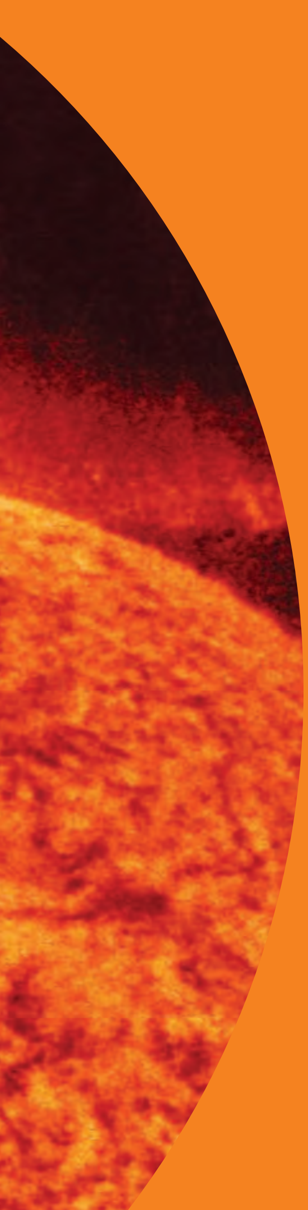
UNIT D

Heat in the Environment



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

Unit Overview

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.

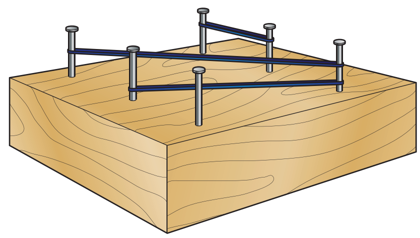


Figure 10.9 Set-up for Station 1

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.

(a) (b) (c) (d)

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?

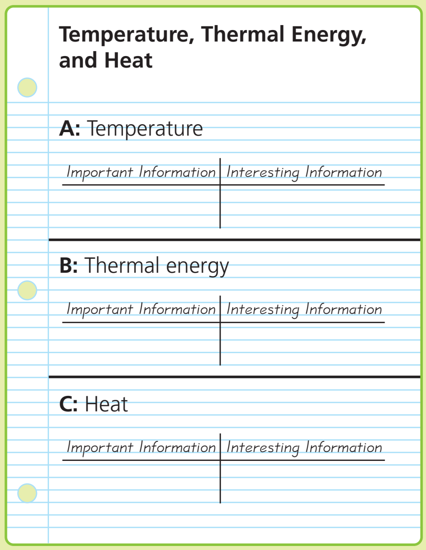


Figure 10.14 Heat InfoBox

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.

D10 *Inquiry Activity* Toolkit 2

SKILLS YOU WILL USE
- Measuring
- Recording and organizing data

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.

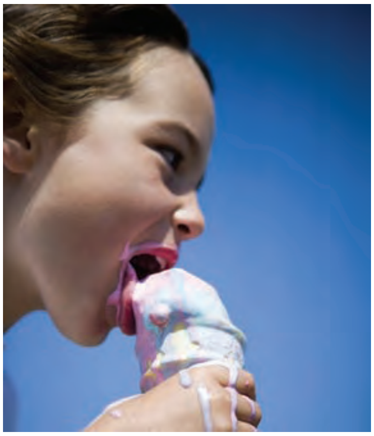


Figure 10.18 Ice cream tastes good, even when it melts.

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.

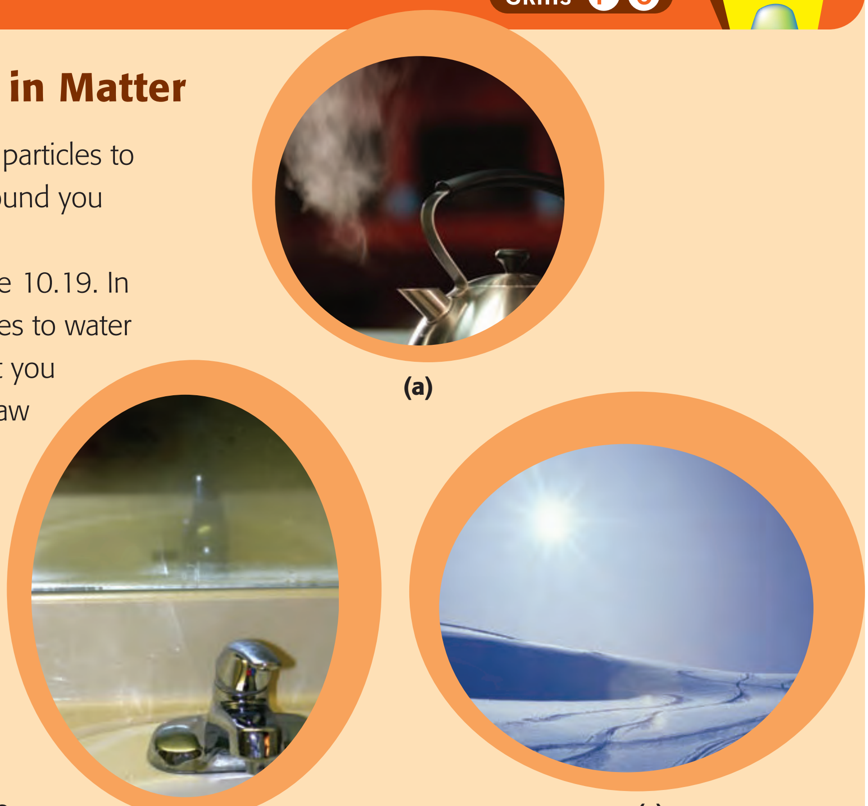
D12 *Starting Point*

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**.

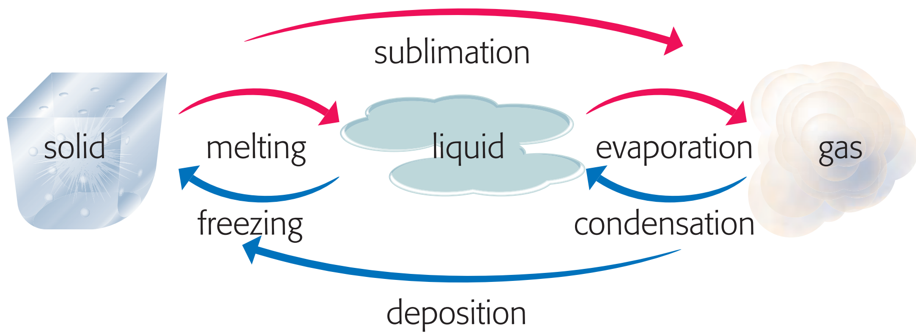


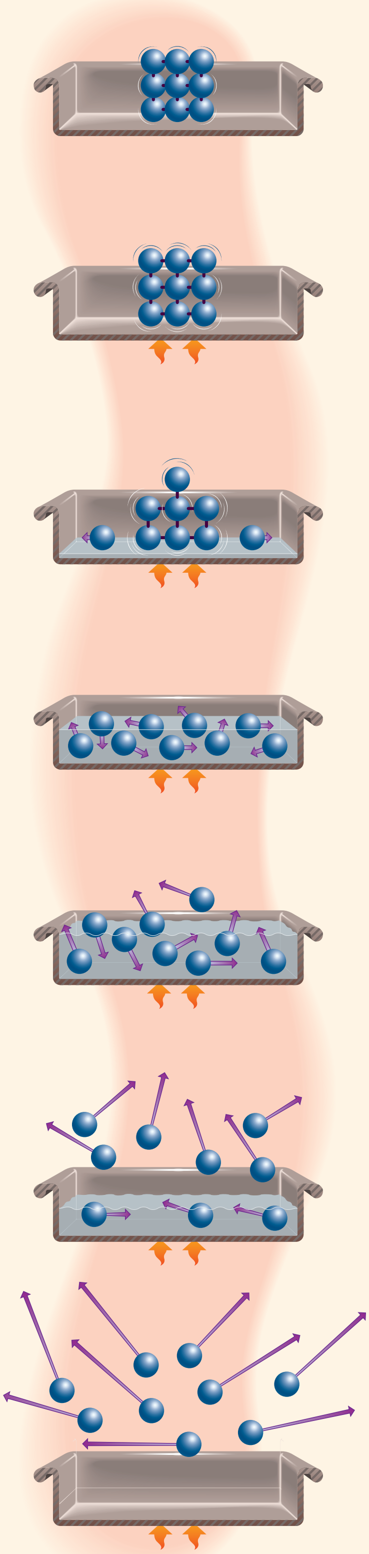
Figure 10.20 Changes in states of matter. The red arrows indicate increasing temperature. The blue arrows indicate decreasing temperature.

The Particle Theory and Changes of State

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.

Suggested Activity
D13 Inquiry Activity on page 298

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

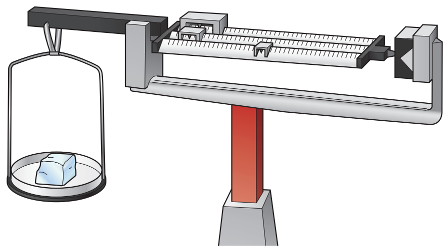


Figure 10.24 Set-up for activity

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.
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).

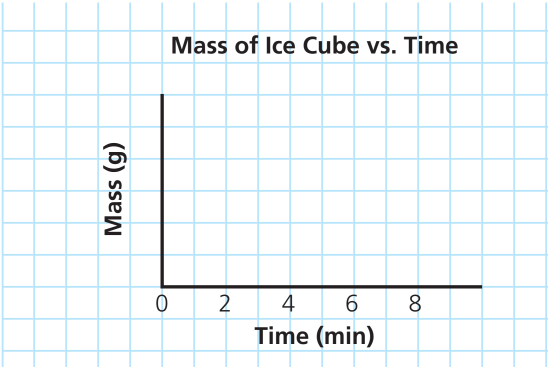


Figure 10.25

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*

STSE

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.

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 10.28 Heat conducts from the hot water to the thermometer.

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

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.

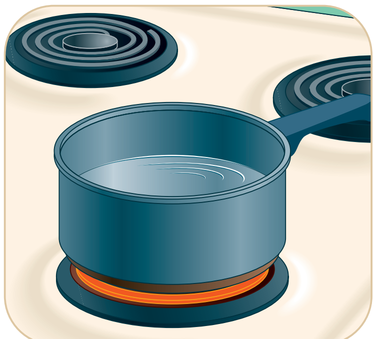


Figure 10.32 (a) The soup was cool to begin with. Heat from the hot element reaches the soup particles at the bottom of the soup by conduction.

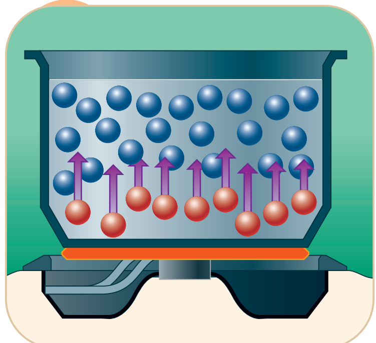


Figure 10.32 (b) The soup particles near the bottom of the pot vibrate quickly, bumping into the particles of the cooler soup above them. The hot soup pushes upward, forcing the cooler soup to the side of the pot.

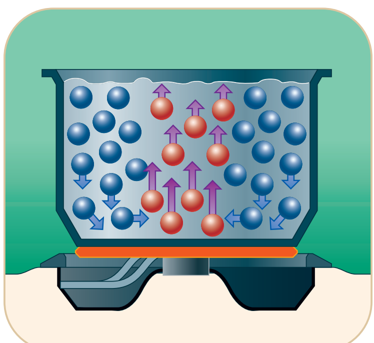


Figure 10.32 (c) The particles of the cooler soup sink closer to the bottom of the pot and begin to circulate.

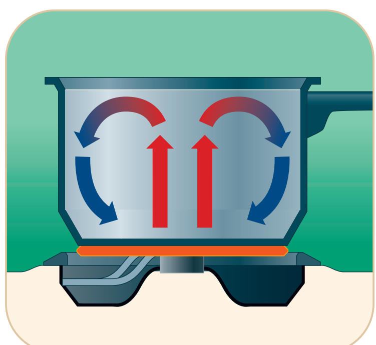


Figure 10.32 (d) As the particles reach the bottom of the pot, they are heated and begin to rise up the middle, creating a convection current.

Suggested Activity • · · · · · · · ·
D18 Quick Lab on page 306

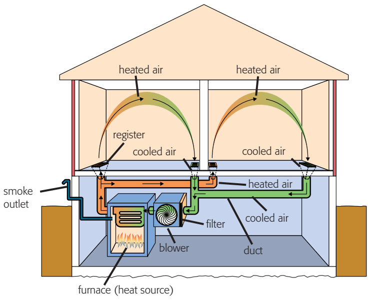


Figure 10.33 Forced-air heating creates convection currents.

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.

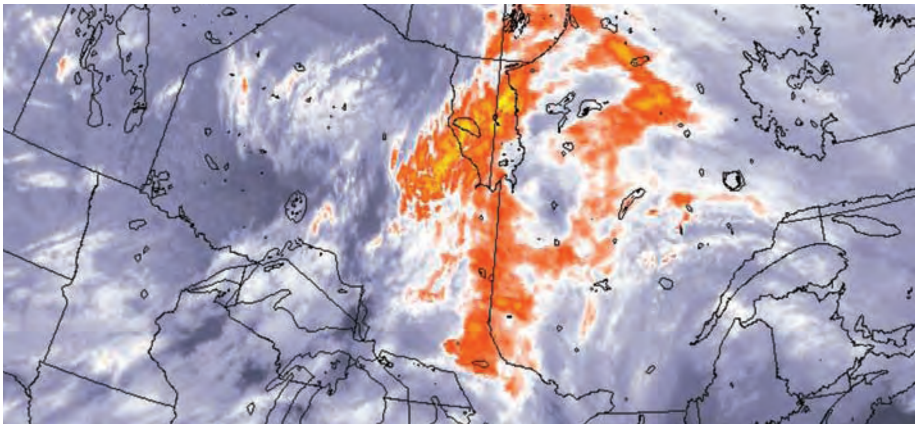


Figure 10.35 This infrared image of Ontario can be used to forecast the weather. High clouds are very cold. They are composed of ice crystals. The colours show the range of temperatures with orange-red being the coldest.

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

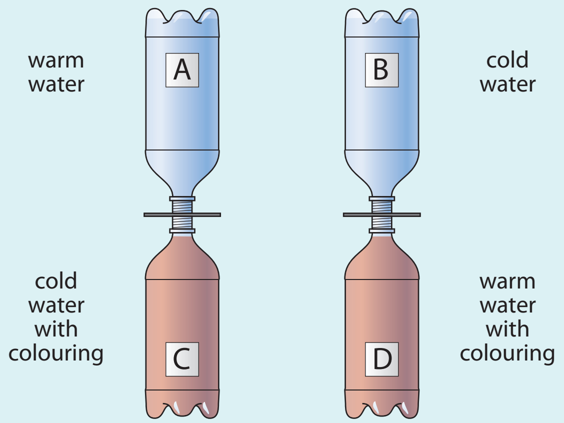


Figure 10.37 Set-up for Quick Lab

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

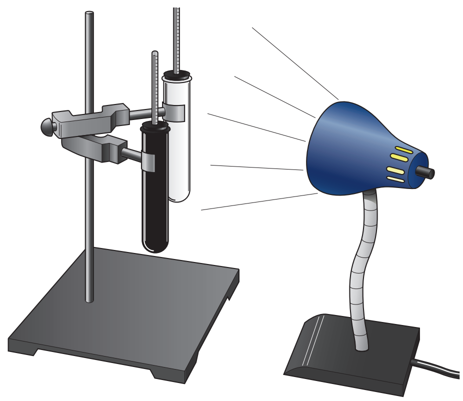


Figure 10.38 Set-up for activity

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?

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

After Reading — Thinking Literacy

Reflect and Evaluate

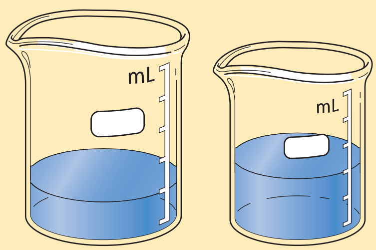
Revisit the mind map you created in the Before Reading activity at the start of this chapter. Add any new information you have learned. Explain your mind map to a partner and listen to your partner share her or his information. Is there any important information you heard from your partner that you need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

Key Concept Review

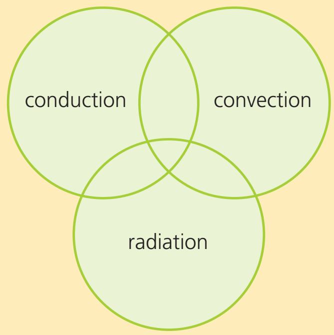
1. What does the particle theory suggest about the motion of the particles of solids, liquids, and gases when they are heated? (k)
2. What happens to the volume (size) of solids, liquids, and gases when they are heated? (k)
3. What happens to the volume (size) of solids, liquids, and gases when they 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. (t)
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)

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. *a*

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

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.

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. *t*

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

D21 *Thinking about Science and Technology*

S T S E

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.