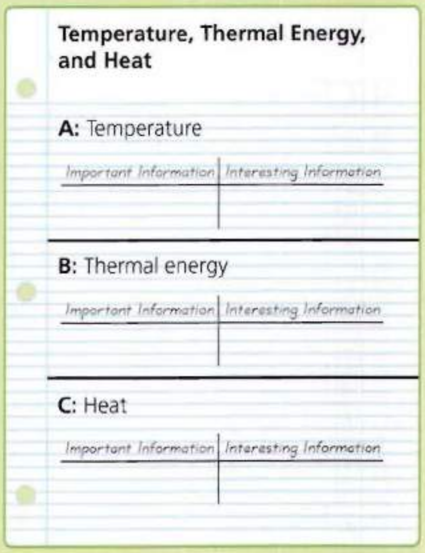


Figure 10.14 Heat InfoBox

Temperature

In your own local environment, it is important for you to know how hot or cold it is. You can tell how hot it is outside by going out. But if you want to know how hot it is before you go out, you can listen to the radio for the temperature. You decide whether to wear a coat or not based on the temperature outside. Temperature is a measure of how hot or cold matter is. But what is temperature actually measuring?

Figure 10.15 This tea is hot because of the rapid movement of particles.

To understand temperature, think about the particles that make up all matter. Everything is made up of particles, and these particles are constantly moving. Moving particles have energy because of their motion. All of the particles in the cup of hot tea in Figure 10.15 are moving quickly, so the tea is hot. But the tea particles do not all move at the same speed. Some move faster than others.

Temperature is a measurement of the average energy of all the particles in a solid, liquid, or gas. So, for example, the particles in the cup of hot tea in Figure 10.15 are moving faster than those in a cup of iced tea. The temperature of the hot tea is higher than the temperature of iced tea. When the particles of the tea in the cup slow down, the tea becomes cooler, so its temperature drops.

Measuring Temperature

You can measure the temperature of the tea by using a thermometer (Figure 10.16). A **thermometer** is an instrument used to measure the temperature of solids, liquids, and gases. Scientists have invented a wide range of thermometers for measuring temperatures from hundreds of degrees below zero Celsius to thousands of degrees above zero Celsius.

WORDS MATTER

Therm or thermo: The prefixes *therm* and *thermo* come from the Greek *thermos,* meaning warm or hot.

Figure 10.16 Mercury thermometers and digital thermometers are common types of household devices for measuring body temperature.

Thermal Energy and Heat

There are three important terms that you need to know to understand heat. One is temperature, which you just read about. Another one is thermal energy. And the third one is the word "heat" as a scientific term.

In section 10.1, you learned that thermal energy is one of 10 forms of energy. **Thermal energy** is the total energy of all the moving particles in a solid, liquid, or gas. The more moving particles there are in a sample of matter, the greater the thermal energy.

Suppose you have a pot of hot tea, and you pour some into a cup. You immediately measure the temperature of the tea in the pot and the tea in the cup. The temperatures are the same. That means the *average* energies of the tea particles in the pot and in the cup are the same. But the tea in the pot has much more thermal energy than the tea in the cup because there are more tea particles in the pot than in the smaller cup of tea (Figure 10.17). Therefore, the *total* energy of all the particles in the pot is greater than the total energy of all the particles in the cup.

Take It **Further**

Think of all the uses we have for thermometers in our homes, schools, and workplaces, or during leisure activities. Find out about different types of thermometers. Begin your search at ScienceSource.

Transferring Thermal Energy

When we boil water to make the pot of tea, we say that we are *heating* the water. We actually mean that we are transferring energy to *all* the particles of the water, thus increasing the total energy of all the water particles. As a result, the average energy of motion of each particle increases. This means that the temperature increases.

Suppose you pour a cup of steaming hot tea from a teapot (Figure 10.17). You touch the cup with a finger. Somehow, the cup has become hotter, maybe hot enough to burn your finger. Thermal energy in the tea has transferred to the cup and then to your finger. The amount of thermal energy transferred is called **heat**. Heat is the thermal energy transferred from a solid, a liquid, or a gas at a higher temperature to a solid, a liquid, or a gas at a lower temperature. Heat also refers to the thermal energy that transfers within a solid, a liquid, or a gas.

Figure 10.17 A pot full of tea has more thermal energy than a cup of tea at the same temperature.

SKILLS YOU WILL USE
- Measuring
- Recording and organizing data

D10 *Inquiry Activity*

Toolkit 2

Heating Up

In this activity, you will investigate the rate of heating of two different liquids.

Question

Does tap water or salt water boil faster?

CAUTION: Be careful around hot objects and hot water.

Materials & Equipment

- salt solution (10 g salt per 250 mL of solution)
- 2 beakers
- stirring rod
- hot plate
- graph paper
- 250 mL tap water
- 2 thermometers
- tongs or oven mitts

Procedure

1. Create a data table in your notebook similar to the table below.

Table 10.1 Heating of two liquids

Tap Water		Salt Water	
Time (s)	Temperature (°C)	Time (s)	Temperature (°C)
0		0	

2. Pour 250 mL of tap water into a beaker. Measure the temperature of the water and record this "Temperature" value in your table beside the 0 (zero) value in the "Time" column.
3. Add 250 mL of salt solution to the second beaker. Measure the temperature of the solution and record this "Temperature" value in your table beside the 0 (zero) value in the "Time" column.
4. Place both containers on a hot plate. Turn the hot plate on. Predict which liquid will boil first.
5. Measure the temperature of the liquid in each beaker every 30 s. Record in your data table when each liquid begins to boil. Continue to take two more temperature readings of each liquid after boiling.
6. Turn off the hot plate and allow the two liquids to cool. Your teacher will tell you when it is safe to pour the water down the sink. Use tongs or oven mitts to carry your beaker.

Analyzing and Interpreting

7. Use the data you collected to draw a line graph that shows the rate of heating for both liquids. The vertical axis is for temperature and the horizontal axis is for time. The line on your graph for each liquid is called the heating curve for that liquid.
8. Is there a difference between the two heating curves? Describe the differences.
9. How does your graph show that one liquid reached boiling point before the other? Was your prediction accurate?

Skill Builder

10. Suppose you were to repeat this experiment with a salt solution that contained 20 g of salt in 250 mL of solution. Predict and sketch the heating curve of the new liquid.

Forming Conclusions

11. Write a summary paragraph that answers the question for this experiment. Make sure you support your answer with the data you collected and the graph you created.

10.2 CHECK and REFLECT

Key Concept Review

1. What is the difference between thermal energy and heat?

2. What is temperature?

3. How do we measure temperature?

4. State which of the following are sources of energy: wood, bicycle, oil, gasoline, paper, and light bulb. Give a reason for including or excluding each choice.

5. How are renewable and non-renewable energy sources different? List two examples of each of these types of energy sources.

Connect Your Understanding

6. In the past, many Canadians used wood stoves or fireplaces to heat their homes. Today, most Canadian homes burn oil or natural gas or use electric heating. Suggest more than one reason why this change has occurred.

7. People who live in northern Ontario experience cold temperatures for long periods of time in winter. How do you think their homes are built differently from homes in southern Ontario?

8. Many electrical devices in your home are designed to maintain a constant temperature. Name at least three of these devices. Suggest why it is important to keep temperature constant.

Practise Your Skills

9. The photograph below shows a person on a camping trip. Explain what he is trying to do.

For more questions, go to ScienceSource.

D11 *Thinking about Science and Technology*

Heat Technologies in Your Life

In this section, you have learned about temperature, thermal energy, and heat. You have also read about ways that people have used their understanding of these three concepts to meet their needs. For example, understanding how to produce heat has allowed people to live comfortably in houses during cold winters. Think about and describe a situation where an understanding of temperature, thermal energy, or heat has helped create a technology that improves the lives of you and your classmates. Include any situations that you can think of where this technology might affect the environment or your community negatively.

10.3 Changes of State

Here is a summary of what you will learn in this section:

- The particle theory describes how particles of solids, liquids, and gases move.
- The particle theory explains how matter can change from one state to another.
- Heat causes particles to move faster.
- The particle theory explains the expansion and contraction of solids, liquids, and gases.

Figure 10.18 Ice cream tastes good, even when it melts.

When you eat ice cream on a hot summer day, it does not take long for the ice cream to start melting (Figure 10.18). Why does the cold ice cream start to melt? Where is the heat coming from to cause the change of state from a solid to a liquid?

These changes in the ice cream can be explained using the particle theory of matter. The **particle theory of matter** is a theory that explains the behaviour of solids, liquids, and gases. In this section, you will investigate changes in matter and the reason for these changes.

D12 *Starting Point*

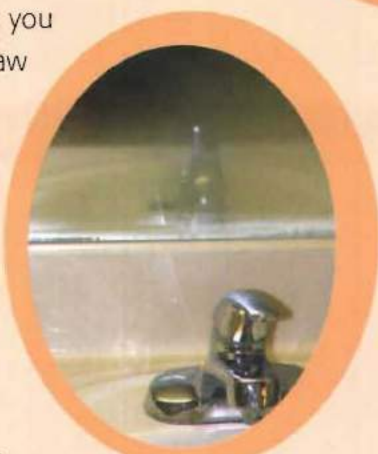
Skills P C

Particles and Changes in Matter

You can use your understanding of particles to explain what happens to matter around you every day.

Look at the photographs in Figure 10.19. In your notebook, describe any changes to water that were required to produce what you see in these three photographs. Draw diagrams to show the spacing between water particles in each picture.

(a)



(b)

(c)

Figure 10.19

Matter Can Change

You may have learned that solid, liquid, and gas are the names of the three **states of matter**. Ice melting is an example of a **change of state**. Solid water (ice) changes to liquid water. A change of state is a change from one of the three states of matter to another.

There are six changes of state, as shown in Figure 10.20. A change from a solid to a liquid is **melting**. A change from a liquid to a gas is **evaporation**. (This is also known as vaporization.) A change from a gas to a liquid is **condensation** and from a liquid to a solid is **freezing**. A solid can also change directly into a gas. This process is called **sublimation**. And a gas can change directly to a solid. This is called **deposition**.

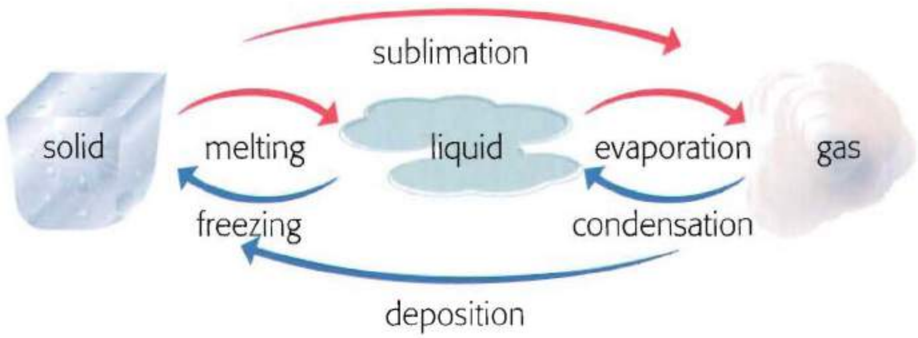


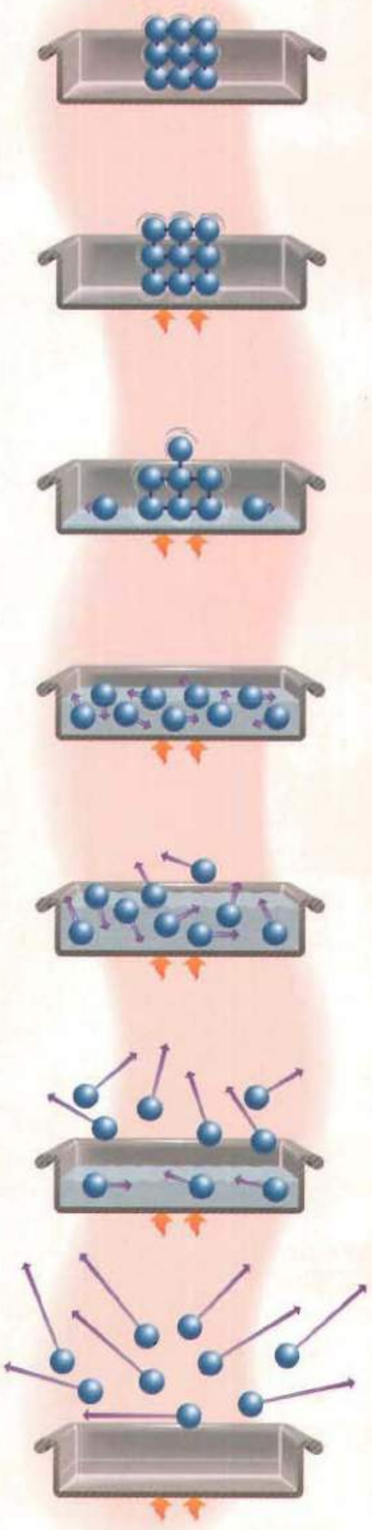
Figure 10.20 Changes in states of matter. The red arrows indicate increasing temperature. The blue arrows indicate decreasing temperature.

The Particle Theory and Changes of State

Suggested Activity
D13 Inquiry Activity on page 298

We can use the particle theory to explain each of the changes of state. The chart in Figure 10.21, on the next page, shows what happens to the particles of a solid when heat is added. The particles of the solid move more quickly and spread apart as the solid slowly melts. As more heat is added, the particles of the liquid have more energy and move more rapidly until they break free from the liquid, forming a gas.

Particle Theory



1 Solid
- Particles of a solid are packed closely together.
- Strong attractions, or bonds, hold the particles together.
- Solids have a fixed shape.
- The particles vibrate, or shake back and forth, in a fixed position.

2 Heating a Solid
- Transferring heat to a solid makes the particles vibrate more energetically.
- Some of the particles move farther away from one another.
- The solid expands—its volume increases.

3 Melting a Solid
- As more heat is transferred to a solid, the particles vibrate even more.
- The particles bump against one another.
- Some of the particles break loose.
- The solid structure begins to break down—the solid melts.

4 Liquid
- The particles have more energy to move about.
- The bonds that hold the particles together are weak.
- Liquids take on the shape of their containers.

5 Heating a Liquid
- Transferring heat to a liquid makes the particles move more vigorously.
- The particles move farther apart.
- The liquid expands—its volume increases.

6 Boiling a Liquid
- As more and more heat is transferred to a liquid, the particles bump and bounce around even more.
- Some of the particles are "kicked" out of the liquid.
- The liquid boils—it changes to a gas.

7 Gas
- Particles of gas move about very quickly in all directions.
- Bumping and bouncing keep them far apart.
- Gas particles will fill up the space of any container.
- On heating, gas particles spread out even more—the gas expands.

Figure 10.21 Stages in the conversion of a solid into a gas

Heat Affects the Volume of Solids, Liquids, and Gases

It is going to be a home-made pizza for dinner, complete with sliced olives. You pick up a jar of olives, but, trying as hard as you can, you cannot turn the metal lid to open the jar (Figure 10.22). A friend suggests that heating the lid with hot water would help. You carefully hold the jar so that hot water runs over the lid. After you dry it off, you can turn the lid easily.

You can use the particle theory to explain what happened to the lid. Thermal energy transferred from the hot water to the particles of the lid of the jar. This caused the particles of the metal in the lid to vibrate faster and move farther apart. As a result, the size of the lid increased slightly — just enough that the lid became looser on the jar. When a solid increases in size, we say that it expands (grows larger). The glass in the jar also expands when heated but not as much as the metal lid does.

Figure 10.22 The particle theory explains why heating the lid of a jar makes it easier to twist off.

Expansion and Contraction in Liquids and Gases

We can see an example of expansion and contraction of a liquid in a thermometer. Liquid is placed in a narrow glass tube. As the liquid becomes warmer, it expands and rises in the glass tube. As the liquid cools, it contracts (grows smaller) and drops down the tube.

Similar principles are at work when there is a change in the thermal energy of a gas. Imagine that you are invited to a party in January. At the end of the party, you take home some helium balloons tied to ribbons. It is very cold, so you walk quickly. The farther you go, the more the balloons "wilt." They no longer pull at the ribbons, but now bob near your shoulders. By the time you reach home, the balloons are smaller and wrinkled (Figure 10.23). However, after they have been in your bedroom for an hour, they look the same as when you left the party. Both contraction and expansion have been at work!

Figure 10.23 The gas in the balloons is affected by the warm air indoors and the cold air outside.

Take It **Further**

When a bridge is built, gaps are present in the road surface. Find out why these gaps are included in the design. Begin your search at ScienceSource.

DI Anchor Activity

D13 *Inquiry Activity*

Toolkit 2

SKILLS YOU WILL USE
- Measuring
- Organizing data

Melting Away

You have often seen ice cubes melting. In this chilling activity, you will predict and then measure how long it takes for an entire ice cube to melt.

Question

How long would it take for an entire ice cube to melt in your hand?

CAUTION: Stop holding the ice cube if your hand becomes too cold.

Materials & Equipment

- 1 ice cube per student
- triple-beam balance
- waxed paper
- digital watch or clock
- margarine tub or small beaker
- cloth or paper towels
- graph paper and ruler

Procedure

1. Draw Table 10.2 in your notebook.
2. Predict how long (in minutes) it would take for an ice cube to melt in your hand. Record your prediction.
3. Use the triple-beam balance to measure the mass of your ice cube (Figure 10.24). Record the mass in your table.
4. Place the ice cube on waxed paper. Pick up the ice cube and waxed paper together, so that the ice cube is surrounded by the paper.
5. Hold the ice cube in your fist for 2 min. Allow any water to drip into the tub or beaker.
6. After 2 min, quickly wipe any liquid from the surfaces of the ice cube. Measure the mass of the ice cube. Record the mass.

Figure 10.24 Set-up for activity

7. Repeat steps 4–6 for another 2 min. Use your other hand this time.
8. Repeat steps 4–6 for two more trials (total of 8 min).
9. Pour the melted water into the sink. Dry your work area.

Table 10.2 Melting of an ice cube

Time (min)	Mass of Ice Cube (g)
0	

Analyzing and Interpreting

10. Calculate the total loss of mass in grams of your ice cube over 8 min. Show how you calculated the change in mass.

11. Calculate the rate at which your ice cube was melting. In your notebook, write the following formula and then calculate the rate of melting.

$$\text{rate of melting (g/min)} = \frac{\text{overall change in mass of my ice cube (g)}}{\text{8 min}}$$

12. Calculate how long it will take the entire ice cube to melt in your hand. In your notebook, write the following formula; then calculate the expected melting time for the entire ice cube.

$$\text{expected melting time for the entire ice cube} = \frac{\text{starting mass of unmelted ice cube (g)}}{\text{rate of melting (g/min)}}$$

D13 *Inquiry Activity* (continued)

Skill Builder

13. Use a ruler and pencil to draw the x-axis and y-axis of a graph. The x-axis will represent time while the y-axis will represent the mass of your ice cube. Label the x-axis and y-axis (Figure 10.25).

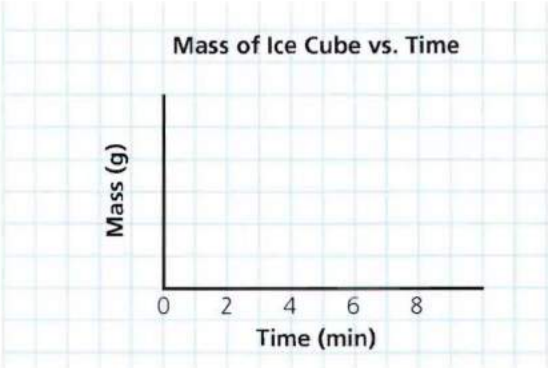


Figure 10.25

14. Use a pencil to plot the data from Table 10.2.

Forming Conclusions

15. How close was your prediction of the melting time to the value calculated in step 12?

16. Extend the line on your melting graph down to the x-axis (completely melted). What value for time do you obtain? Compare this value with the value you calculated in step 12.

17. Suggest one or more reasons to explain why your calculated time for the entire cube to melt is different from the value from the graph.

18. Use the particle theory to explain why an ice cube melts. Include words like "energy," "motion," and "space" in your answer.

D14 *Quick Lab — Teacher Demonstration*

Fast Change

Purpose

To observe the effect of cooling a gas

Materials and Equipment

- aluminum can
- water
- 5-mL measuring spoon
- hot plate
- large, clear bowl
- ice cubes
- tongs

Procedure

1. Pour 5 mL of water into an aluminum can and place the can onto a hot plate. Turn the hot plate on.

2. Add water to a large, clear bowl. Add ice cubes. The ice cubes will cool the water.

3. When the water in the can is boiling, use the tongs to carefully remove the aluminum can from the hot plate.

4. In a quick turning motion, flip the can over and immerse the can in the ice water to a depth of approximately 2 cm.

Questions

5. Describe what happened to the aluminum can after it was immersed in the ice water.

6. How does the particle theory explain your observations of the aluminum can after it was immersed in the ice water?

7. Would the same effect occur if the aluminum can was immersed in hot water? Explain your answer.

10.3 CHECK and REFLECT

Key Concept Review

1. Name the six changes of state.

2. For each of the six changes of state, list the starting state of matter and the ending state of matter. Devise your own chart for your answers.

3. What happens to the particles of solids, liquids, and gases when they are heated?

4. What happens to the volume of solids, liquids, and gases when they are heated. Devise your own chart for your answer.

5. (a) Predict what might happen to the size of a blown-up ball if you place it into a refrigerator or freezer.

(b) If possible, test your hypothesis for part (a). Include labelled diagrams in your report of the test.

Connect Your Understanding

6. Sealed bottles of juice or other drinks are not filled to the top. Use the particle theory to suggest a reason for this.

7. When Ontario hydro workers set up electrical cables during the summer, they allow the cables to sag. Suggest a reason for this. In your answer, refer to the particle theory. (**Hint:** Consider what will happen in the winter.)

Practise Your Skills

8. Compare the motion of the particles in a solid, a liquid, and a gas. Illustrate your descriptions and label your drawings.

9. How would the particle theory be useful to explain the situation shown below?

The coffee mug cracked after boiling water was poured into it.

For more questions, go to ScienceSource.

D15 *Thinking about Science and Technology*

Keeping the Warm Air In

Consider the entrances to your school. Inside, the door is warm from the heat of the air in the school. Outside, in winter the door is cold from the outside air. The door expands and contracts as these temperatures change. This is true for the doors of any building. If possible, take a look at an entrance door to your school. Draw and label a diagram to explain how we prevent warm air from leaking out through the space between a door frame and a door.

10.4 Heat Transfer

Here is a summary of what you will learn in this section:

- Heat is transmitted through the environment by conduction, convection, and radiation.
- Conduction is the transfer of heat through a solid or between a solid and another solid, a liquid, or a gas that it is touching.
- Convection is the transfer of heat through a fluid (a liquid or a gas).
- Radiation (radiant energy) is the transfer of heat in the form of waves.

On a hot summer day, you open your lunch bag to find a warm drink and a melted and mushy cheese sandwich. It would be much more appetizing to have both the drink and the sandwich at the right temperature. Understanding how heat transfers between materials is the first step to creating the properly cooled drink and sandwich for your lunch.

This warm lunch is only one of many examples where heat can be undesirable. Often, the transfer of energy is very useful. When is heat transfer helpful? What can we do to reduce heat transfer when it is not helpful? Figure 10.26 shows examples of heat transfer.

(d)

(a) (b) (c)

Figure 10.26 Heat is transferring in different ways in these situations.

D16 *Starting Point* Skills A C

Thinking Things Through

You have learned about heat as being the thermal energy transferred from an area of higher temperature to an area of lower temperature. Now, consider common situations where heat is useful. In your notebook, write a title and five or more situations where heat is useful at home, school, work, or leisure. Then, under a separate title, list five or more situations where heat is *not* useful or may even be harmful. Illustrate some of the situations you listed.

Figure 10.27 Oven mitts prevent the rapid transfer of heat to this person's hands.

Figure 10.28 Heat conducts from the hot water to the thermometer.

Figure 10.29 Heat is transferring by conduction from the hot air to the baby.

Three Types of Heat Transfer

There are three types of heat transfer. The word "*transfer*" means to carry across. When heat transfer occurs, the energy is carried through or across from one solid, liquid, or gas to another. In the following section, you will learn about all three types of heat transfer—conduction, convection, and radiation.

Conduction

If you have ever tried to remove a hot cookie sheet filled with cookies from an oven, you will know how quickly heat can transfer from one solid, the cookie sheet, to another solid, the oven mitt covering your hand (Figure 10.27). This is an example of rapid heat transfer by the heating of a solid, the oven mitt.

Conduction is the transfer of heat through a solid or between a solid and another solid, a liquid, or a gas that is in contact with it. The oven mitts are an example where solids are touching. Conduction also occurs where energy is transferred between a liquid and a solid or a gas and a solid (Figures 10.28 and 10.29). Notice that conduction occurs in one direction only — from a region that is warmer to a region that is cooler.

Figure 10.30 shows a pot of soup heating up on the element of a stove. The particles in the stove element are moving rapidly. They are vibrating rapidly, bumping into their neighbours — the particles on the bottom of the pot. Some of the energy of the particles in the red-hot element transfers to the metal pot. This makes the particles of the pot vibrate faster. Some of this energy transfers to the particles of the soup at the bottom of the pot, making the soup hotter. Conduction has played a role twice in this example. The result? A bowl of delicious hot soup, courtesy of conduction.

Figure 10.30 A pot of soup heating up on the element of a stove

Convection

In the example of the tasty hot soup, there is also another type of heat transfer occurring. Heat first transfers from the hot element to the bottom of the pot by conduction. In turn, heat transfers from the hot bottom of the pot to the soup at the bottom of the pot. This is also conduction. Then the soup particles at the bottom of the pot begin to move around rapidly. They bump into each other and spread apart. This is just like a curling rock bumping into several curling rocks on a sheet of ice (Figure 10.31). In other words, the hot soup at the bottom of the pot expands (pushes out and up).

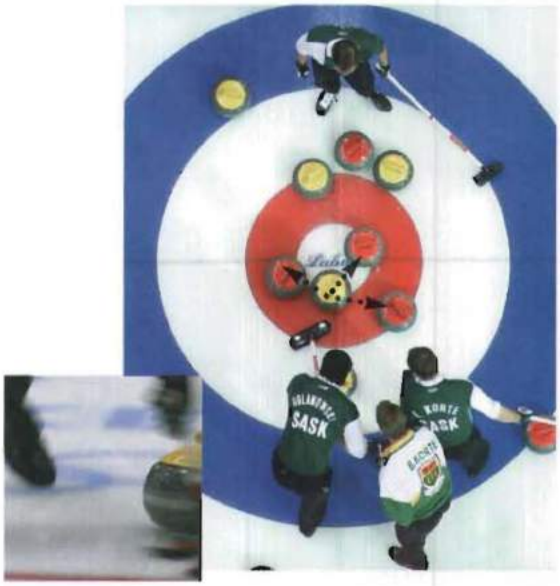


Figure 10.31 Curling rocks are models for how rapidly moving particles transfer energy by bumping into each other. The collision transfers energy from the yellow curling rock in the centre to the red curling rocks on the left and right.

Movement of Particles

The hot soup begins to rise to the surface of the soup, pushing the cooler particles at the surface to the sides of the pot. There, the cooler particles sink to the bottom to take the place of the rising hot particles. When the cooler particles reach the bottom, they bump into the hot bottom of the pot and the circular pattern continues (Figure 10.32).

When the circulating hot liquid reaches the top of the pot, energy from the particles of the liquid transfers to the air particles. These particles of liquid, therefore, become somewhat cooler. They are pushed to the side of the pot as more hot liquid rises to the surface. As they drop down to the bottom, they again transfer energy to the sides of the pot, which are in contact with cooler air outside. This continuous motion sets up a pattern that continues as the soup is heated.

Figure 10.32 (a) The soup was cool to begin with. Heat from the hot element reaches the soup particles at the bottom of the soup by conduction.

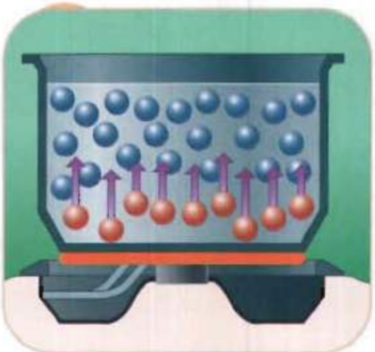


Figure 10.32 (b) The soup particles near the bottom of the pot vibrate quickly, bumping into the particles of the cooler soup above them. The hot soup pushes upward, forcing the cooler soup to the side of the pot.

Figure 10.32 (c) The particles of the cooler soup sink closer to the bottom of the pot and begin to circulate.

Figure 10.32 (d) As the particles reach the bottom of the pot, they are heated and begin to rise up the middle, creating a convection current.

Suggested Activity •

D18 Quick Lab on page 306

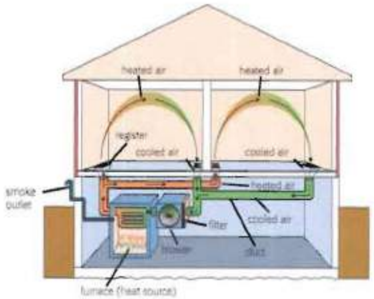


Figure 10.33 Forced-air heating creates convection currents.

This transfer of thermal energy by moving particles occurs in **fluids** — liquids and gases. It is called **convection**. The circular pattern of moving particles within fluids is called a **convection current**. Convection currents transfer heat from the hotter region to the cooler region, just as in conduction.

Convection Currents Affect Your Life

Convection currents occur in many places in nature and in structures such as buildings. These currents can make a big difference to your living conditions. Think about being in a cold room that has a heater in one corner or a hot-air vent in the floor (Figure 10.33).

When you turn the heater on or when the furnace pushes hot air through the vent, the first part of the room that warms up is near the heater or vent. As the particles of air move more rapidly, they push out and up. The hot air rises and meets the ceiling of the room, where it transfers some energy to the ceiling. The air then cools and drops down along the walls. A convection current forms in the room until the entire room becomes warm, just like the pot of soup did.

D17 *Learning Checkpoint*

Identifying Heat Transfers

Here is a chance to practise your skills in non-fiction writing as you share what you have learned about heat transfer. Think about interesting and fun ways to inform your classmates.

1. Describe how heat transfer occurs when you place your hand in a sink full of hot water.
2. Why does convection not occur in solids?
3. How does heat flow in these situations?
   (a) an egg on a hot frying pan
   (b) a candle in air

Take It Further

Fire walkers walk across red-hot coals with bare feet but do not burn themselves. Find out how they do it. Begin your search at ScienceSource.

Heat Transfer by Radiation

Conduction and convection are two ways in which heat transfers between solids, liquids, and gases. Radiation is the third way. Both conduction and convection involve the movement of particles. Radiation does not. **Radiation** (radiant energy) is the transfer of energy by invisible waves given off by the energy source.

Thermal energy is one of the many forms of energy radiated by the Sun and other stars. Thermal energy from the Sun reaches Earth by radiation. Heat is the radiant energy that you feel on your skin. On the opening pages of this unit (pages 272 and 273), the photograph of the Sun reveals details that our eyes cannot see. Heat is transferred by invisible waves called **infrared waves**. All hot solids (including you), liquids, and gases radiate invisible heat waves (Figure 10.34). Images taken with a camera capable of recording infrared waves give information that we could not get from visible-light pictures.

Scientists use infrared waves to detect many things in nature that otherwise could not be observed. For example, satellites that orbit Earth can detect infrared waves that reflect off Earth and into space. These infrared images help people to discover how pollution spreads, where insects are damaging forests, and what the weather might be like in your region for the next several days (Figure 10.35).

Figure 10.34 This image gives a different view of a familiar animal. It was taken using a camera capable of recording infrared waves. The orange areas are the warmest and the white-blue areas are the coldest.

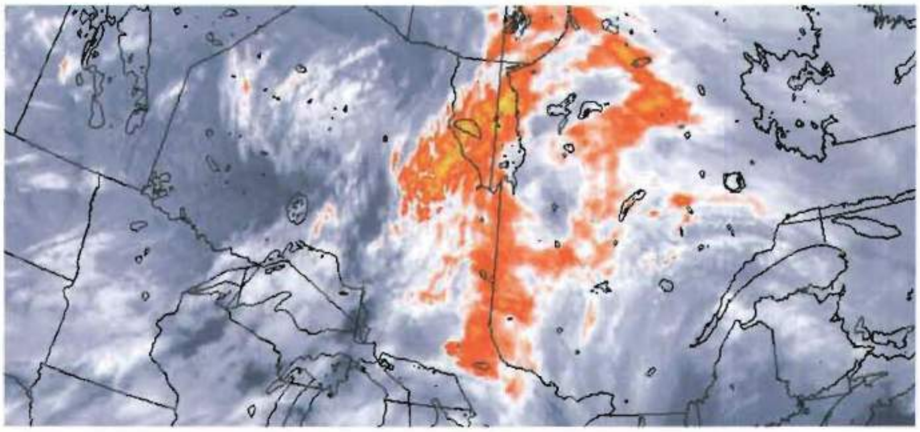


Figure 10.35 This infrared image of Ontario can be used to forecast the weather. High clouds are very cold. They are composed of ice crystals. The colours show the range of temperatures with orange-red being the coldest.

How Radiant Energy Warms Up Objects

When invisible waves of radiant energy come into contact with a solid, the particles in the solid vibrate faster. The solid becomes hotter. The solid can in turn, reradiate some of this energy back into the area where it is standing (Figure 10.36).

Suppose you open the doors of your family car on a sunny day in winter. The air in the car may feel quite warm. Touch the plastic dashboard beneath the windshield. It might feel hot, yet the windshield and other windows in the car may feel almost as cold as the air around the vehicle. This example shows that coloured solids can absorb and reradiate infrared waves, but transparent solids, liquids, and gases allow infrared waves to pass easily through them.

Figure 10.36 Even on a cold day, radiation from the Sun can warm the floor and objects inside a room.

D18 *Quick Lab*

Battling Bottles

Purpose

To observe convection using coloured water

Materials & Equipment

- 4 identical colourless plastic bottles
- masking tape or labels
- marking pen
- water
- food colouring
- 2 file cards

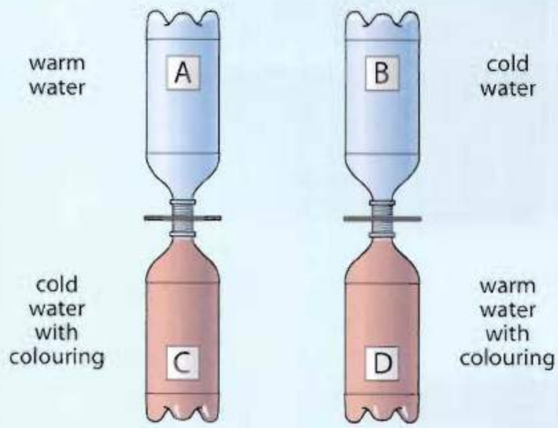


Figure 10.37 Set-up for Quick Lab

Procedure

1. Label the four bottles A, B, C, and D.
2. Fill bottles A and D with warm water.
3. Fill bottles B and C with cold water.
4. Add enough food colouring to bottles C and D so that you can see it easily. Mix thoroughly.
5. Cover the openings of bottles A and B with the file cards. Place bottles A and B upside down on top of bottles C and D. Make sure the bottles are centred – right on top of each other.
6. While one partner holds bottle A and another partner holds bottle B, carefully remove the file cards. Continue to hold the upper bottles.
7. Observe what happens to the coloured water.
8. When you have finished the activity, follow your teacher's instructions for recycling the plastic bottles and other materials, if possible.

Questions

9. At the beginning, in which bottles were the particles of water moving more quickly?
10. Describe what happened to the colour in both sets of bottles.
11. Draw two diagrams of the four bottles. Label one "Before removing the file card." Label the other "After removing the file card."
12. Write a paragraph or two to describe your observations. Use "convection" and "convection current" in your descriptions.

D19 *Inquiry Activity*

Toolkit 2

SKILLS YOU WILL USE
- Predicting
- Organizing data

You're Getting Warmer

In this activity, you will be able to observe and measure the effects of radiant energy.

Purpose

To observe and measure changes in temperature caused by radiant energy

Materials & Equipment

- 2 large test tubes
- tape
- black paper and white paper
- ring stand
- 2 test tube clamps
- water
- 2 one-holed rubber stoppers
- 2 thermometers
- bright light bulb or sunlight
- a clock or watch for timing

Figure 10.38 Set-up for activity

Hypothesis

Suggest what happens to dark- and light-coloured objects when a strong light shines on them.

Procedure

1. Draw Table 10.3 in your notebook.
2. Tape white paper to completely cover one test tube and black paper to completely cover the other. Set up the test tubes.
3. Place equal volumes of water into the two test tubes and insert the thermometers, supported by the rubber stoppers.
4. Measure the starting temperature of the water in each of the test tubes. Record the results in your table.
5. Turn on the light. Let it shine equally on both test tubes.
6. Measure and record the temperature of the water every minute for 20 min.
7. Turn off the light when you have completed your measurements.

Table 10.3 Temperature change

Time (min)	Temperature of Water in White Test Tube (°C)	Temperature of Water in Black Test Tube (°C)
0		
1		

Analyzing and Interpreting

8. Suggest a reason for the temperature differences you observed in this activity.

Skill Builder

9. Use the data from this activity to draw a graph that will have two separate coloured lines. One line will represent the black test tube. The second line will represent the white test tube. Use graph paper. Be certain to label the *x*-axis and *y*-axis and to give your graph a title. Include a legend for the colours you use.

Forming Conclusions

10. Suggest how you could modify this activity to find out how infrared waves are absorbed by other colours.

10.4 CHECK and REFLECT

Key Concept Review

1. In what state of matter can conduction occur?

2. Can convection occur in both liquids and gases? Suggest a reason for your answer using the particle theory.

3. List two things that happen when invisible waves of radiant energy come into contact with a solid.

Connect Your Understanding

4. Think about how a microwave oven heats food. Do you think this type of heating is due to conduction, convection, or radiation?

5. Describe a situation not mentioned in this section in which energy transfer by conduction is important.

Practise Your Skills

6. A heat lamp was shining on two test tubes of water in a way similar to Inquiry Activity D19. The test tubes were covered with either black paper or white paper. The table below shows the data that were collected when the heat lamp shone on the two test tubes. Decide which column of data represents the black test tube and which represents the white test tube. Provide reasons to justify your answer.

Time (min)	Temperature of Water in Test Tube A (°C)	Temperature of Water in Test Tube B (°C)
0	20	20
3	22	21
6	25	22
9	28	23
12	30	24
15	33	25

For more questions, go to ScienceSource.

D20 *Thinking about Science and Technology*

Hot or Not?

Figure 10.39 (a) (b)

Discuss the following questions.

1. What differences will there be in what the student feels under the conditions shown in Figures 10.39(a) and 10.39(b)?

2. How would your answer change if the cardboard in Figure 10.39(b) were replaced by a glass plate?

Science and Technology in Your World

Phil Nuytten — Engineer and Deep-Sea Explorer

Figure 10. 40 Phil Nuytten

If you have ever been swimming in ocean or lake water, you know that keeping warm when in cold water can be a problem. Scientists who explore the ocean depths in Canada's northern waters are even more concerned about staying warm. That is the problem that Canadian Phil Nuytten decided to solve.

Phil Nuytten is a sub-sea engineer, inventor, and diver who lives in Vancouver. He operates Nuytco Research Ltd., a world leader in developing underwater technology. Nuytten has developed underwater submersibles — mini-submarines that can be used for exploration and other tasks. But he is most famous for developing the Newt Suit — a flexible hard suit that protects the wearer to depths of 300 m (Figure 10.41). His more recent Exosuit is even lighter.

These suits are used during undersea exploration and construction. They are standard equipment used by the navies of many countries. Astronauts from the Canadian Space Agency use Nuytten's underwater suits to train for their work on the International Space Station.

Figure 10.41 The Newt Suit

Questions

1. One of Phil Nuytten's goals is to design and manufacture exploration equipment that will help to keep divers safe. Suggest two or more ways that the Newt Suit protects divers.
2. Which aspect of Phil Nuytten's work do you find the most interesting? Explain why.
3. Research careers in underwater exploration. Find out what education or training you would need for these careers. Begin your search at ScienceSource.

10.0 Chapter Review
Assess Your Learning

Key Concept Review

1. What does the particle theory suggest about the motion of the particles of solids, liquids, and gases when they are heated? K

2. What happens to the volume (size) of solids, liquids, and gases when they are heated? K

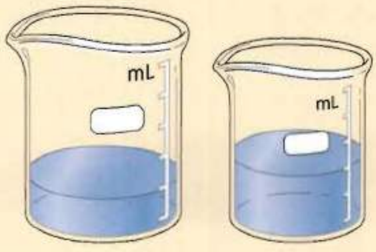
3. What happens to the volume (size) of solids, liquids, and gases when they cool? K

4. Name three types of energy transfer and provide an example of each. K

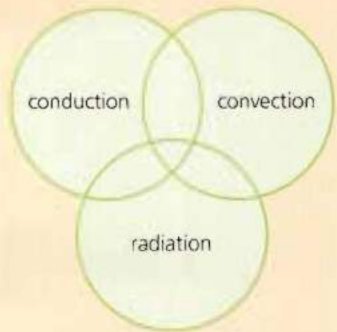
Connect Your Understanding

5. Suggest a reason why many frying pans have plastic handles. T

6. The diagram below on the left shows two beakers of water at the same temperature. Which beaker would have more thermal energy? Give a reason for your answer. T



These beakers contain the same volume of water.



A three-circle Venn diagram

7. Copy the Venn diagram shown above on the right. Then, use the information you gained in this chapter to complete the diagram. C

8. Describe three or more applications (uses) scientists have for infrared radiation. Then, try to suggest at least one more application that was not mentioned in this chapter. A

After Reading Thinking Literacy

Reflect and Evaluate

Revisit the mind map you created in the Before Reading activity at the start of this chapter. Add any new information you have learned. Explain your mind map to a partner and listen to your partner share her or his information. Is there any important information you heard from your partner that you need to add to your mind map? What strategies and text features did you use to determine what was important when you read?

ACHIEVEMENT CHART CATEGORIES
K Knowledge and understanding T Thinking and investigation C Communication A Application

9. Copy the "heat" phrases and expressions in column A of the table below into your notebook. Select the matching description from column B of the table. In your notebook, record the description beside the "heat" phrase it matches.

Column A: Heat Phrases and Expressions	Column B: Descriptions (Scrambled)
If you can't stand the heat, get out of the kitchen.	A popular location
Dead heat	Right out of the oven
Piping hot	Getting into trouble
Hot off the press	Everybody is buying one!
Hot spot	The latest news
Hot button issue	Tied score or evenly matched
Getting into hot water	A person who gets angry easily
Strike while the iron is hot.	An issue people rather not deal with
Selling like hot cakes	Complete the task while you are able.
A hot potato	To stop an activity that is causing you stress
Hot headed	A concern held by many people

Practise Your Skills

10. Examine the scene on the right. Name as many examples as you can for each of the three types of energy transfer.

11. Suggest how you might use metal and plastic spoons to determine which of these materials conducts heat more quickly.

Unit Task Link

Insulation is the opposite of conduction. A good insulator does not conduct heat well.

With an adult, talk to staff at a hardware or builders' supply store. Find out about the types of insulation materials that you could use to cover a 2-L plastic soft drink bottle.

D21 *Thinking about Science and Technology*

Heating Past and Present

Where and how do we use ideas about heat and the particle theory to make our lives easier? Create your own Devices InfoBox. In Section A, brainstorm a list of five appliances, machines, or devices that are related to the ideas in this chapter. In Section B, suggest what devices were used (if any) before the devices in Section A were invented. In Section C, describe the benefits of using each device in Section A. In Section D, suggest new devices that might be developed in the next 20 years.