DISCOVERING SCIENCE 7
TEACHER'S RESOURCE

UNIT 2: HEAT

Table of Contents

McGraw-Hill Ryerson

UNIT 2: OVERVIEW

Unit 2 provides students with an introduction to the study of heat. The unit begins with the development of the concept of temperature and methods of describing and measuring temperature. Students are given an opportunity to measure temperatures of several substances as well as to build and calibrate a thermometer.

The relationship between temperature and heat is developed by explaining and describing the particle theory of matter. The concepts of the particle theory of matter and of temperature help students understand the reason for the states of matter. Models are used extensively to help students understand the states of matter. Students are given the opportunity to investigate the effects of a change in temperature on solids, liquids, and gases. The particle theory is also used to explain how heat is transferred from one object to another and from one place to another. These concepts are related to the students' everyday lives by using examples such as weather, living organisms, and home heating and insulating.

Chapter 4: Temperature describes how hot or cold an object is.
Chapter 4 begins by familiarizing the student with the temperatures of common examples from everyday life. Such topics as the importance of body temperature, air temperatures, cooking temperatures, and appropriate refrigerator and freezer temperatures are used to relate the subject to the students' lives.

The chapter then presents the history of the development of technologies for measuring temperatures. It begins with the air thermoscope of Galileo and the further development of thermometers by other scientists. The chapter continues by discussing the reasons and methods for developing temperature scales. The Fahrenheit, Celsius, and Kelvin scales are explained in detail. The concept of calibrating a thermometer is explained. Finally, more modern technologies for measuring temperatures, including the bimetallic strip, the thermocouple, and infrared thermograms are introduced along with applications of each technology.

Chapter 5: Scientists use the particle theory of matter to describe temperature.
Chapter 5 starts by developing concepts that are necessary in order to explain the relationship between temperature and heat. The particle theory of matter is developed using models in order to help make the theory concrete for the grade 7 student. The concept of kinetic energy and the method of calculating an average value are introduced so the motion of particles can be related to temperature. The particle theory is used to explain the states of matter with which the students are familiar–solids, liquids, and gases. Models, using people as particles, are presented to help students develop a sense of how particles interact in solids, liquids, and gases. The particle theory is also used to explain why matter usually expands when heated and contracts when cooled. Practical applications of thermal expansion and contraction, including the design of large structures, are presented to help students understand why the topic is important in everyday life.

The six changes of state are named and described. Illustrations help the student learn the names and their meanings. The concepts of melting points and boiling points are defined. Once again, the particle theory is used to explain why a substance undergoes a change of state. The chapter explains how to use the values of melting points and boiling points to predict the strength of the attractive forces among the particles of specific substances. Finally, heating curves are used to help students better understand how a substance's particles behave while it is heated.

Chapter 6: Heat is transferred from one object to another by three different processes.
The three methods of heat transfer–conduction, convection, and radiation–are introduced in Chapter 6. The example of a pot on a stove is used to relate conduction to everyday life. Wind is used as an example to help the student relate to convection. Radiation is a more abstract concept so general information about waves is presented to help the student understand radiation. Practical examples, such as a microwave oven and the warmth of sunlight, make radiation more meaningful to the student. Some examples involving light, which the student can see, help the student understand how electromagnetic waves interact with matter. The concept that the energy of waves must be absorbed by matter in order to transfer heat to an object is emphasized. All of the methods of heat transfer are brought together by applying them to home heating.

Varying rates of conduction of heat are introduced by using the example of cookware. The use of radiators for home heating and for automobile engine cooling also helps the student understand the importance of the concept of thermal conductors. Insulators are presented as substances that are very poor conductors of heat. The insulation of homes and other buildings is used to help the student identify with the concept of insulators.

The last section of Chapter 6 emphasizes the difference between temperature and heat. The concept of kinetic energy of particles is, once again, used to enhance the students' understanding of the contrast between heat and temperature. In the context of heat and temperature, the concept of specific heat capacity is introduced. The influence of large bodies of water on weather,due to the large specific heat capacity of water helps students understand the everyday significance of specific heat capacity.

MULTIPLE INTELLIGENCES CORRELATION FOR UNIT 2 ACTIVITIES AND INVESTIGATIONS

The table below identifies possible multiple intelligences that could be incorporated into activities and investigations in this unit. For more information concerning differentiated instruction and multiple intelligences, see the essay on page TR-11 of the Introduction and Implementation section in this Teacher's Resource.

Multiple Intelligences:	VL	VS	BK	MR	LM	N	E	IA	IE
UNIT 2: Heat									
Find Out Activity: Baffle Your Skin	■		■		■			■	
Chapter 4: Temperature describes how hot or cold an object is.									
Find Out Activity 4-1A: Boiling Hot, Freezing Cold	■				■				
Find Out Activity 4-2A: Building a Thermoscope	■	■	■		■				
Conduct an Investigation 4-2B: Make Your Own Thermometer	■	■	■		■				■
Chapter 5: Scientists use the particle theory of matter to describe temperature.									
Find Out Activity 5-1A: Modelling the Particle Theory	■	■	■		■				
Think About It 5-1B: Average Kinetic Energy					■				
Think About It 5-1C: Detect a Connection	■				■				
Find Out Activity 5-2A: Is it a Solid, Liquid, or Gas?	■	■	■		■				
Conduct an Investigation 5-2B: Bulging Balloons	■	■	■		■				
Conduct an Investigation 5-2C: Race for the Top	■	■			■				
Conduct an Investigation 5-2D: Expanding Solids	■	■			■				
Find Out Activity 5-3A: How Low Can It Go?	■	■	■		■				
Think About It 5-3B: State the State	■				■				
Conduct an Investigation 5-3C: The Plateau Problem	■	■	■		■				■
Chapter 6: Heat is transferred from one place to another by three different processes.									
Find Out Activity 6-1A: Currents in a Pie Pan	■	■	■		■				
Find Out Activity 6-1B: Displaced Drops	■	■	■		■				
Think About It 6-1C: Energy Transfers and Home Heating Systems	■	■	■		■				
Find Out Activity 6-1D: Absorb That Energy	■	■	■		■				
Conduct an Investigation 6-1E: Blowing in the Wind	■	■			■				
Conduct an Investigation 6-1F: Convection in Water	■	■			■				
Find Out Activity 6-2A: The Super Stirrer	■	■	■		■				
Conduct an Investigation 6-2B: Heat Conductivity Rate	■	■	■		■				
Conduct an Investigation 6-2C: Keep it Cool	■	■	■		■				
Conduct an Investigation 6-2D: When You're Hot…	■		■		■			■	
Find Out Activity 6-3A: Mix It Up	■		■		■			■	
Conduct an Investigation 6-3B: Keeping It Cool	■		■		■				
Unit 2 Project: Water Heater	■	■	■		■				
Unit 2 Integrated Research Investigation: Building Codes and Insulation	■	■			■				

Multiple Intelligence codes:
VL = Verbal-Linguistic Intelligence; VS = Visual-Spatial Intelligence; BK = Body-Kinesthetic Intelligence; MR = Musical Rhythmic Intelligence; LM = Logical-Mathematical Intelligence; N = Naturalist Intelligence; E = Existential Intelligence; IA = Intrapersonal Intelligence; IE = Interpersonal Intelligence

Planning Chart for Activities and Investigations for Unit 2: Heat

ACTIVITY/ INVESTIGATION	ADVANCE PREPARATION	APPARATUS/MATERIALS	TIME REQUIRED
Unit 2: Heat			
Find Out Activity: Baffle Your Skin	• 3 days before: – Collect bowls that are large enough to put hands into. Each group of students will need three bowls. • 1 day before: – Put some water in a refrigerator to cool. – Leave some water out overnight to adjust to room temperature.	For each group: – 3 bowls large enough to put hands into – hot (not burning) water – room-temperature water – cold water (refrigerator temperature)	• 20-30 min
Chapter 4: Temperature describes how hot or cold an object is.			
Find Out Activity 4-1A: Boiling Hot, Freezing Cold	• 1 day before: – Prepare table with answers for the Activity	For each group: – pencil and paper	• 20-30 min
Find Out Activity 4-2A: Building a Thermoscope	• 1 day before: – Set up and test the apparatus.	For demonstration: – one hole rubber stopper – glass tubing, 25 cm – spherical flask, 500 mL – beaker, 500 mL – food colouring in water – retort stand – clamp – cloth - ice water	• 10 – 20 min
Conduct an Investigation 4-2B: Make Your Own Thermometer	• 1 month before: – Start collecting small glass bottles with narrow necks. Ask students to do the same. • 3 days before: – Several hair dryers are required. Consider borrowing them from other staff or asking students to bring them in. – make a model of the thermometer for students to see and follow. • 1 day before: – Purchase or make ice cubes for making ice-cold water.	For each group: – small glass bottle with a narrow neck (for example, a small pop bottle) – drinking straw or a length of glass tubing – laboratory stand and ring clamp – dish cloth – paper, pen, ruler, calculator – bowl of water with food colouring added – modeling clay – ice-cold water – 2 calibrating devices, assembled and with a regular lab thermometer – hair dryer for warming bottle	• Part 1: 30-50 min • Part 2: 30-50 min
Chapter 5: Scientists use the particle theory to describe temperature.			
Find Out Activity 5-1A: Modelling the Particle Theory	• 1 week before: – Obtain and prepare materials	For each group: – funnel – 2 100 mL graduated cylinders – 250 mL graduated cylinder – 50 mL ethanol – marbles (50 mL) – 50 mL sand – stirring rod	• 30 min
Think About It Activity 5-1B: Average Kinetic Energy	• 1 day before: – You might want to have extra sets of numbers for students to practice taking averages.	For each group: – pencil – paper – calculator	• 20 min

ACTIVITY/ INVESTIGATION	ADVANCE PREPARATION	APPARATUS/MATERIALS	TIME REQUIRED
Think About It Activity 5-1C: Detect a Connection	• 1 day before: – If you choose to, find other examples or demonstrations that will help instill the concepts in the students minds. For example, have a power drill and drill a hole in wood. Let the students feel the drill bit after drilling. There are many possibilities.	Only those materials for extra demonstrations	• 10 min
Find Out Activity 5-2A: Is It a Solid, Liquid, or Gas?	• 1 week before: – Obtain and prepare the materials.	For each group: – rock – marshmallow – square of gelatin dessert – glass of milk – whipped cream (or shaving cream) from aerosol can – empty jar with a lid on it (for a gas) – glass of water – vegetable oil	• 20 min
Conduct an Investigation 5-2B: Bulging Balloons	• 3 days before: – obtain balloons – obtain hair dryer or electric heater – ensure that a freezer or refrigerator is available. If not, obtain a cooler and ice.	For each group: – space in a refrigerator or freezer – access to hair dryer or electric heater – two identical balloons	• 30 to 40 min
Conduct an Investigation 5-2C: Race for the Top	• 3 days before: – Obtain or prepare ice cubes. – Insert glass tubes into the stoppers for the students. • 1 day before: – Prepare coloured water by adding a few drops of food colouring. – Set up a sample apparatus for the students to study.	For each group: – 3 large test tubes – 3 one hole stoppers with 50 cm lengths of glass tubing inserted – laboratory stand and clamps – 2 large tin cans or 500 mL beakers – 3 liquids (coloured water, ethyl alcohol, and cooking oil) – rubber bands – markers – very hot water – ice-cold water	• 30 - 45 min
Conduct an Investigation 5-2D: Expanding Solids	• 3 days before: – Collect apparatus – Do Part 1 to determine the best length of wire to be used. The longer the wire, the more it will have to be heated. • 1 day before: – Set up apparatus for Part 1 as a sample that students can study.	For each group: Part 1 – long copper or iron wire – small hooked mass (200 g or 500 g) – metre stick – candles – matches Part 2 – ball-and-ring apparatus – laboratory burner – cold water – matches	• 45 min
Find Out Activity 5-3A: How Low Can It Go?	• 3 days before: – Cut cloth or paper towels into thin strips. • 1 day before: – Leave a sample of water in the classroom overnight to adjust to room temperature.	For each group: – lab thermometer or computer temperature sensor – electric fan – 2 strips of cloth or paper towel – room-temperature water – room-temperature alcohol	• 30 - 40 min
Think About It Activity 5-3B: State the State	None	– pencil – paper – Table 5.1, page 162	• 15 - 20 min

ACTIVITY/ INVESTIGATION	ADVANCE PREPARATION	APPARATUS/MATERIALS	TIME REQUIRED
Conduct an Investigation 5-3C: The Plateau Problem (Core Activity)	• 3 days before: – Purchase or make crushed ice. – Be sure that you have a supply of graph paper.	For each group: – 2 laboratory thermometers – stirring rod – hot plate – kettle – 2 beakers (250 mL) – clock or watch – crushed ice – ice-cold water – hot water (almost boiling)	• 30 - 50 min
Chapter 6: Heat is transferred from one place to another by three different processes.			
Find Out Activity 6-1A: Currents in a Pie Pan	• 1 week before: – Obtain pie pans, liquid soap, and food colouring. – Test the activity to find the level of heat on the hot plate that will give the best results.	For each group: – aluminum pie pan – hot plate (not a coil burner) – stirring rod – liquid hand soap (or shampoo) that has a pearly appearance – food colouring – water	• 20 - 30 min
Find Out Activity 6-1B: Displaced Drops	• 1 day before: – Purchase or make ice cubes. – Leave a sample of water in the classroom overnight so it will reach room temperature.	For each group: – dropper – 250 mL beaker of room-temperature water – 100 mL of coloured ice-cold water – 100 mL of coloured very hot water	• 15 - 20 min
Investigation 6-1C: Energy Transfers and Home Heating Systems	none	– illustration in text	• 20 – 30 min
Find Out Activity 6-1D: Absorb That Energy (Core Activity)	• 2 weeks before: – Begin gathering, or ask students to gather, empty pop cans. You will need two cans per group.	For each group: – 2 thermometers – light (at least 100 W) – ruler – 2 empty pop cans – dark- and light-coloured cloth or black and white paint – aluminum foil – 200 mL cooking oil – tape or elastic bands	• 30 - 45 min
Conduct an Investigation 6-1E: Blowing in the Wind	• 1 week before: – Obtain an aquarium with a mesh top and cardboard larger than the aquarium.	For one demonstration: – aquarium with screen top – 100 mL beaker – 1000 mL beaker – Petri dish – scissors – cardboard larger than aquarium lid – ice – short, fat candle – matches – paper towels – tape	• 20 - 30 min
Conduct an Investigation 6-1F: Convection in Water	• 1 week before: – Obtain glass baking dish (or dishes if you are letting students do the investigation in groups) The glass must be able to withstand direct heat from a hot plate. – Obtain wood block(s) that is the same height as hot plate that you plan to use.	For one demonstration or for each group: – hot plate – block of wood same height as hot plate – large clear-glass baking dish – water – food colouring	• 25 - 30 min

ACTIVITY/ INVESTIGATION	ADVANCE PREPARATION	APPARATUS/MATERIALS	TIME REQUIRED
Find Out Activity 6-2A: The Super Stirrer	• 3 days before: – Gather the materials. The greater the selection, the better the results will be. • 1 day before: – Using the available samples, complete the activity to make sure you know the proper ranking.	For each group: – equal-length pieces of: • copper wire • long iron nails • wooden craft sticks (or wooden pencils) • plastic from pen – very hot water	• 15 - 20 min
Conduct an Investigation 6-2B: Heat Conductivity Rate	• 1 day before: – Assemble the equipment.	For each group: – Bunsen burner – 2 clamps – glass rod and metal rods of equal diameter and length – heat conductivity apparatus – 2 laboratory stands – timing device – ruler – matches – candle	• 45 - 60 min
Conduct an Investigation 6-2C: Keep It Cool	• 1 week before: – Collect materials not usually found in the school. • coffee cans: ask staff/students to collect them • foam pellets and bubble wrap: these might be available free at electronics or computer stores • poured insulation: available at a local hardware store • wood shavings: check with the school's woodworking shop or local pet stores • ice cubes: buy a bag or make in ice-cube trays • 2 days before: – Check to see that all materials are put aside and ready for use.	For each group: – scale or balance (1 for every 2 groups) – 6 coffee cans with lids – large basin (must fit 6 coffee cans at once) – thermometer – ice cubes of similar size and shape – resealable plastic bags – paper towels – foam pellets – wood shavings – aluminum foil – poured insulation – plastic bubble wrap	• 45 - 60 min
Conduct an Investigation 6-2D: When You're Hot….	• 1 week before: – Begin collecting materials. – Ask students/colleagues to help find materials • 1 day before: – Organize and set up materials in the lab.	For each group: – plastic bags – wool blankets or scarves – aluminum foil – newspapers – foam pellets – duct or electricians' tape – string	• 40 - 60 min
Find Out Activity 6-3A: Mix It Up	• 3 days before: – Obtain vegetable oil and check to be sure that the other materials are available. • 1 day before: – Leave water, alcohol, and vegetable oil out in the lab so they are all at room temperature when it is time to carry out the activity.	For each group: – 3 50 mL beakers – 25 mL graduated cylinder – laboratory thermometer – stirring rod – ice water – room-temperature water – room-temperature alcohol – room-temperature vegetable oil	• 20 - 30 min

ACTIVITY/ INVESTIGATION	ADVANCE PREPARATION	APPARATUS/MATERIALS	TIME REQUIRED
Conduct an Investigation 6-3B: Keeping it Cool	• 1 week before: – Obtain any materials not available at school: motor oil (or alternative), vegetable oil, marbles, steel shot. (Shot is available in hardware stores.) • 1 day before: – Set aside a container of water (500mL per group) to be at room temperature when the investigation begins. – Assemble equipment for groups and set it out. – Set up a station for pouring oil.	For each group: – hot plate – 500 mL beakers – graduated cylinder – thermometer – retort stand – thermometer clamp – stopwatch – balance and masses – stir sticks – room-temperature water – 250 mL oil (mineral oil, paraffin, or motor oil) – 250 mL vegetable oil – glass marbles – sand – steel shot – oven mitts – masking tape	• 45 - 60 min
Unit 2 Project: Water Heater	• 1 month before: – Begin to collect nonflammable containers, fasteners, and insulation. Ask students to begin to do the same. • 2 days before: – Remind students to bring in the nonflammable materials that they have collected.	For each group: – thermometer – birthday candle – 100 mL room-temperature water – nonflammable containers, fasteners, and insulation – matches	• 120 - 200 min – steps 1 and 2: 40-60 min – step 3: 50-90 min – step 4: 30-50 min
Integrated Research Investigation: Building Codes and Insulation	• 3 days before: – Arrange for access to computers and research materials.	For whole class: – research materials	• 60 min research time (additional time outside of class) • Additional time for presentations.

TALKS AND TOURS

Speaker and field trip suggestions for Unit 2:

- Invite a paramedic to speak about rescuing a person who has, or was near to having, hypothermia.
- Invite a meteorologist to speak about weather forecasting in Newfoundland and Labrador. Ask the speaker to include topics such as wind chill and temperature scales.
- Invite a civil engineer to speak on the challenges of engineering bridges and buildings as it applies to thermal expansion and contraction.
- Invite a building contractor to speak about heating, cooling, and insulating buildings.
- If you live near L'Anse aux Meadows, take a field trip to the restored sod huts in which the Norse settlers lived.

Teaching Notes
for
Pages 104 to 225 of the Student Book

UNIT 2 OPENER, pp. 104-105

USING THE UNIT OPENER

The unit opener is a photograph of the Sun, the source of nearly all the heat and energy that makes Earth a viable planet for life to exist. The questions are designed to stimulate the students to think about heat and temperature. Ask the students if they know how hot the surface of the Sun is. Someone might have heard that it is 6000ºC. If not, tell them. Then ask them how astronomers can measure the temperature of the Sun. (The answer is a feature on page 130.) Ask the students how they measure their own temperature and how they measure the temperature of a room. Initiate a discussion on heat using the questions beside the photograph of the Sun as a starting point.

GETTING STARTED, pp. 106-107

USING THE TEXT

The scenario in the "Getting Started" section presents the concept of heat and temperature in a very practical way. The camping scenario mentions many different concepts that will be studied throughout the chapter. The campfire heats your body by radiation. Rubbing your hands together creates friction that makes the particles on the surface of your skin move faster. The students will discover that the speed of particles is related to temperature. A jacket and sleeping bag are not sources of heat, yet they keep you warm. These items provide insulation which prevent body heat from escaping. A gentle breeze across your shoulders removes heat from your body. Wind, itself, is a form of convection.

When you cook on a camp stove, the pots are somewhat primitive and often do not have insulated handles. The fire heats the pot by radiation, and the pot heats its contents by conduction. Heat is distributed throughout the liquid in the pot by convection. Heat reaches the handle of the pot by conduction. Point out the examples to the students (but do not use the terminology) so students will remember them when they study the various topics in the Unit.

USING THE ACTIVITY

Find Out Activity

Baffle Your Skin, p. 107

Purpose

- Students will discover that estimating temperature by touch is strongly affected by the initial temperature of the skin.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Collect bowls that are large enough to accommodate the hands. Each group of students will need three bowls.	For each group: – 3 bowls large enough to immerse their hands in – hot (not burning) water – room-temperature water – cold water (refrigerator temperature)
1 day before	Put some water in a refrigerator to cool. Leave some water out overnight to adjust to room temperature.	

Time Required

- 20–30 min

Safety Precautions

- Make sure the hot water is not hot enough to burn students' hands.
- Spills are common in this activity. You might want to suggest that students work on newspaper. Have towels ready to dry hands and clean up.

Science Background

In the beginning of this unit, temperature will be defined as "how hot or cold something is." Later in the unit, a more technical definition will be given, and methods of measuring temperature will be presented. Touch is a very poor way of estimating temperature because temperature sensors in the skin do not respond in the same way that artificial temperature measuring devices do. There are a variety of temperature-sensing neurons in skin, and their mechanism of action is complex and poorly understood. In some cases, these sensors seem to respond to a shift in temperature rather than the temperature itself. In general, the sensation of hot and cold is dependent on the initial temperature of the skin.

Activity Notes

- Students should work in groups of no more than three. Every student should have an opportunity to complete the activity.
- When students move their hands from one bowl to the next, it should be done quickly. Evaporation of water from the skin will rapidly change the skin temperature.

Supporting Diverse Student Needs

- To help ESL (English as a Second Language) students, you might make cards that are labelled, "HOT," "COLD," and "?" and place them beside the appropriate bowls of water.

What Did You Find Out? Answers

1. The hand that was in cold water sensed the room-temperature water as warm, and the hand that was in hot water sensed the room temperature as cool.
2. Regardless of which hand was in the cold water or the hot water, the overall result will be the same.
3. When you are adapted to hot weather, moderate weather seems cool. When you are adapted to cold weather, moderate weather seems warm.

CHAPTER 4 OPENER, p. 108-109

USING THE PHOTO AND TEXT

The following points could be used to lead a discussion on the meaning of the word "temperature."

- Ask the students how often they have had their temperature taken.
- Discuss the concept of "taking a temperature."
- Discuss what it means to "have a temperature."
- Note that everyone has a temperature all of the time, but it is usually 37°C. So what does it mean when someone says that they "have a temperature?"

In order to lead into a discussion on the importance of being able to measure temperatures, point out that an excessively high body temperature can be dangerous. Most students know when their body temperature is high, however, it is critical to know how high to determine whether it is dangerous. How would students know if their body temperature had reached a dangerous level? This is just one reason why it is important to understand how to measure levels of temperature.

USING THE WHAT YOU WILL LEARN/WHY IT IS IMPORTANT/SKILLS YOU WILL USE

Use this feature to start thinking about temperatures of things other than people. Ask:

- What should the temperature of an oven be in order to bake cookies?
- If one or more students give an answer, ask if the temperature they reported is on the Celsius or Fahrenheit scale.
- Do they know the difference between the two scales?
- What scale is used by weather forecasters?
- Tell the students that they will be able to answer all of these questions when they finish studying this chapter.

USING THE FOLDABLES™ FEATURE

See the Foldables™ section of this resource.

4.1 DESCRIBING TEMPERATURE

BACKGROUND INFORMATION

The goal of the section is to have students become familiar with the concept of temperature, including the temperatures of things around them in everyday life. However, there are a few items that need to be clarified.

Temperatures, including oven temperatures for baking, are all given for the Celsius scale. However, most stoves have Fahrenheit temperatures on the temperature controls. An alert student who cooks regularly might notice the apparent contradiction.

Another apparent contradiction is found in the discussion of hypothermia. On page 113, the text says that if a person's body temperature drops below 32°C, it is difficult to revive them. In the WWW feature on page 117, it says that the lowest body temperature a person has had and survived is 14.2°C. This is over 17°C lower than the quoted 32°C. It is critical to note that the person who survived the 14.2°C temperature was a two-year old child. Very young children have been known to survive much lower body temperatures than adults. Nevertheless, medical professionals were astounded that the two-year old child survived the 14.2°C temperature.

A bit of controversy still exists around the thermoregulation in the oryx (see Figure 4.5 on page 114). The horns of the oryx, and most ungulates, are highly vascularized. For a long time, it was believed that the horns radiated heat and cooled the blood, helping to cool the brain. Recent research has created doubt about the concept.

COMMON MISCONCEPTIONS

- A misconception that might arise in this section involves the reference to cod fish. In earlier grades, students were introduced to the term, "cold-blooded" for animals that do not maintain a constant body temperature. This is a very misleading term. Certainly, the body of the arctic cod is very cold. However, many animals in this category do not have cold bodies. The distinction between birds and mammals ("warm-blooded") and other animals ("cold-blooded") is whether they can generate enough heat within their bodies to maintain a constant temperature or absorb heat from the environment.

ADVANCE PREPARATION

- There are no complex activities in this introductory section.
- Look through the list of BLMs for those that might be used when teaching this section.

INTRODUCING THE SECTION, pp. 110–111

Using the Text

To initiate a discussion on temperature, ask the students how they decided what to wear to school today. Ask them if they knew what the temperature was before they got dressed. Discuss what they had for breakfast. Was it hot, cold, or room temperature? Ask them how they would enjoy hot milk or cold soup. Ask them why.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the student book and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review.

Using the Did You Know, p. 110

Ask the students to imagine how hot 57.7°C would feel and how cold -89.2°C would feel. Lead a discussion on the extremes of temperature on Earth. Use this discussion as a lead in to the Find Out Activity. Tell them that the range of temperatures on Earth is really very small compared to the extremes in the universe.

USING THE ACTIVITY

Find Out Activity 4-1A

Boiling Hot, Freezing Cold, p. 111

Purpose

- Students test their knowledge of temperatures of some common items and of some extremes in the universe.
- Students check their predictions with the correct answers and learn about some temperature extremes.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
One day before	Prepare table with answers for the activity.	No materials other than pencil and paper are required.

Time Required

- 20–30 min

Expected Results

DESCRIPTIONS	TEMPERATURES (°C)
Temperature of lava from Hawaiian volcanoes	1150
Temperature of ocean currents off Canada's east coast	1
Temperature of ocean currents off Canada's west coast	4 to 10
World record coldest air temperature	–87
Comfortable room temperature	20 to 25
Body temperature of a budgie bird	40
Temperature outside the Space shuttle while it orbits Earth	–121 to –156
Temperature of a candle flame	800
Comfortable temperature for heat-loving bacteria	92
Normal human body temperature	37
Temperature of ice cream	–5
Oven temperature for baking bread	200
Temperature of food in a freezer	–10 to –15
Temperature of the interior of the Sun	15 000 000
Temperature of hot tea or coffee	55
Temperature of boiling water at sea level	100
Temperature of a slush of pure water and ice	0
Temperature of the surface of the Sun	6000

Activity Notes

- This activity is best done in pairs so the students can discuss their thoughts with a partner.
- To introduce the activity, ask the class for examples of things that are considered either hot or cold. What are some of the everyday temperatures that students already know?

Supporting Diverse Student Needs

- To help students with reading difficulties with the vocabulary, you might want to create a set of index cards with pictures and descriptions. Students could separate the cards into groups, "hot" and "cold," leaving out the "everyday" group. The index cards will also be useful for students who find focusing on text difficult.
- Visual learners might benefit from drawing a large thermometer and writing the descriptions in the appropriate place along the scale. Note that this will just be a sketch and is not intended to be an accurate scale.

What Did You Find Out? Answers

1. Students might get only four or five correct answers. Rather than letting them be disappointed, encourage them to be excited about what they are about to learn.
2. Because some students might not have a sense of temperatures, this answer might be surprising. A probable example is the difference between the temperatures in the interior and on the surface of the Sun.
3. Make note of what the students said surprised them the most so you can use it to stimulate interest in various places in the chapter.

TEACHING THE SECTION, pp. 110–119

Using Reading

Pre-reading—Predict-Read-Verify

Direct the students to predict and record answers to the following questions. As they read the section, they should verify their predictions and make notes for the cases in which their predictions were far from the actual answers.

- What is a comfortable temperature for sleeping?
- How low can your body temperature get and still fully recover?
- Can fish live in freezing water?
- What is the average temperature in July in the region where you live?

During Reading—Note-taking

Have the students take notes by writing each subsection title and then writing one full sentence that they think is the most important concept in that subsection.

After Reading—Reflect and Evaluate

Ask the students what information in the section was totally new to them. Have them write questions about other things they would like to learn that involve these concepts.

Reading Check Answers, p. 115

1. Comfortable room temperatures vary from one individual to another. Most people find it comfortable between 20ºC and 23ºC.
2. The temperature in a refrigerator should be 4ºC.
3. Normal body temperature for humans is 37ºC.
4. Hypothermia is the condition when the body becomes too cold to function properly.

Reading Check Answers, p. 116

1. Yes, it could be colder in Gander than in Goose Bay in January even though the average temperature in Gander is warmer than the average temperature in Goose Bay. On any given day the temperature can vary greatly from the average temperature.
2. Halifax, Nova Scotia and Vancouver, British Columbia have a higher average temperature in January than does Gander. Toronto, Ontario has the same average temperature as Gander in January. All of the other cities in the list have lower average temperatures in January than does Gander.
3. (a) The regions of Newfoundland and Labrador that are, on the average, warmest in January are by the ocean.
   (b) The regions of Newfoundland and Labrador that are, on the average, coldest in January are inland.

USING THE FEATURES

www science: Going to (Temperature) Extremes, p. 117

This feature offers the opportunity to compare extremes on Earth to extremes in the universe. Explain that the lowest temperature recorded on Earth occurred in Antarctica. No humans ever lived there until research stations were built. No one lives there permanently. Nevertheless, the extremes recorded on Earth seem tremendous. However, when you compare temperature extremes on Earth to those throughout the universe, the temperature range on Earth is very small. There is no other planet in our solar system with the small range and appropriate temperatures for life. One biologist calls Earth's temperature range the "Goldilocks" temperatures because they are not too hot, not too cold, but just right.

Science Watch: Wind Chill, p. 118

Many students have probably heard reference to wind chill and the "feels like" phrase in weather reports. In order to help them understand the meaning, ask the students what is the coldest temperature they can remember experiencing outside. Ask if anyone has experienced frost bite. Provide BLM 2-8 with the wind chill chart, and show them how to use it. Choose some combinations of temperature and wind speed, and ask them to find the wind chill and then check the table to find the possible hazards of being outside under those conditions.

Science Watch Answers

1. Wind chill is the temperature of still air that would cause the same effect on the skin as the combination of the actual temperature and wind speed.
2. Cover as much skin as possible and keep moving.

SECTION 4.1 ASSESSMENT, p. 119

Check Your Understanding

Checking Concepts

1. When your body temperature is above 37ºC, you probably have some type of infection such as a cold, flu, or other more serious illness.
2. Hypothermia is the condition in which the body temperature is so low that the organs cannot function properly.
3. The freezer compartment of a refrigerator should be at a temperature of –18ºC.
4. Some common oven temperatures are:
   baking cookies 175ºC
   cooking a roast 160ºC
   baking pizza 250ºC
5. Answers will be taken from Figure 4.6 on page 115 of the student textbook.

Understanding Key Ideas

6. It would probably be in a refrigerator because refrigerators are kept at 4ºC.
7. If you think that your refrigerator is not maintaining the correct temperature, you should put in a thermometer to check the temperature. Some people keep thermometers in the refrigerator all of the time to ensure that their food is stored at a safe temperature.
8. Answers should be close to the following estimates:
   (a) 50ºC
   (b) 800ºC
   (c) -54.4ºC
   (d) –5ºC
   (e) 39ºC
   (f) -15ºC
   (g) 4ºC
   (h) 20ºC
9. (a) The sharp point of the thermometer is pushed into a large roast or turkey before it is put in the oven to cook.
   (b) To ensure that the meat has reached a temperature at which micro-organisms have been destroyed and the meat is safe to eat. The thermometer is the best way to measure the inner temperature of roasts and other solid, large forms of meat.

Pause and Reflect Answer

The person's wet clothing must be removed and the person should be wrapped in anything dry—such as clothing, coats, or blankets—that is available. The person should be rushed to an emergency room as soon as possible. If it is necessary to wait for emergency equipment, be sure that the person is sheltered from any wind. If there is no other place for the person lie down except the ground, be sure that he or she is insulated from ground by coats, a sleeping bag, or even branches or leaves. If anyone has a thermos of a warm liquid that has no caffeine in it, let the person drink it very slowly. Other people should sit close or hold the person for warmth.

Other Assessment Opportunities

- Look through the list of BLMs for those that might be used when teaching this section.

4.2 MEASURING TEMPERATURE

BACKGROUND INFORMATION

Although Galileo is usually given credit for inventing the thermometer, many other scientists were developing instruments to measure temperature. Among them were Avicenna, Cornelius Drebbel, and Robert Fludd. In fact, Galileo and many of the others developed only a thermoscope, which had no scale. Santorio Santorio, an Italian scientist and physician, is given credit for developing the first scale to be applied to a thermoscope, and thus the first true thermometer.

The first thermoscopes registered changes in the volume of air at different temperatures. These original thermoscopes were quite inaccurate because they were affected by changes in barometric pressure as well as temperature. Liquid thermometers, which were less affected by barometric pressure, were developed soon after the air thermometers. A coloured liquid, often wine, was used to make reading the measurements easier, and alcohol was often chosen because its freezing point is lower than that of water. Gabriel Fahrenheit, a German instrument maker, chose to develop the mercury thermometer because it had a greater thermal expansion than the other common fluids in use at the time. Also, the temperature range in which mercury is a liquid is very broad, allowing mercury thermometers to produce measurements over a much wider range than other common liquids.

Fahrenheit worked with Ole Rømer, a Danish astronomer, to develop his scale. Fahrenheit used a mixture of ice, water, and salt to create a solution as cold as was possible in the laboratory at the time. He assigned a value of zero to the temperature of the solution. He assigned a temperature of 100 to what was, at that time, measured to be human body temperature. Later, when the scale was perfected, it was discovered that body temperature was really 98.6 degrees. Similarly, Anders Celsius worked with others to develop the scale named after him. French scientist René de Réaumur developed the scale. The scale was named after Celsius because he carried out more detailed and precise experiments. Also, Celsius used 0º as the boiling point of water and 100º as the freezing point. It was not until after his death that Carolus Linnæus (Carl von Linné in Swedish) (1707-1778) reversed the numbers to 0º as the freezing point of water and 100º as the boiling point.

Lord Kelvin proposed the absolute temperature scale when data was being accumulated about the properties of gases. On all pressure/temperature graphs and volume/temperature graphs, the lines extrapolated to –273.15ºC for zero volume or zero pressure. Of course, zero pressure and zero volume cannot be attained, but the extrapolated graphs still have a great significance. Kelvin proposed that the meaning was based on zero kinetic energy of gas molecules. As we now know, temperature is directly related to average kinetic energy of the molecules. Therefore, zero kinetic energy must be related to the lowest possible temperature. The temperature of –273.15ºC is absolute zero. The magnitude of the temperature units on the Kelvin scale is identical to the magnitude on the Celsius scale. The scale is just shifted so that 0 K is at –273.15ºC.

Modern temperature measuring devices such as bimetallic strips and thermocouples are based on some intrinsic properties of metals. Every metal has its own specific coefficient of thermal expansion. Thus, when strips of two metals are sealed together and one expands or contracts more than the other when heated, the bimetallic strip will bend. To generate the greatest amount of bending, metals with the greatest difference in coefficient of thermal expansion are chosen.

When any two metals are joined at both ends, a temperature difference between the two ends will generate a potential difference, and thus a current will flow. A meter can be inserted into one of the metals without changing the properties. The meter can measure the amount of current flowing. This combination constitutes a thermocouple.

All objects emit infrared radiation. The intensity of the infrared radiation is determined by the temperature of the object. Therefore, by detecting the amount of infrared radiation emitted by an object, you can observe temperature differences throughout the object. This phenomenon is the basis for thermograms.

COMMON MISCONCEPTIONS

- The zero-degree point on the Celsius and Fahrenheit temperature scales has no scientific significance. The temperature of zero on those scales is artificially selected. The zero-degree point has significance only on the Kelvin scale.

ADVANCE PREPARATION

- A display and/or demonstration of different temperature measuring devices would enhance the students' interest and understanding of the topics in this section. This could include a demonstration of the bending of a bimetallic strip held over a flame.
- If possible, allow students to dismantle an old thermostat. However, be very careful to prevent breakage of the capsule containing the mercury.
- Look through the list of BLMs for those that might be used when teaching this section."

INTRODUCING THE SECTION, pp. 120–121

Using the Text

Tell the students to imagine that they are in their room doing homework while someone is fixing dinner. Ask how they know that someone is cooking something. Then tell them to imagine that they go to the kitchen. List all of the ways that they can tell that something on the stove is hot. Encourage them to use as many senses as possible. Ask if there is any way they can tell exactly what the temperature of the oven or pot on the stovetop is. Lead them to think about the oven knob setting. Also, lead them to think about something such as a vegetable in boiling water in a pot on the stove. The boiling water is probably at 100ºC because that is the boiling point of water. Finally, ask them how the temperature of objects and solutions can be measured precisely.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the student book and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review.

Using the Did You Know, p. 120

Ask the students if any of them have seen a potter's kiln. Explain that the temperatures affect the way that clay and a glaze are fired. If you put a home thermometer in the kiln, it would probably melt. Even if a thermometer did not melt, you couldn't get close enough to read it. Discuss how potters use cones that are made of special clays that bend at different temperatures.

Using the Activity, p. 121

Find Out Activity 4-2A

Building a Thermoscope

Purpose

- Students will observe and describe a thermoscope.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Set up and test the apparatus.	– one hole rubber stopper – glass tubing, 25 cm – spherical flask, 500 mL – beaker, 500 mL – food colouring in water – retort stand – clamp – cloth – ice water

Time Required

- 10–20 min

Expected Results

Even when students see photographs and simulations, they have a hard time believing that a phenomenon really happens. The thermoscope will show them it works. It will demonstrate that as air cools, it appears to shrink into a smaller volume and draw water up into the glass tubing. In reality, as the air inside the flask cools the pressure goes down. The pressure inside the flask is then less than atmospheric pressure, and the atmospheric pressure pushes the water up into the glass tubing. This concept might be too difficult for the students at this level. Nevertheless, they will witness the water going up into the glass tubing. The water level is directly related to the temperature of the gas inside the spherical flask.

Activity Notes

- This activity will be done as a demonstration.
- To assist in setting up the apparatus and to include students, you might ask a student to attach the clamp to the flask that you are holding in your hands to keep it warm.

Supporting Diverse Student Needs

- For students with reading difficulties, discuss the new terms used in this activity including "thermoscope," "flask," "pressure," "volume," and any others that you might use.
- If you have some very advanced students, you might want to discuss the concept described above under "Expected Results." That is, that nothing really draws a liquid up into a tube but instead, atmospheric pressure pushes the liquid up.

What Did You Find Out? Answers

1. The coloured water moved up the glass tubing when the air inside the flask cooled to room temperature.
2. The coloured water continued to move up the glass tubing as the air inside the flask became cooler than room temperature.
3. When air cools, the volume decreases.

Using a Demonstration

You might want to do a demonstration to show that water undergoes a reduction in volume upon cooling. You could put some room temperature water in a long-neck flask such as a volumetric flask and fill it so the water level is high in the neck. Mark the level of the water and put it in a refrigerator at the beginning of class. Be sure that the refrigerator is not below 4°C because water will began to expand if it goes below 4°C. Take it out at the end of class and observe the level of the water in the neck of the flask.

TEACHING THE SECTION, pp. 122–127

Using Reading

Pre-reading— K-W-L (Know, Want to Know, Learned)
Have the students write the following headings on a piece of paper: "Temperature Scales" and "Temperature Measuring Devices." First, have them write the things that they know about these topics. Then have them write questions about what they want to know. Instruct them to write answers as they study the section.

During Reading—Note-taking
As the students read the section, have them write each subtitle in the section in their notebook or on their "Foldables™." Instruct the students to write down at least two notes about important facts in each subsection.

After Reading—Semantic Mapping
Students could make a timeline about the development of the thermometer and more modern temperature measuring devices.

Reading Check Answers, p. 125

1. A thermoscope has no scale and can only determine that a temperature is increasing or decreasing. A thermometer has a scale that can give a specific temperature.
2. The Fahrenheit scale was the first temperature scale to be widely used.
3. The magnitude (size) of a unit of temperature is the same on the Celsius and Kelvin scales. They assign the value of zero to different temperatures. The Celsius scale assigns zero as the freezing point of water whereas the Kelvin scale assigns zero to absolute zero, the lowest possible temperature.
4. The freezing and boiling points of water are influenced by atmospheric pressure. Therefore, specific conditions had to be chosen so that the freezing and boiling points of water would be constant.

Reading Check Answers, p. 127

1. To calibrate a thermometer means to mark at least two numbers on the thermometer when the bulb of the thermometer is in substances that have known temperatures.
2. A bimetallic strip bends when it is heated. The word, bimetallic, means two metals. Flat strips of two different metals are sealed together to make a bimetallic strip. One metal will expand more than the other when they are heated. The one that expands less will pull on the other and make the strip bend.
3. A thermocouple is made by joining the ends of wires of two different metals. When the two joined ends are at different temperatures, a current flows through the wires.
4. Film and other devices can detect infrared radiation. The amount of infrared radiation that an object emits is related to its temperature. When the device detects different amounts of infrared radiation, it means that those two objects or regions of one object are at different temperatures.

USING THE ACTIVITY

- Activity 4-2B on page 128 of the student book is best used after the section, "Calibrating a Thermometer" on page 125.

Detailed notes on doing the activity follow.

Conduct an Investigation 4-2B

Make Your Own Thermometer, pp. 128-129

Purpose

- With a lot of guidance students will design, construct, and calibrate their own air thermometer.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 month before	Start collecting small glass bottles with narrow necks. Ask students to do the same.	For each group: – small glass bottle with a narrow neck (for example, a small pop bottle) – drinking straw or a length of glass tubing – laboratory stand and ring clamp – dish cloth – paper, pen, ruler, calculator – bowl of water with food colouring added – modeling clay – ice-cold water – 2 calibrating devices, assembled and with a regular lab thermometer – hair dryer for warming bottle

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Several hair dryers are required. Consider borrowing them from other staff or asking students to bring them in. Make a model of the thermometer for students to see and follow.	
1 day before	Purchase or make ice cubes for making ice-cold water.	

Time Required

- Part 1: 30–50 min
- Part 2: 30–50 min

Safety Precautions

- The food colouring in the bowls of water can stain clothing so care should be taken when handling the coloured water.
- Glass tubing is very fragile so, if it is used, it should be handled very carefully.

Science Background

When a gas such as air cools, the pressure it exerts on the walls of a container decreases. In this case, the gas inside the bottle is also exerting pressure on the surface of the water in the straw. When the pressure that the air inside the bottle exerts on the water decreases, it becomes less than the atmospheric pressure. The atmospheric pressure then pushes on the surface of the water in the bowl and pushes the water up the straw until the pressures are balanced. The temperature of the air inside the bottle is, thus, directly related to the height of the water in the straw above the water level in the bowl. Note, however, that if the atmospheric pressure changes, it also changes the height of the water in the straw. On two different days, the calibration of this "thermometer" will be different.

Activity Notes

- Construct a model of the thermometer for students to see and use as a reference.
- Discuss with the class any steps in the construction that might be a challenge.
- Let students know that they will have one class to assemble the thermometer and make sure it works. During the second class, the thermometer will be calibrated and tested.
- At the beginning of the second class, before students complete the calibration, review the steps in the process with them. It would be ideal to go through an entire example with the students before they attempt to do it themselves.
- As students construct and calibrate their thermometers, circulate in the classroom to help them solve any problems they encounter.

Supporting Diverse Student Needs

- For ESL and Special Needs students, you might want to write out the steps of this investigation in simplified language and in greater detail. Alternatively, you could pair these students with a lab partner with good reading skills.
- Consider having a second model of the thermometer available for Special Needs students so they can take it to their work station and follow it closely.
- Gifted or enriched students might enjoy the challenge of designing and constructing their own thermometer rather than following the model given.

Evaluate Answers Part 1

1. The air inside the bottle responds to the change in temperature. (a) When the air cools, it contracts and the water level in the straw goes up. (b) When the air warms, it expands and pushes the water level in the straw down.
2. Without numbers, the thermometer shows only that the temperature is increasing or decreasing. Numbers will tell what the temperature is.

Evaluate Answers Part 2

1. For some students, the answer will be yes, the thermometer met the specifications but for other students, it will not meet specifications. They might suggest using a larger cloth or a smaller bottle to ensure that all of the air reaches the temperature of the water on the cloth. They might suggest continuing to drip water of the correct temperature onto the cloth so that the cloth itself does not change temperature.
2. Some students might say that their thermometer was not airtight. Other students might say that they had trouble understanding the calculations for the calibration process.
3. They might say that the thermometer is too bulky and flimsy for everyday use. A few might understand how atmospheric pressure affects the thermometer. Some might say that the thermometer could not measure temperatures below 0ºC because the water would freeze.

USING THE FEATURE

www science: Measuring the Temperature of Stars, p. 130

- Before reading the article, ask students how astronomers determine the temperature of stars. Remind the students that the temperature of the Sun has already been mentioned on page 117. Also ask them where the description "red hot" came from. Ask them if they have ever heard the description "blue hot."
- While reading the feature, students might need some help understanding it. Have a class discussion to ensure that they get the general idea.
- Advanced students might want to do more research. The actual techniques for measuring precise temperatures involve using filters to get two specific colours and using ratios of the intensities of the two colours.

SECTION 4.2 ASSESSMENT, p. 131

Check Your Understanding Answers

Checking Concepts

1. A thermometer has a scale to allow reading of specific temperatures. A thermoscope has no scale and can only detect changes in temperature.
2. Galileo's air thermometer had an inverted bulb with a long stem that sat in a coloured liquid. As the air in the bulb cooled, it contracted and the liquid in the stem rose. When the air in the bulb warmed, it expanded and pushed the water down the stem.
3. The Fahrenheit scale was the first temperature scale to be widely used.
4. The temperatures that are represented by 0 and 100 degrees are different for the two scales. On the Fahrenheit scale, 0° is the temperature of a water, salt, and ice mixture. On the Celsius scale, it is the freezing point of water. On the Fahrenheit scale, 100° was originally intended to be human body temperature. (Body temperature is now known to be 98.6°F.) On the Celsius scale, 100° is the boiling point of water.
5. The size (or magnitude) of a unit (1°C or 1 K) is the same on the Celsius scale and the Kelvin scale. The scales, however, set zero at a different place. 0°C is the freezing point of water and 0 K is absolute zero.
6. To calibrate a thermometer means to expose the thermometer bulb to two known temperatures and mark the level of the liquid at those known temperatures.
7. One metal of the two in the bimetallic strip expands more on heating than the other. The metal that does not expand as much pulls on the other and causes both of them to bend.

Understanding Key Ideas

8. A device must include something that changes visibly when the temperature changes so the changes can be seen and interpreted as temperature.
9. Wine had a strong colour that was easily visible.
10. You have to use two different temperatures so you can measure the distance between them on your scale and determine how much distance represents one degree on your temperature scale.
11. The freezing and boiling points of water are easier to duplicate than the values of zero and 100 on the Fahrenheit scale.
12. Absolute zero is the coldest possible temperature that anything can have. It would be the temperature of an object in which all of the particles had zero kinetic energy.
13. A furnace is turned on and off electrically. When current is flowing in a control circuit, the furnace is on. When the current goes off, it signals the furnace to turn off. In the thermostat, there are two wires that are part of the circuit. When there is no electrical connection between these two wires, no current can flow. When the bimetallic strip in the thermostat cools, it uncoils a little and a sealed glass capsule tips and a ball of mercury slides along the capsule to the ends of the wires. When the mercury is between the wires, it completes the control circuit and an electric current begins to flow and turns the furnace on.
14. Thermocouples can withstand much higher temperatures than thermometers and other temperature measuring devices.

Pause and Reflect Answer

The sign on the bank was flashing between Fahrenheit and Celsius temperatures. A temperature of 11°F is equal to –11°C.

Other Assessment Opportunities

- Look through the list of BLMs for those that might be used when teaching this section."

CHAPTER 4 ASSESSMENT, pp. 132-133

PREPARE YOUR OWN SUMMARY

Student summaries should incorporate the following main ideas:

1. Temperatures of Everyday Items and Places
   - Body temperature is 37ºC.
   - Room temperature is between 20ºC and 23ºC.
   - The freezing temperature of water is 0ºC
   - The boiling temperature of water is 100ºC.
   - The temperature in a refrigerator is 4ºC.
   - The temperature in a freezer is –18ºC.
2. Thermoscopes and Thermometers
   - Thermoscopes have no scale and show only changes in temperature.
   - Thermometers have scales that can show numerical values of temperature.
   - Thermoscopes and thermometers must contain something that changes visibly when the temperature changes.
3. Temperature Scales
   - Many scientists developed temperature scales.
   - Two substances of known temperature are needed to calibrate a thermometer to create a scale.
   - The Fahrenheit scale was the first widely used scale. On the Fahrenheit scale, 32ºF is the freezing point of water and 212ºF is the boiling point of water.
   - Today, the Celsius scale is the most widely used scale. On the Celsius scale, 0ºC is the freezing point of water, and 100ºC is the boiling point of water.
   - The Kelvin scale is based on absolute zero. The lowest possible temperature is assigned a value of 0 K on the Kelvin scale.
4. Modern Temperature Measuring Devices
   - When flat strips of two different metals are sealed together, they form a bimetallic strip that bends when heated or cooled. This phenonenon can be used to measure temperature.
   - When wires of two different metals are joined together at both ends, they form a thermocouple. When the two joined ends are at different temperatures, a current passes through the wires. The amount of current can be correlated with the temperature difference between the two ends.
   - The amount of infrared radiation emitted by an object is related to its temperature.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. Students will choose a variety of items. They will probably get these items from the Find Out Activity on page 111 or from the www science feature on page 117.
2. A temperature of –6ºC is too high for a freezer. Food will spoil much sooner than it would at –18ºC.
3. Birds tend to have body temperatures higher than mammals, so a robin would probably have a higher body temperature than a human.
4. The sensation in your skin when you touch an object is affected by the previous temperature of your skin.
5. Galileo's first thermoscope was made with a glass bulb with a long, thin stem. It was inverted and the end of the stem placed in a vessel with a coloured liquid.
6. Fahrenheit did detailed studies of thermometers using alcohol and mercury as the liquid that changes volume with changes in temperature. He perfected the mercury thermometer.
7. The only difference between the Kelvin scale and the Celsius scale is the temperature that is assigned a value of zero. The magnitude (size) of the units is the same.
8. Lord Kelvin proposed that there is such a thing as the lowest temperature. This is called absolute zero temperature.
9. A device that detects infrared radiation is exposed to an object such as a building or a body. The amount of infrared radiation detected is converted into colours, and an image is formed.

Understanding Key Ideas

10. A temperature of –14ºC is nearly as cold as a freezer. You could hold it in your hands very briefly but not for more than a few seconds.
11. If the two people in the question had put their hands in water of very different temperatures, the one whose hand had been in cold water would think that the object was warm. The person whose hand had been had been in hot water would think that the object was cool
12. You should disagree with the classmate. Temperatures have been well below –21ºC in places in Newfoundland and Labrador on many occasions. In fact, the average temperature in parts of Newfoundland and Labrador is lower than –21ºC in January.

13. Your body temperature would be 37°C. Your body regulates its temperature so it would not change when the air temperature changes.
14. Students might mention irons, ovens, or many other items.
15. The water will feel cool to Val and warm to Erin because Val's skin temperature was warm due to the Sun and Erin's skin was cool due to the shade before they went into the water.
16. Coloured liquids make the liquid in a thermometer more visible than clear liquids.
17. Celsius did many experiments to determine whether the freezing point and boiling point of water was affected by atmospheric pressure. Since he found that these points were affected by atmospheric pressure, he chose standard atmospheric pressure at sea level as his standard for assigning 0° and 100° for his temperature scale.
18. A temperature of –273.15°C is the coldest possible temperature. It is absolute zero. Therefore, it is assigned a value of 0 K on the Kelvin scale.
19. Bimetallic strips bend when heated or cooled. When the temperatures of the two ends of a thermocouple are at different temperatures, an electric current flows through the wires.

Pause and Reflect Answer

The number of units between the freezing point of water and the boiling point of water is divided into 100 units on the Celsius scale. For this reason, it was often called the Centigrade scale for the "centi-" (100) units.

CHAPTER 5 OPENER, pp. 134-135

USING THE PHOTO AND TEXT

The marathon runners make an excellent visual model of the particle theory of a fluid. The farther away the observer is from the runners, the more difficult it is to see individual runners/particles. At a great enough distance, you can no longer see the runners but see only a flowing substance. All matter is made of particles, but they are too small to see, even under a normal microscope. An average person is about 2.3×10^{27} (23 with 26 zeros) times larger than a water particle. Nevertheless, as water flows in a stream, water particles are jostling along, bumping into each other, some moving faster than others.

USING THE WHAT YOU WILL LEARN/WHY IT IS IMPORTANT/SKILLS YOU WILL USE

Present all of the terms in the What You Will Learn section and ensure that the students understand the terms. Using these terms correctly will be necessary in order to understand the concepts as they are used throughout the chapter. For example, introduce the terms "particle," "theory," "states of matter," "kinetic energy," "temperature," "expansion," and "contraction."

Discuss the idea that an engineer who designs buildings and bridges must understand the nature of the materials such as concrete in order to use them correctly. For example, the engineer must understand how the particles of concrete interact to ensure that the proper mixture is used to prevent the concrete from crumbling under the weight of the large structure.

USING THE FOLDABLES™ FEATURE

See the Foldables™ section of this resource.

5.1 PARTICLE THEORY OF MATTER

BACKGROUND INFORMATION

The **particle theory of matter** simply states that all matter is made of small particles. These particles are actually atoms and molecules, but these terms will not be introduced to the students in grade 7. The theory continues to explain that all particles are always moving. The theory that explains why particles are never at rest is beyond the scope of high school science. All particles experience attractive forces among themselves. These attractive forces vary tremendously with the types of particles. For example, water particles have a much stronger attraction for each other than do carbon dioxide particles. The particle theory also states that particles of different substances are different. For example, a water particle is made of two hydrogen atoms and an oxygen atom, H_2O. Carbon dioxide particles have one carbon atom and two oxygen atoms, CO_2. Once again, atoms and molecules will not be mentioned in the student book.

Kinetic energy is the energy of motion. Any moving object has kinetic energy. The student book discusses the concepts that mass and velocity contribute to kinetic energy. The formula, $\frac{1}{2}mv^2$, will not be given to students, but it might it might make it easier for you to understand. A moving large object such as a baseball or a bowling ball has, in a sense, two types of kinetic energy—the motion of the object as a whole and the random motion of the individual particles. The random motion of the individual particles is usually called thermal energy. The thermal energy of an object is the sum of all of the kinetic energies of all of the particles.

The student book introduces the concept of average kinetic energy to lead to **the meaning of temperature.** Temperature is directly related to the average kinetic energy of the particles of a substance. Thermometers and temperature scales were developed well before the concepts related to thermal energy, thus the units of degrees and kelvins are not units of energy. The direct mathematical relationships between the average kinetic energy of particles and the temperature of an object are well beyond the scope of high school science. Nevertheless, these relationships exist.

COMMON MISCONCEPTIONS

- Technically, the term "heat" means the transfer of energy from one object to another or from one place to another. The proper term for what the layperson calls heat is thermal energy. However, this is often a difficult concept for students, even at higher grades than grade 7. Therefore, the term heat is usually used in place of thermal energy in this unit to avoid confusion for grade 7 students.
- Sometimes the terms fluid and liquid are considered to be synonymous. A fluid is actually anything that flows, so it includes both liquids and gases.

ADVANCE PREPARATION

- For Activity 5-1A, you will need marbles and sand which might not be stored in a stock room. Other equipment for the activities in this section is commonly found in school laboratories.

- If the model of Lego® blocks is appealing to you as a model for the lessons on particle theory, you might want to have some on hand while introducing and discussing the particle theory.
- Look through the list of BLMs for those that might be used when teaching this section.

INTRODUCING THE SECTION, pp. 136–137

Using the Text

Just as marathon runners made a good model for the particle theory of fluids, Lego® blocks make an excellent model for the particle theory of solids. The appearance and function of an object built with Lego® blocks depends on the nature of the blocks from which it was built.

Ask the students if they have ever built something with Lego® blocks. If they have, let them tell about it. Discuss the idea that everything is made of individual particles. The particles must be assembled in just the right way to make all objects serve their function properly. Use a very simple object, such as a wooden pencil, as an example. Ask them how many different types of particles they think were needed to make the object.

Also, the attractive force between particles of solids must be strong or the object would fall apart. You might compare children's building blocks with Lego® blocks to discuss how easily something could come apart if the forces holding the particles together were not strong enough. Here, you could compare a wooden dowel with a metal rod. The wooden dowel is easy to break, but the metal rod is not. There must be a weaker force holding the particles of wood together than the forces holding the particles of metal together.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the student book in the section, students should be able to define the terms listed in the Key Terms by scanning the student book and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review.

Using the Did You Know, p. 136

You can use the Did You Know section to help students grasp the smallness of particles. If you stacked as many pennies as there are particles of water in a drop of water, you would have 30 million stacks that go from Earth to the Sun. It isn't really possible to grasp these large numbers, but it will help a little to think about particles this way.

USING THE ACTIVITY

Find Out Activity 5-1A

Modelling the Particle Theory, p. 137

Purpose

- Students will use combinations of water, sand, marbles, and ethanol to develop a sense of the space between particles in a substance.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Obtain and prepare materials.	For each group: – funnel – 2 (100 mL) graduated cylinders – 250 mL graduated cylinder – 50 mL ethanol – marbles (50 mL) – 50 mL sand – stirring rod

Time Required

- 30 min

Safety Precautions

- Ethanol is poisonous. Ensure students do not ingest it.

Expected Results

The two 50 mL volumes of water will have an actual volume of 100 mL. However, a few drops might be lost when pouring or stirring. The 50 mL volumes of water and ethanol will have a total volume of less than 100 mL. Water and ethanol molecules bind to each other in a way that takes up less volume than either pure substance. When sand is added to the marbles, it will filter down into the spaces between the marbles. The total volume will be much less than the sum of the two volumes. When the water is added to the sand and marbles, it will fill the gaps between grains of sand as well as between the marbles. Nevertheless, the total volume will be much smaller than the sum of the three volumes.

Activity Notes

- Emphasize to the students that they must be very careful not to spill or drip the water and ethanol when combining. Any drops that do not make it into the final container will affect the accuracy of their results.
- Tell students to touch the stirring rod to the inner top of the cylinder after they stir the mixtures to try to let all of the water or alcohol run off the stirring rod back into the mixture.
- Students should be very careful when stirring the mixtures containing sand or marbles. The stirring rods could break.
- Ensure that the students use the order of adding items that is written in the directions.

Supporting Diverse Student Needs

- Water and ethanol will look the same. Be sure that the ESL students understand the difference.

What Did You Find Out? Answers

1. The only reason that the two 50 mL samples of water would not be 100 mL would be loss of water to spillage.
2. The water and ethanol particles fit into the spaces between particles that were in pure water and in pure ethanol.
3. The sand filtered down into the spaces between the marbles.
4. When water was added to the marbles and sand, it flowed down into the spaces between grains of sand that were in the spaces between the marbles.
5. If marbles had been added to the sand, the total volume would have been much larger. The sand would form a firm layer and the marbles would not have been able to push through the sand.

TEACHING THE SECTION, pp. 138–141

Using Reading

Pre-reading— Key Word Concept Maps

Review the key words with the students so they have a good idea of their meanings before reading. Ask them to describe how the terms are related to each other. As they read, they can improve their comprehension of the relationships among the key terms.

During Reading—GIST (general idea)

After reading each subsection, ask the students to condense the ideas in that subsection. Have them write the GIST of the information in each subsection in 20 words or less.

After Reading—Reflect and Evaluate

The subsections within this section are closely related to each other. Have students reflect on each subsection and explain how the topics depend on one another.

Reading Check Answers, p. 139

1. All matter is made of particles that are too small to be seen. All particles are always moving, and have space between them. All particles are attracted to each other but to greatly differing extents. Particles of different substances are unique.
2. A moving object has kinetic energy.
3. The mass and the speed of an object, large or small, affect the amount of kinetic energy the object has.

Reading Check Answers, p. 141

1. The particles in a stationary object are moving in random directions within the boundaries of the object's surface. They collide with each other and bounce back and forth.
2. The *average* kinetic energy of all the particles in an object or a substance is directly related to the temperature of the object or substance.
3. Add the numbers and then divide the total by the number of numbers.

USING THE ACTIVITIES

- Activity 5-1B on page 139 of the student book is best used with the subsection on Average Kinetic Energy. It will help students understand the following subsection.
- Activity 5-1C on page 140 of the student book is best used at the beginning of the subsection on Kinetic Energy and Temperature where it is located in the text.

Detailed notes on doing the activities follow.

Think About It Activity 5-1B

Average Kinetic Energy, p. 139

Purpose

- Students will practice taking the average of a set of numbers representing kinetic energy.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day ahead	You might want to have extra sets of numbers for students to practice taking averages.	For each group: – pencil – paper – calculator

Time Required

- 20 min

Science Background

This activity is purely mathematical and designed to reinforce students' understanding of the concept of averages.

Activity Notes

- Students should work alone and then compare notes with a partner.
- At the end, check to see that all students were able to do the math and get the correct answer.

Supporting Diverse Student Needs

- Some students might have heard the mathematical terms “mean,” “median,” and “mode.” Tell them that an average is the same thing as the mean. Median and mode are different.
- Challenged students might need a set of fewer numbers that are all integers.

What Did You Find Out? Answers

1. The average kinetic energy is in the middle of the values for kinetic energy of the individual balls.
2. Students might say an hour or a day.

Think About It Activity 5-1C

Detect a Connection, p. 140

Purpose

- Students relate the concept of increased motion or kinetic energy with an increase in temperature.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day ahead	If you choose to, find other examples or demonstrations that will help instill the concepts in the students' minds. For example, have a power drill and drill a hole in wood. Unplug the drill, and let the students feel the drill bit after the drilling. There are many possibilities.	Only those materials for extra demonstrations.

Time Required

- 10 min

Science Background

The temperature of an object or substance will increase if there is an increase in the motion of the particles for any reason. For example, hundreds of bees wings flapping in an enclosed hive will significantly increase the motion of the air particles, or a mixer agitating water will increase the motion of the water particles. In fact, this type of motion was used by James Joule when he was determining the numerical relationship between the temperature of water and the mechanical work that was done on the water. He verified the relationship between heat and energy. The friction between the stick and the log will significantly increase the motion of the particles in the wood. Early humans did not know about the motion of particles but they knew that spinning a stick on a log would make it very hot. They used this knowledge to start fires.

Activity Notes

- Students should work in pairs for this activity.

Supporting Diverse Student Needs

- As students are analyzing the illustrations, students with reading difficulties might need help in understanding the terms in the labels.
- Challenged students might need to have the action in the illustrations explained to them. You might want to pair an advanced student with a challenged student.
- Advanced students might want to set up some type of device similar to the last illustration and test it.

What to Do Answers

1. (a) The motion or speed of the air particles increases. (b) The thermometer shows that the temperature of the air inside the hive is higher than the air outside the hive.
2. (a) The motion or speed of the particles of water increases. (b) The temperature of the water increases.
3. (a) To start a fire, the end of the stick and the log must have had a large increase in temperature. (b) The friction of the stick and log rubbing on each other dramatically increased the motion of the particles where the contact occurred.

What Did You Find Out? Answers

1. In every case, an increase in the motion or speed of the particles resulted in an increase in their temperature.

USING THE FEATURE

Science Watch: Absolute Zero: As Cold as It Gets, p. 142

This feature will help students understand how scientists were able to determine that absolute zero is –273.15ºC well before they had any modern technology. In fact, in high school lab experiments, it is possible to collect data that, when extrapolated, will give values very close to –273.15ºC.

Students will also see how difficult it is to create extremely low temperatures. The instruments in the photograph should communicate the complexity. It should be noted that modern scientific theories indicate that it is impossible to get to absolute zero, but scientists are getting very close.

Science Watch Answers

1. At absolute zero, all particles would have zero kinetic energy. Since temperature is directly related to average kinetic energy of particles, and the average kinetic energy cannot be less than zero, the temperature cannot go below absolute zero.
2. Some scientists have developed a theory of a maximum temperature. However, it is so much higher than any temperature in the universe and so much higher than any temperatures produced in the laboratory that it is unlikely it will be possible to verify this proposed "highest possible temperature."
3. Some students might quote temperatures between –35ºC and –40ºC, but most will probably say around –30ºC.

SECTION 5.1 ASSESSMENT, p. 143

Check Your Understanding

Checking Concepts

1. Matter is anything that has mass and takes up space. Light and sound are not matter.
2. All matter is made of particles. The particles are always moving. There is space between the particles. There are attractive forces between particles. Particles of different substances are different.
3. The motion that gives the entire bowling ball kinetic energy is a motion of the complete ball that goes on one direction. It is the visible motion of the ball rolling down the alley. While the ball is rolling or stationary, each individual particle making up the ball is moving. However, the particles are moving in random directions along very short pathways. They just bounce back and forth around one spot within the ball. These motions are not visible.
4. The amount of kinetic energy an object has is determined by its mass and its speed. Since the two baseballs have the same mass, the one with the higher speed has the most kinetic energy. Therefore, the ball with a speed of 35 m/s has the most kinetic energy.
5. Since the billiard ball and the Ping-Pong™ ball are moving at the same speed, the one with the greater mass has the most kinetic energy. Therefore, the billiard ball has the most kinetic energy.
6. The word "average" is missing. "The temperature of an object is a measure of the average kinetic energy of its particles."

Understanding Key Ideas

7. Students will likely use other toys such as building blocks. They might use pieces of a puzzle. Accept any reasonable answer with a paragraph that shows that they understand the concept.
8. When you rub your hands, the kinetic energy of your hands, as a whole, causes the skin of one hand to push against the skin of the other hand giving kinetic energy to the particles in

your skin. As their kinetic energy increases, so does the temperature of your hands. You could stamp your feet or jump up and down in place to help warm your body.

9. The golf ball that has been lying in the sun is warmer than the one in the shade, therefore, its particles have a higher average kinetic energy.

Pause and Reflect Answer

The two balloons have the same number of particles (11) inside them. The average speed of the particles in the red balloon is higher than the average speed of the particles in the purple balloon. Therefore, the particles in the red balloon are hitting the inside surface of the balloon harder and more frequently. The balloon is elastic so if the particles are hitting it harder and more often, the balloon should expand. The red balloon should be larger than the purple balloon.

Other Assessment Opportunities

- Look through the list of BLMs for those that might be used when teaching this section."

5.2 STATES OF MATTER

BACKGROUND INFORMATION

This section is about the properties of matter in its different states—solid, liquid, and gaseous. A solid has a fixed shape. A liquid assumes the shape of its container and forms a flat, horizontal surface inside the container. A gas assumes the shape of its container and fills the container. At any given temperature, a substance is solid, liquid, or gas, depending on the strength of the attractive forces (bonds) between the particles (atoms and molecules). At a given temperature, of course, particles of all objects have the same average kinetic energy. If the attractive forces between particles are strong enough, the energy of the particles will not be sufficient for the particles to pull away from each other. The substance would be a solid. For substances that are liquids at the same given temperature, the particles have just enough kinetic energy to break the attractive forces or bonds between the particles. However, new bonds form immediately with an adjacent particle. In a liquid, attractive forces or bonds are constantly being formed and broken. Particles do not have enough kinetic energy to completely escape from the other particles. If the attractive forces or bonds between the particles are weak, the kinetic energy of the particles will be great enough to completely break the bonds and the particles remain free from each other. They bounce off of each other like billiard balls. The substance is in a gaseous state.

When the temperature of any substance increases, the kinetic energy of the particles increases. For gases, the particles collide with a greater force, and they push each other farther apart. If the container is flexible, the volume of gas gets larger. If the container is not flexible, the pressure of the gas against the walls of the container increases. For liquids, the particles can break bonds more easily and form bonds more slowly. The particles, on the average, spend more time farther apart. Therefore, the volume of the liquid increases. In solids, particles vibrate more rapidly when the temperature increases. They do not pull away from each other, but they collide harder and spread out a very small amount. As a result, the solid enlarges slightly.

COMMON MISCONCEPTIONS

- Often, specific substances are referred to as being solid or liquid or gas because that is their state at room temperature and under standard atmospheric pressure. In reality, any substance can become a solid or a liquid or a gas under the right conditions of temperature and pressure.

ADVANCE PREPARATION

- For Activity 5-2A, you will have to obtain the materials several days in advance. The gelatin dessert will have to be prepared at least one day in advance.
- For Investigation 5-2B, it would be advisable to obtain balloons and test them ahead of time. Some balloons might not withstand the change in temperature and will burst. Be sure that the balloons will be durable enough to withstand the procedure.
- For Investigation 5-2D, be sure that the school labs have all of the needed equipment such as the ball and ring apparatus.
- Look through the list of BLMs for those that might be used when teaching this section.

INTRODUCING THE SECTION, pp. 144–145

Using the Text

Have the students analyze the picture in Figure 5.6 silently for a minute or two. Ask them what substance is prominent in the picture. What is unique about the substance? If no students mention that water is present as a solid, a liquid, and as a gas, give them hints. Ask them if they can think of any other substance that they encounter in everyday life that is found in all three states. Help them to appreciate the uniqueness of water. Although it is not mentioned in the section, you might tell the students that the solid form of nearly every other substance will sink in a container of its liquid form. Solid water (ice) floats in liquid water.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the student book and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review.

Using the Did You Know, p. 144

Students might not have heard of the state of matter called plasma. Explain that when matter becomes extremely hot, even the "particles within particles" gain so much kinetic energy that they break apart. Some students might have heard of negative electrons and positive nuclei of atoms. If so, you can tell them that the electrons come off the atoms. Tell the class that the most common state of matter in the universe is the plasma state. See if any of the students can explain why. (Matter in the core of all stars is plasma because stars are so hot.)

Probably none have ever heard the name, Bose-Einstein condensate. You could refer back to the feature on page 142 and tell them that the very small particles that the scientists brought down to a temperature of 0.000 000 170 K were Bose-Einstein condensates.

USING THE ACTIVIY

Find Out Activity 5-2A

Is It a Solid, Liquid, or Gas?, p. 145

Purpose

- Students will analyze several samples and decide whether they are solid, liquid, or gas. They will attempt to define the characteristics that determine whether a substance is in the solid, liquid, or gaseous state.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week ahead	Obtain and prepare the materials.	For each group: – rock – marshmallow – square of gelatin dessert – glass of milk – whipped cream (or shaving cream) from aerosol can – empty jar with a lid on it (for a gas) – glass of water – vegetable oil

Time Required

- 20 min

Safety Precautions

- Emphasize to the students that they must not taste any of the objects.

Expected Results

- The rock is a solid.
- The marshmallow is a mixture of a solid and a gas.
- The gelatin is a solid, but some liquid is trapped inside.
- The milk is a liquid.
- The whipped cream (or shaving cream) is a mixture of a liquid and a gas.
- The jar with a lid on it contains a gas.
- The water is a liquid.
- The vegetable oil is a liquid.

Activity Notes

- Tell them that the contents of the jar (with the lid) is the substance that they are supposed to analyze.
- After the students have had time to think through all of the samples, give them a hint that some of the substances might contain mixtures of two substances that are in different states.

Supporting Diverse Student Needs

- Some students might need an explanation of how an aerosol can works, i.e., a gas under pressure pushes the substance out of a very small hole.
- Some students might need an explanation of how gelatin was made.

What Did You Find Out? Answers

1. The students might have trouble with the marshmallow, the gelatin, or the whipped cream.
2. Some might not agree on the state(s) of the whipped cream.

TEACHING THE SECTION, pp. 146–150

Using Reading

Pre-reading—Predict-Read-Verify

- In the opening Find Out Activity, the students predicted what properties a substance would need to have in order to be classified as a solid, a liquid, or a gas. They could read the first subsection to verify or refute their predictions.
- Next, they could predict how the particle theory explains the states of matter. They could test their predictions by reading the next subsection.
- The students have just discovered that solids and liquids are uncompressible. The students could predict what will happen when the temperature changes. As before, they could test their predictions by reading the subsection on Expansion and Contraction of Matter.
- Finally, they could predict how the particle theory explains thermal expansion and contraction and test their predictions by reading the last subsection.

During Reading—Where Do I Find the Answer? (QAR — Question-Answer Relationship Strategy)

The predictions described in the Pre-reading section above generate questions. During reading, the students should find the answers and relate them to their predictions and questions.

After Reading—Reflect and Evaluate

Having students make predictions creates a serious obstacle: students often remember the incorrect prediction. After reading, have the students reflect on the predictions that had to be corrected. Ensure that the students have understood why the predictions were incorrect and are clear about the correct answer.

Reading Check Answers, p. 148

1. (a) Solids – (1) have a fixed shape, (2) shape is not affected by shape of container
   (b) Liquids – (1) changes to fit the container, (2) forms a flat surface inside the container
   (c) Gases – (1) changes to fit the container, (2) fills the container
2. Particles in a solid are packed closely together, often in a symmetrical pattern. They are strongly attracted to each other.
3. Particles in a liquid can break away from each other but are then attracted to a nearby particle. In a solid, the particles do not break away from each other. They remain attracted to the same particles.
4. Children playing tag are trying to avoid touching each other. However, they might occasionally bump into each other.

Reading Check Answers, p. 150

1. Thermal expansion means that when a substance or object becomes warmer, it becomes larger or its volume increases.
2. When the temperature of a gas increases, the particles gain more kinetic energy. When the particles collide with the walls of the container, the collisions are more forceful. These forceful collisions push the walls of the container outward, increasing the volume of the container.
3. When the liquid is in a long, thin tube, you can see the change in the volume of the liquid as it undergoes thermal expansion. This property can be used to determine the temperature.

USING THE ACTIVITIES

- Activity 5-2B on page 151 of the student book is best used at the beginning of the discussion on expansion and contraction of matter (top of page 149).
- Activity 5-2C on page 152 of the student book is best used near the beginning of the discussion of the particle theory and expansion and contraction (middle of page 149).
- Activity 5-2D on page 154 of the student book is best used at the end of the discussion of expansion in solids (end of page 150).

Detailed notes on doing the activities follow.

Conduct an Investigation 5-2B

Bulging Balloons, p. 151

Purpose

- Students will demonstrate that gases in a flexible container expand when heated and contract when cooled.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Obtain and test balloons.	For the class: – refrigerator or freezer (if unavailable, a cooler filled with ice will work) – hair dryer or electric heater For each group: – 2 identical balloons

Time Required

- 60 min

Science Background

When gases are heated, the particles gain kinetic energy. The particles collide with the inside surface of the container more frequently and with a greater force. Therefore, the pressure of the gas pushing outward on the walls of the container is greater. If the outside pressure pushing inward on the walls of the container remains the same, there is more pressure pushing out than pushing in. If the walls of the container are flexible, they will move until the pressures on the walls from the inside and from outside are the same. In the case of the balloons, the outside pressure pushing inward is the atmospheric pressure.

Activity Notes

- Read the Procedure steps as a class, so that each student understands what is expected. Ask students what they expect to see and have them write their predictions in their notebook. This will prepare them to answer the questions in the Analyze section.
- Use question 4 under Analyze to assess students' understanding of controls and variables. If necessary, review the concept of controlling variables.
- After the students have completed the investigation, discuss their observations and explanations of their observations.

Supporting Diverse Student Needs

- You might want to do this activity with the students that have learning difficulties.. This will allow you to discuss the test and control variables in simple language.

Analyze Answers

1. When we took the balloon out of the refrigerator, it was smaller than the control balloon. It had contracted. When we blew warm air on the balloon, it got larger. It had expanded.
2. In most cases, the students probably made correct predictions.
3. Students might say that the balloon did not contract or expand as much as they expected.
4. The balloon that remained at room temperature was the control. The balloon that was cooled and then warmed was the test. The control is the balloon that you compare the test balloon with. You need a control so you can tell whether the balloon that had been subjected to tests had actually changed.

Conclude and Apply Answers

5. The particles in the air were farthest apart when the balloon was warmed with the heater. The particles were closest together when the balloon was in the refrigerator.
6. Students might refer to the air thermometers that they made, however accept all reasonable answers that clearly demonstrate the expansion of a gas.

Conduct an Investigation 5-2C

Race for the Top, pp. 152-153

Purpose

- Students hypothesize whether all liquids expand and contract to the same extent and test their hypothesis.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Obtain or prepare ice cubes. Insert glass tubes into the stoppers for the students.	For each group: – 3 large test tubes – 3 one-hole stoppers with 50 cm lengths of glass tubing inserted – laboratory stand and clamps – 2 large tin cans or 500 mL beakers – 3 liquids (coloured water, ethyl alcohol, and cooking oil) – rubber bands – markers – very hot water – ice-cold water
1 day before	Prepare coloured water by adding a few drops of food colouring. Set up a sample apparatus for the students to study.	

Time Required

- 30–45 min

Safety Precautions

- Do not allow students to insert glass tubes into the stoppers. Accidents can occur too easily when this is not done correctly.
- Remind students that safety glasses must be worn at all times.
- Coloured water can stain clothes, so remind students to be careful to avoid spills.

Science Background

All substances expand to a different extent when the temperature is increased by a given amount. The amount of expansion is described by a substances' coefficient of thermal expansion. In this investigation, cooking oil will probably expand the most and water the least.

Activity Notes

- Assure students that their hypothesis does not have to be correct. The purpose of doing scientific investigations is to determine how a substance will behave under changing conditions.
- Demonstrate how to set up the apparatus, clearly pointing out steps in which you think confusion might occur.
- When the students put the stoppers with glass tubing into the full test tubes, some spilling will occur. Have them work over a sink or a bowl.
- Tell students to fill a can or beaker of hot or cold water to only about three-fourths full.
- When they have completed the investigation, have the students share their results. Which liquid rose faster than the others when the liquids were warmed?
- To review the particle theory, ask students which material they think has stronger attractive forces between the particles.

Supporting Diverse Student Needs

- Consider setting up steps 1 and 2 of the procedure for challenged students since the apparatus might be difficult for them to handle.

Analyze Answers

1. The liquids did not expand to the same extent when they were warmed.
   (a) The oil expanded more than the water or ethanol.
   (b) Yes, the oil contracted more than the water or ethanol when it was cooled.
2. There are two possible answers depending on whether students let the liquids return to room temperature. If the liquids were still cool, they did not return to their original positions. If the liquids were allowed to return to room temperature, they did return to their original positions (unless there was some spillage).

Conclude and Apply Answers

3. No, all liquids do not expand to the same extent when heated.
4. (a) Because the oil expanded more with the same change in temperature, it would be best for a thermometer that needs to show small changes.
   (b) The coloured water expanded the least so if large changes in temperature need to be measured, water would be best. However, if temperatures are expected to go above 100°C or below 0°C, another liquid would be preferable because the water would boil or freeze before the thermometer reached the final temperature.
5. (a) The bulb allows the thermometer to contain a large amount of fluid for expansion and contraction. The entire liquid expands causing a greater change in the height of the fluid in the small tube.
   (b) The test tubes in the apparatus performed the same function as the bulb in the thermometer.
   (c) Since it is volume that is changing, as the diameter of the tube decreases, the vertical length of the column of fluid increases for the same volume change.

Conduct an Investigation 5-2D

Expanding Solids, pp. 154-155

Purpose

- Through both investigation and demonstration, students identify the expansion effect caused by warming a solid.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Collect apparatus. Do Part 1 to determine the best length of wire to be used. The longer the wire, the more it will have to be heated.	For each group: Part 1 – long copper or iron wire – small mass (200 g or 500 g) with a hook – metre stick – candles – matches
1 day before	Set up apparatus for Part 1 as a sample that students can study.	Part 2 – ball-and-ring apparatus – laboratory burner – cold water – matches

Time Required

- 45 min

Safety Precautions

- Remind students that safety glasses must be worn at all times during this investigation.
- Review with students the safety precautions for working with an open flame. Long hair should be tied back.
- If a burn does occur, immediately hold the skin under cold running water for several minutes.

Science Background

When solids are heated, they expand in every direction. All sides will push outward. A change in the diameter of the wire will be negligible, but the length of the wire will increase by a measurable amount. In Part 2, the ball and ring is interesting because the ring expands in every direction including inward. The hole actually gets smaller.

Activity Notes

- Divide students into small groups of three or four.
- Have students prepare a data table to record the height of the mass at 30 s intervals for 2 to 3 min.
- Demonstrate the set-up of the Part 1 apparatus and the proper way to heat the wire. The candle should be moved slowly along the entire length of the wire rather than being held in one location.
- For the sake of safety, you might choose to do all of Part 2 as a demonstration.
- You might choose to have one student assist you in the demonstration.
- Before demonstrating each step, ask students to make predictions about what they expect to see and to explain their reasoning.
- Have students record their observations after every step of the procedure.
- After the investigation is complete, discuss students' observations and explanations.
- Make sure that the students' answers show that they understand how the particle theory can explain their observations.
- Most ball and ring apparatuses are designed to allow the ball to pass through the ring at room temperature. The procedure for this investigation is written accordingly. A few apparatuses are different in that the ball will not fit through the ring at room temperature. Try to find the first type, or you will have to modify the procedure.

Supporting Diverse Student Needs

- You might need to work along with students who have learning challenges throughout Part 1.

Analyze Answers

Part 1

1. (a) If the wire sags and the mass moves down as the wire is heated, the wire must be getting longer.
   (b) If the mass moves up as the wire cools, the wire must be getting shorter.
2. If the wire sags, it is getting longer and the particles are getting farther apart. If the number of particles does not change, but they get farther apart, the additional distance between the particles becomes part of the length. The wire must get longer.

Part 2

1. At room temperature, the ball fits through the ring. Therefore the diameter of the ball is smaller that the diameter of the hole in the ring. When only the ring was heated, the ball still fit through the ring. When the ring was heated, the metal expanded. Even the hole expanded! When only the ball was heated, it did not fit through the ring. When the metal expanded, the volume of the ball increased. When both the ball and ring were heated, the ball still fit through the ring because they had both expanded by the same amount. The expansion of the ball made its diameter larger and the expansion of the ring made the diameter of the hole larger.

Conclude and Apply Answers

2. If the ball fits through the hole in the ring, it must be smaller than the hole. When the ball was heated, it did not fit through the hole in the ring so it had to have become larger.
3. When the ball and/or ring are heated, the particles vibrate in place with more energy. Therefore, the distance that the particles move back and forth is longer. Each particle is pushing its adjacent particles a little further away. When all of the particles are farther apart than they were originally, the volume is larger. For the ring, a larger volume results in a larger hole.
4. When the particles cool, the extent of the vibration of particles is reduced. The particles move closer together and the volume of the solid decreases.

USING THE FEATURE

National Geographic: Visualizing States of Matter, p. 156

This article is an excellent, highly visual review of the properties of the states of matter. An example of each state (except a Bose-Einstein condensate) is pictured and described. A photograph of an example of each state is shown, along with an illustration of the particles. The plasma state is represented by lightning. Students might be surprised to discover that the temperature of air in a lightning strike is 30 000 K. This is hot enough to cause the particles to break apart into positive and negative charges. Discuss this fact with the students. Have them read the article as a review. Give them an opportunity to discuss anything that they feel that they still do not really understand about the states of matter before proceeding to the next section, which is on changes of state.

SECTION 5.2 ASSESSMENT, p. 157

Check Your Understanding Answers

Checking Concepts

1. Water is the only substance that exists naturally in all three states at the same time on Earth.
2. Solids and liquids are both incompressible. Liquids assume the shape of their container, but solids do not.
3. Liquids and gases both assume the shape of their container. Gases fill their container, but liquids do not. They form a flat surface inside the container.
4. The particles in a liquid have enough kinetic energy to break away from their neighbouring particles, but they immediately form bonds with nearby particles. By breaking and reforming bonds, particles in a liquid can move past each other. The particles in a solid do not have enough kinetic energy to break away from their neighbouring particles. Each particle remains bound to the same particles as long as the object is solid.
5. At a given temperature, the attractive forces between particles in a solid are greatest. Attractive forces between particles in a liquid are intermediate, and the attractive forces between particles in a gas are very weak.
6. Samples of all states of matter expand when heated. However, gases expand much more than do liquids and solids.
7. The particles in a solid vibrate harder, and the length of the path over which they vibrate becomes longer when they are heated. However, even though they are vibrating energetically, they do not break the attractive interaction with the neighboring particles.
8. All materials will expand at summer temperatures and contract in winter temperatures. Even if the expansion is only a few millimetres, it can cause a solid to crack or bend if there is no room for expansion. Engineers must design large structures so that the different parts can expand and contract without jeopardizing the entire structure.

Understanding Key Ideas

9. Student answers should include a reasonable scenario. For example, you could use toothpicks to hold the balls in place. For a solid, you would stack the balls in a very uniform array, held together by toothpicks. For a liquid, you could put them in a random configuration. For a gas, you would only push the toothpick in a very short distance and hold the balls as far apart as the toothpicks would allow.
10. If you heat the metal lid, it will expand and will become slightly larger than the mouth of the jar.
11. While the balloon and bottle are cool, stretch the open end of the balloon around the mouth of the jar. Secure it with a string or elastic band. Place the bottle and balloon in a warm place. The balloon would begin to inflate.

Pause and Reflect Answer

These metal plates are attached to the ends of long sections of the roadway of the bridge. When the air is warm in the summer and the sections of roadway expand, the “teeth” in the photograph can move closer together without creating any pressure on part of the structure. When the sections of roadway contract in the winter and the sections contract, the “teeth” will pull apart, but the design prevents any ruts from forming that will let tires on vehicles sink down. This photograph was probably taken in the winter because there is a lot of space between the “teeth.”

Other Assessment Opportunities

- Look through the list of BLMs for those that might be useful in teaching this section.

5.3 CHANGES OF STATE

BACKGROUND INFORMATION

The physical state—solid, liquid, or gas—of any substance is determined by temperature and pressure. In this text, the pressure is assumed to be standard atmospheric pressure to simplify the discussion. The names of the changes of state are as follows:

- **Melting** is the change from the solid state to the liquid state.
- **Freezing** is the change from the liquid state to the solid state.
- **Evaporation** is the change from the liquid state to the gaseous state.

- **Condensation** is the change from the gaseous state to the liquid state.
- **Sublimation** is the change from the solid state to the gaseous state.
- **Deposition** is the change from the gaseous state to the solid state.

Sublimation and deposition are the least common changes of state because, at standard atmospheric pressure, most substances go from a solid to a liquid to a gas as the temperature rises. However, some substances, such as carbon dioxide, sublime directly from a solid to a gas. Carbon dioxide cannot exist in a liquid state at standard atmospheric pressure; it must be under at least 5.1 atm of pressure to become a liquid.

Every substance has a specific temperature at which it melts and boils (or sublimes) at standard atmospheric pressure. These temperatures are called the melting point and the boiling point for the substance. The reverse process occurs at the identical temperatures. That is, as the temperature goes down, the substance condenses at its boiling point and freezes at its melting point. In other words, the freezing point and melting point are the same, and the boiling point and condensation point are the same.

When the temperature rises, a substance undergoes a change of state because the kinetic energy of the particles reaches the point at which it is great enough to break the bonds (attractive forces) between the particles. Some confusion can arise when discussing boiling points. It is common knowledge that at temperatures well below the boiling point of a substance, such as water, some of the particles have enough kinetic energy to escape from the liquid state and move into the gaseous state. For example, there is always some water vapour (gaseous water) in the air. One might wonder about the meaning of the boiling point. The boiling point is the point at which *all* of the particles will go into the gaseous state. There will be no liquid remaining above the boiling point.

A heating curve displays a lot of information about a substance. It is a plot of temperature versus time and shows the physical state of a substance as the temperature increases from a point well below the freezing point to well above the boiling point. It assumes equal increments of heat are added to the substance in increments of time. Thus the time scale can be thought of as a scale of amount of heat added to the substance. When you first start adding heat to the substance, the temperature of the solid increases, meaning that the kinetic energy of the particles is increasing. When the temperature reaches the melting point, all of the energy is used to break the bonds (attractive forces) between the particles. No energy is used to increase the kinetic energy of the particles, thus the temperature does not rise. When the entire sample has melted, i.e., is in the liquid state, and heat is added, the temperature again rises. That is, the added heat is is being used to increase the kinetic energy of the particles. Eventually, the temperature reaches the boiling point. Once again, all of the heat added is being used to break bonds between the particles and none is being used to increase the kinetic energy of the particles. For this reason, the temperature does not change until all of the bonds (attractive forces) between particles have been broken. All particles are in the gaseous state. Once again, the added heat is being used to increase the kinetic energy of the particles and the temperature again rises.

COMMON MISCONCEPTIONS

- It would be easy to assume that a solid only changes to the liquid state at the melting point. In some cases, a small amount of a solid can sublime directly into a gas. Under certain conditions, more snow sublimes into water vapour than melts.

ADVANCE PREPARATION

- For the opening Find Out Activity, 5-3A, you might want to try to find a sling psychrometer for a demonstration. Also, for the same activity, secure an electric fan.
- When discussing changes of state and explaining sublimation, it would be well worth obtaining some dry ice (solid carbon dioxide) to use as a demonstration. DO NOT handle dry ice with bare hands.
- For Investigation 5-3C, obtain an electric kettle and crushed ice several days ahead of time.

INTRODUCING THE SECTION, pp. 158–159

Using the Text

Use the photographs to initiate a discussion about the fact that when liquids reach a certain temperature, they freeze. Drivers must prevent the freezing of the coolant for an engine because it could crack the radiator or, worse yet, the engine. Therefore, drivers add antifreeze to the water to prevent freezing. Actually, "antifreeze" does not prevent freezing. It lowers the temperature at which freezing occurs. You might discuss the idea of putting salt on streets and sidewalks to "melt" the ice. Once again, salt does not "melt" ice. Instead, it lowers the temperature at which water freezes. Ask the students why they think substances freeze. Also, ask them why different substances freeze at different temperatures. Encourage the students to think about particle theory and how it might help explain freezing and thawing.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the student book and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review.

Using the Did You Know, p. 158

You could use this feature to discuss the idea that some things that help us in some ways (antifreeze to prevent damage to engine) cause problems in other ways. Antifreeze (ethylene glycol) is very toxic. Because it has a sweet taste, animals will drink it if it spills. Young children will also taste it. If not treated immediately, animals and even children can die.

USING THE ACTIVITY

Find Out Activity 5-3A

How Low Can It Go?, p. 159

Purpose

- Students determine differences in temperature change when the two liquids (water and alcohol) evaporate.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Cut cloth or paper towels into thin strips.	For each group: – lab thermometer or computer temperature sensor – electric fan – 2 strips of cloth or paper towel – room-temperature water – room-temperature alcohol
1 day before	Leave a sample of water in the classroom overnight to adjust to room temperature.	

Time Required

- 30–40 min

Safety Precautions

- Students must handle the alcohol with care. They must not taste it or inhale its vapour. Do not use the alcohol near an open flame.
- Safety glasses must be worn at all times during this investigation.

Expected Results

Because alcohol evaporates faster than water, the thermometer touching the alcohol-soaked cloth bulb will register a lower temperature as a result of evaporative cooling (see feature on page 168).

Activity Notes

- To prevent the cloth strips from falling off the thermometers, secure them with elastic bands.
- If you have enough fans available, this activity is best done in groups of three: one member is the timer, one holds the cloth-wrapped thermometer in front of the fan, and one is the recorder. Students can switch roles when the procedure is repeated using the second sample.

Supporting Diverse Student Needs

- Learning challenged students might need help completing the graph.

What Did You Find Out? Answers

1. The particles of the alcohol were evaporating faster. This answer is based on the fact that the temperature of the alcohol dropped more rapidly and to a lower temperature than did the temperature of the water.
2. The water-soaked cloth will take longer to dry because the alcohol is evaporating faster than the water. If either cloth dries completely, the temperature will go back to room temperature because there is no more evaporation occurring.
3. Because the water evaporates more slowly, the water particles must be "holding on to each other" more strongly than are the alcohol particles. The water particles have a stronger attraction to each other than do the alcohol particles.

Using a Demonstration

It would enhance this activity if you could locate a sling psychrometer and demonstrate its use. The directions for use and the chart needed to interpret the results should come with the psychrometer. In general, the difference between the wet and dry bulb readings is used to determine the percent humidity.

For example, if the air is very humid, evaporation from the wet bulb will be suppressed and the difference between the two readings will not be as great as it is when the air is quite dry.

TEACHING THE SECTION, pp. 160–165

Using Reading

Pre-reading—Know, Want to Know, Learned

Have students write down what they know about changes of state. Ask them what the melting and boiling points of water are. Ask them what they know about melting and boiling points of any other substance. Finally, ask them to write questions about these topics for which they do not know the answers.

During Reading—Note-taking

As the students read the section, have them check to ensure that the things they wrote for the "know" exercise on these topics are correct. Have the students look for answers to the questions that they wrote for the pre-reading exercise. Have them make notes on the relationship between the particle theory and the processes of changing state. Use the section on heating curves to review and synthesize what they have learned in this section.

After Reading—Reflect and Evaluate

Have the students list four points they learned in this section that they did not know before. Have them evaluate the way this information enhances what they learned previously.

Reading Check Answers, p. 163

1. Water vapour is also called gaseous water or water in the gaseous state.
2. (a) Condensation is opposite to evaporation.
   (b) Freezing is opposite to melting.
   (c) Sublimation is opposite to deposition.
3. The boiling point of a substance is the point at which all of the substance changes state from liquid to gas.
4. Sulfur boils at 445°C.

Reading Check Answers, p. 165

1. The particles must have enough kinetic energy to break the attractive forces between particles in order for a solid substance to begin to melt.
2. When particles have enough kinetic energy, they can break all attractive forces with other particles and escape out of the liquid and become a gas.
3. When a substance is going through a phase change (solid to liquid or liquid to gas) all of the heat (energy) is used to break bonds or attractive forces with other particles and none is left to be used to increase the kinetic energy of the particles.

USING THE ACTIVITIES

- Activity 5-3B on page 162 of the student book is best used immediately after learning about melting points and boiling points.
- Activity 5-3C on page 166 of the student book is best used at the very end of the section.

Detailed notes on doing the activities follow.

Think About It Activity 5-3B

State the State, p. 162

Purpose

- Students interpret data to determine which state of matter is found at given temperatures.

Advance Preparation

- none

Time Required

- 20–30 min

Science Background

All pure substances have unique melting and boiling points. These points are dependent on pressure but are usually recorded for standard atmospheric pressure. Before modern techniques were available, chemists used boiling and melting points to identify compounds. Below its melting point, a substance is a solid. Between its melting point and boiling point, a substance is a liquid. Above its boiling point, a substance is a gas. For example, at a temperature of 200°C, sulfur is a liquid because 200°C is above its melting point (115°C) and below its boiling point (445°C). It is a little trickier with negative temperatures because the larger magnitude negative numbers are lower than smaller magnitude negative numbers. For example, at –200°C, oxygen is a liquid because –200°C is higher than –219°C, the melting point of oxygen.

Activity Notes

- Review the meaning of "melting point" and "boiling point" and the states of matter with students.
- It might be helpful to write the following on the board:
  solid → melting point → liquid → boiling point → gas

Supporting Diverse Student Needs

- For some students, it might be helpful to have them reproduce Table 5.1 in their notebooks and write "solid" to the left of the melting point column, "liquid" between the two columns, and "gas" to the right of the boiling point column.

What to Do Answers

1. (a) gas
   (b) liquid
   (c) solid
   (d) gas
   (e) liquid
2. (a) freezing
   (b) freezing
   (c) no change of state
   (d) no change of state
   (e) freezing

What Did You Find Out? Answers

The melting point for aluminum is 660°C and for tin is 232°C. Since it takes a higher temperature and therefore greater kinetic energy of particles for aluminum to melt than for tin, the particles of aluminum must have a stronger attractive force between each other than those of tin.

Conduct an Investigation 5-3C

The Plateau Problem (Core Lab), pp. 166-167

Purpose

- Students discover that the temperature of a substance remains constant while a change of state is occurring.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Purchase or make crushed ice. Be sure that you have a supply of graph paper.	For each group: – 2 laboratory thermometers – stirring rod – hot plate – kettle – 2 beakers (250 mL) – clock or watch – crushed ice – ice-cold water – hot water (almost boiling)

Time Required

- 30–50 min

Safety Precautions

- Remind students that safety glasses must be worn at all times during the investigation.
- Remind students to use oven mitts or tongs when handling hot beakers.
- Be sure that students do not use thermometers to stir materials.
- Be sure students unplug the hot plates and allow them to cool before putting them away.

Science Background

At the beginning of the Investigation, the hot water will have a temperature below the boiling point. As the water heats on the hot plate, you will see steam rising before the water has reached 100°C because many water molecules will have enough kinetic energy to break the bonds between molecules. When the water comes to a rolling boil, the temperature will be at or near 100°C. It will stay at 100°C as long as there is liquid water remaining in the beaker because all of the heat entering the liquid water at 100°C will be used to break bonds between water molecules and not to change the kinetic energy of the molecules. The technical explanation for why this is true is beyond the scope of high school science. The investigation must be stopped before the water has boiled away.

The slush should be at 0°C at the beginning of the investigation. However, depending on the amount of water added and the temperature of the water, the temperature might be above freezing. As the slush comes to temperature equilibrium, it will be at or near 0°C. The temperature will remain at 0°C as long as there is solid ice in the slush because any heat entering the system will be used to break the bonds between water molecules in the ice, causing it to melt. If all of the ice melts, the temperature will begin to rise above 0°C.

Activity Notes

- Discuss the procedure with the class to be sure that everyone understands the steps.
- Discuss the need for constant stirring to keep the temperatures in the beakers uniform throughout.
- The investigation will probably work best in groups of four. Let the students decide who will be the timer, the person who stirs and measures the temperature of the water on the hot plate, the person who stirs and measures the temperature of the ice water, and the recorder.
- If you choose to do so, after the first few readings of the slush, have the students put the beaker on the hot plate. This will cause the ice to completely melt, and the students will get some readings of the increase in temperature after the ice has melted.

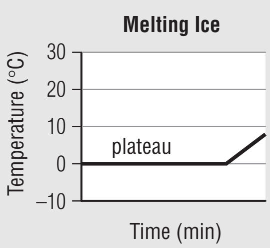
- Discuss and demonstrate the method for drawing the line graph. Refer students to Science Skill 1: Organizing and Communicating Scientific Data on pages 455-456.
- Make a chart on the board for recording the results for question 8. Enter the data from each group.
- At the end of the investigation, discuss the shapes of the graphs.
- Discuss with students what was happening to the heat entering the hot water from the hot plate when the temperature of the water was not rising.

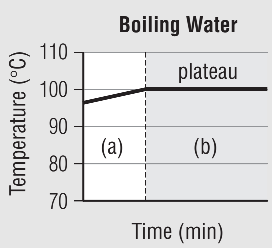
Supporting Diverse Student Needs

- Consider preparing the data table ahead of time for the learning challenged students.
- You might need to work directly with learning challenged students when they are creating their graphs.

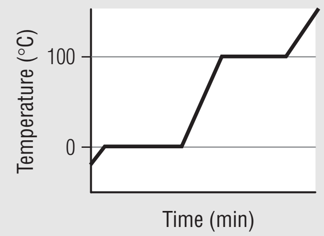
Analyze Answers

1. (a) The dependent variable was the temperature of the sample.
   (b) The independent variable was time because I (the student) chose the times at which to read the temperature.
2. See graphs below. The starting point of the graph for Boiling Water will be the starting temperature of the hot water and will vary. On the graph for Melting Ice, the starting temperature could be above zero, depending on the amount of water and ice originally.





3. On the graph for question 2, Boiling Water, the section where the water was hot but not boiling is labelled (a). The section where the water is boiling vigorously is labelled (b).
4. The plateaus are labelled on the graph for question 2.
5. (a) If the two temperatures are almost the same, the small difference could be due to reading the thermometer at an angle. Also, the water might not be pure. Impurities can alter the melting and boiling points. As well, incomplete mixing could affect the measurements.
   (b) The "official" melting and boiling points are for sea level. The altitude of the laboratory might be far enough from sea level to alter the melting and boiling points. Also, the atmospheric pressure affects the boiling point, and it changes from day to day.
6.



7. On the graph for question 6, the labels are the "correct" labels. Students' labels will vary.
8. In general, the average will be closer to the accepted values. All individual measurements have random errors. When you take an average, many of the random errors cancel each other out. As the number of trials increases, random errors are more likely to be cancelled.

Conclude and Apply Answers

9. When water is undergoing a phase change, the temperature remains constant.
10. The answer will depend on the hypothesis. Most students probably made a hypothesis that agrees with the results.
11. (a) Student answers will vary. Some might say they had trouble stirring the slush. Others might say they get confused when reading and recording data.
    (b) Again, student answers will vary. Some might say they should start the two measurements at different times so they aren't trying to read and record the two types of data at the same time.

USING THE FEATURE

www science: Evaporating Cooling, p. 168

Present the idea that changes of state are very important to everyday life. A lot of energy is exchanged between a living organism and the environment when a phase change occurs. You might suggest that the students moisten the palm of their hand and blow on it. Ask them how it feels. Ask why. Then ask them why they sweat. Some students might have trouble understanding the examples of kinetic energies before and after evaporation of the most energetic particles. Draw a vertical line on the board and put an X on the centre of the line. Then erase a short segment at the top of the line. Tell the students that this represents the evaporation of the most energetic particles. Now put an O in the centre of the shortened line. Show them that the new average (O) is lower than the original average (X). Finally, ask them if they can think of any other examples of animals that use evaporation of water as a mechanism for cooling.

SECTION 5.3 ASSESSMENT, p. 169

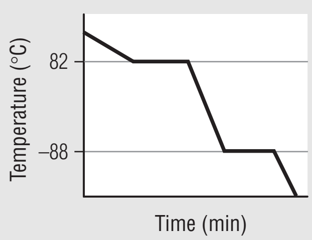
Check Your Understanding

Checking Concepts

1. For a substance, the word "state" means whether the substance is a solid, liquid, or gas. A "change of state" means that a substance is going from one of these conditions to another of these conditions.
2. Sublimation means to go from a solid directly to a gas. Evaporation means to go from a liquid to a gas. The end result is the same, but the beginning point is different.
3. (a) liquid
   (b) gas
   (c) Tin is a liquid from 232ºC to 2602ºC.
4. In a solid, the attractive force between particles is so strong that the kinetic energy of the particles is not great enough to pull the particles apart. A substance melts when the kinetic energy of the particles becomes great enough to break the attractions between particles so they can move away from the neighbouring particles.
5. According to particle theory, there are attractive forces between all particles. However, particles of different substances have different properties. Particles of some substances have much stronger attractive forces than do others. It requires much more kinetic energy, thus higher temperatures, to pull these particles apart, which is necessary for a change of state. Due to the differences in attractive forces between the particles, different substances have different melting and boiling points.
6. A heating curve is a graph of the temperature of a substance versus time. As time passes, heat is added to the substance so the time axis is, essentially, a heat axis. The curve shows how the temperature of the substance changes as heat is added to the substance. The curve starts when the substance is a solid and continues until the substance is a gas.

Understanding Key Ideas

7. Pure substances have specific melting and boiling points. After salt is added to water (or ice) it is no longer pure. A solution of salt water has a lower melting point than pure water. Students might recall that when Fahrenheit established his temperature scale, he made a mixture of water, ice, and salt to create the lowest temperature possible at that time.
8. There was water vapour, or gaseous water, in the air. The temperature of the air near the outside of the glass had decreased, causing some of the water vapour to condense on the cold surface of the glass.
9. At room temperature, water is a liquid and table salt is a solid. At a given temperature, the attractive forces between the particles in a solid are stronger than the attractive forces between the particles of a liquid. Therefore, the attractive forces between the salt particles must be greater than the attractive forces between the particles of water.
10.



11. In a liquid, the particles have a variety of different amounts of kinetic energy. It is only the average kinetic energy that determines the temperature. There are always a few particles in the liquid that have enough kinetic energy to escape from the attractive forces of the other particles and get through the surface of the liquid to change into the gaseous state.

Pause and Reflect Answer

Pure water and pure antifreeze have their own specific freezing points. When they are mixed together, the freezing point of the solution is different than that of either pure liquid. This new freezing point of the solution is lower than that of pure water, preventing the coolant from freezing in the engine in the winter.

Other Assessment Opportunities

- Look through the list of BLMs for those that might be used when teaching this section.

CHAPTER 5 ASSESSMENT, pp. 170-171

PREPARE YOUR OWN SUMMARY

Student summaries should incorporate the following main ideas:

1. The Particle Theory of Matter
   - All matter is made of tiny particles.
   - Particles are always moving and thus have kinetic energy.
   - There are spaces between particles.
   - There are attractive forces between particles.
   - Particles of one substance differ from particles of all other substances.
2. Temperature and the Kinetic Energy of Particles
   - Kinetic energy is the energy of motion.
   - Mass and speed determine a particle's kinetic energy.
   - The average kinetic energy of the particles of a substance is directly related to the temperature of a substance.
3. States of Matter
   - The three common states of matter on Earth are solid, liquid, and gas.
   - Solids have a fixed shape.
   - Liquids take the shape of the container and form a surface in the container.
   - Gases take the shape of the container and fill the container.
   - The strength of the attraction between the particles of a substance and the amount of kinetic energy of the particles (temperature) determine whether a substance is a solid, a liquid, or a gas.
4. Expansion and Contraction of Matter
   - Substances in all states of matter expand when the temperature increases.
   - Gases expand much more than liquids and solids.
   - Even a very small amount of expansion or contraction of solids during a temperature change can damage structures.
5. Changes of State
   - When matter goes from one state to another state, it is called a change of state.
   - Energy is absorbed when a substance changes state from a solid to a liquid (melting), a liquid to a gas (evaporation), or from a solid to a gas (sublimation).
   - Energy is released when a substance changes state from a gas to a liquid (condensation), a liquid to a solid (freezing), or a gas to a solid (deposition).
6. Melting Points and Boiling Points
   - Every pure substance has a unique melting point and boiling point.
   - The melting and boiling points of a substance are determined by the strength of the attractive forces between the particles of the substance.
   - A heating curve is a graph of temperature versus time when the substance is being heated.
   - The temperature of a substance does not change while it is undergoing a change of state.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. In order to have kinetic energy, an object must be moving.
2. Temperature is directly related to the average kinetic energy of the particles of a substance.
3. A solid has a fixed shape. Liquids take the shape of the container and form a surface in the container. Gases take the shape of the container and fill the container.
4. Answers will probably resemble the illustrations in Figure 5.9 on page 147.
5. Substances expand when the temperature increases. Gases expand most upon heating.
6. The particles in a liquid have enough kinetic energy to break away from adjacent particles but are then attracted to other particles. This "changing partners" allows the liquid to flow.
7. (a) freezing
   (b) sublimation
   (c) condensation
8. When the temperature of a liquid is raised high enough, that is, the particles have enough kinetic energy, they can break away from all attractive forces with all other particles. They become completely free of other particles and are in the gaseous state.
9. If the melting temperature of a substance is –40°C, the attractive forces between particles are weak. The reason is that the particles of a substance have a very low average kinetic energy at –40°C but can still break away from adjacent particles.
10. The temperature of a pure substance does not change while it is melting.
11. (a) The figures are models of solids, liquids, and gases.
    (b) In the figure on the left, particles are touching and holding on to each other and are closely packed. This represents a solid. In the central figure, particles are holding on to some particles but reaching for others. This represents a liquid. In the figure on the right, the particles are not touching

and appear to be bouncing around. This represents a gas.

(c) It might be better if it was more obvious that the particles in the solid were holding tightly to each other. Also, it might be better if each diagram had the same number of particles.

Understanding Key Ideas

12. Lego® blocks can be attached to each other in a wide variety of ways to make very complex structures. They have raised circles and posts that can snap together creating attractive forces between the blocks.
13. The golf ball that has the greatest speed has the most kinetic energy.
14. When one substance rubs against another, the friction causes the particles on the surface to gain kinetic energy, thus raising the temperature. Since the temperature goes up, rubbing can be called a "burn."
15. Both liquids and gases take on the shape of the container. It is a liquid only if it forms a surface inside the container.
16. The attractive forces between particles of mercury must be weaker than the attractive forces between the particles of any other metal.
17. The water in the glass must have been cold. As the water warmed, it expanded and spilled out of the glass.
18. Heat the outer glass by running hot water over it. The glass will probably expand just enough to slip off of the inner glass.
19. The wind probably speeded up the sublimation of the snow into water vapour.
20. You should use an aluminum container because tin melts at 232°C and aluminum melts at 660°C. At 450°C, tin would be a liquid, but the aluminum would still be a solid.
21. While water is boiling in the pot, it stays at 100°C. Since it is touching the bottom of the pot, the water removes heat from the pot, preventing it from getting hotter than 100°C. After the water in the pot boils away, the pot continues absorbing heat from the burner and gets much hotter and burns the eggs.

Pause and Reflect Answer

On a very hot summer day, the concrete expanded. The sidewalk must not have been built in a way that would allow for the expansion, and the sidewalk buckled.

CHAPTER 6 OPENER, pp. 172-173

USING THE PHOTO AND TEXT

Ask the students what they expect to happen when a strong wind is blowing and the trees are swaying. Guide them to the idea that a storm might be coming. Ask them what often happens to the temperature of the air when a storm comes. Guide them to the idea that the temperature of the air often drops significantly. A drop in temperature means that the particles of air have less kinetic energy. Since there is less kinetic energy (thermal energy), there is less heat. What happened to the heat that was in the air when the temperature was higher? How is heat transferred from one place to another or from one object to another? Let the students discuss these ideas and questions and formulate hypotheses to explain how heat can be transferred. Also, ask them to formulate a hypothesis about what makes wind blow.

USING THE WHAT YOU WILL LEARN/WHY IT IS IMPORTANT/SKILLS YOU WILL USE

Terms in the What You Will Learn feature might seem daunting to some students. Ask them what the following words mean in everyday language: "conduction," "radiation," "capacity." Discuss the idea that the same words have more precise meanings when they are applied to scientific concepts. However, learning the scientific meanings and the concepts that they are involved in have some very practical applications in everyday life. Learning these concepts will help them understand a little about weather.

USING THE FOLDABLES™ FEATURE

See the Foldables™ section of this resource.

6.1 PROCESSES OF TRANSFERRING HEAT

BACKGROUND INFORMATION

The only three mechanisms of heat transfer are conduction, convection, and radiation. Conduction and convection involve the motion of particles (atoms and molecules). In conduction, particles do not move away from their original location. They transfer energy by colliding with adjacent particles. In a system at a constant temperature, the particles are constantly colliding with one another and exchanging energy, but the average kinetic energy of the particles remains constant. If some of the particles receive energy from another source, these more energetic particles will collide with those near them and spread out the energy. Eventually, the excess energy is shared with all of the particles in the system, and the whole system is at a higher temperature.

Convection involves energetic particles moving from one place to another, carrying the energy with them. Wind is an example of convection. Convection is also the reason that "heat goes up." When the temperature of a fluid increases, it expands. The expansion causes the density to decrease. Cooler, more dense fluid is pulled downward by gravity, and it pushes less dense fluid up out of its way. Sometimes, when you look out of a window that is above a radiator that is on, you can see strange images that look like twisting motion of objects. These images are caused by light passing through air of different temperatures. The motion of the air is caused by convection currents. Warm air is rising and mixing with cool air that is dropping. Light is refracted to a different extent by cold versus warm air, and you see what looks like ripples in the air.

Radiation is the process of energy (heat) being carried by electromagnetic waves that consist only of energy and no matter. No matter is moving when energy is transferred by waves. Also, electromagnetic waves carry energy through a vacuum so no particles are needed to transfer the energy. For radiation to transfer energy to matter, the matter must absorb the waves. Light is a form of electromagnetic waves for which it is easy to see whether or not they are absorbed. Any clear object allows light to pass through, thus the energy is not absorbed. Mirrors and shiny surfaces reflect light so the energy is not absorbed. (Note that clear objects and mirrors absorb a tiny amount of the energy, but, in most circumstances, the amount absorbed is negligible.) Every type of surface except a dull, black surface reflects some light. The nature of a surface determines how much light it absorbs. The situation is similar with other forms of electromagnetic waves, such as infrared, UV, radio, and microwaves. However, each type of electromagnetic wave interacts with different types of surfaces in a unique way. For example, water transmits light but absorbs microwaves. When the surface of an object absorbs the electromagnetic waves, the particles in the object gain kinetic energy.

COMMON MISCONCEPTIONS

- When people think of waves, they nearly always think of something, such as water waves, going up and down. However, this is not always the case. Nothing is going up and down in electromagnetic waves. Certain properties of the electric and magnetic energy are getting stronger and weaker. This is a difficult concept to understand, but it is not

critical to a very basic understanding of radiation. Just emphasize that energy is being transferred through space.
- The word "conduction" is often related to electric current. There is no electric current involved in the conduction of heat. Thermal energy can be conducted as well as electric current.

ADVANCE PREPARATION

- For Activity 6-1A, the hot plate should be a laboratory hot plate and not like a stove burner. The heat should be as evenly distributed throughout the surface of the plate as possible.
- The liquid hand soap or shampoo (that appears pearly) should have a sheen to it. When it runs, you should be able to see shadowy lines that show the direction that it is flowing. An excellent brand of liquid hand soap for the activity is Softsoap™.
- Food colouring is used in several activities in this chapter. You should have at least two different colours of food colouring available.
- For Activity 6-1D, you will need items that are not typically in a laboratory stock room. For each group you will need: two, empty, clean soft drink cans; one 100 W light bulb; dark- and light-coloured cloth or paint; aluminum foil; elastic bands; and 200 mL of cooking oil.
- For Investigation 6-1E, you will need items that are not typically found in a laboratory stock room. For each group, you will need: an aquarium with a screen top; cardboard larger than the aquarium top; ice; a short, fat candle; and matches.
- For Investigation 6-1F, you will need a large, clear glass baking dish, and a block of wood that is the same height as a hot plate.
- Look through the list of BLMs for those that might be used when teaching this section."

INTRODUCING THE SECTION, pp. 174–175

Using the Text

Ask the students what the major difference is between animals such as reptiles and amphibians (frogs and lizards) compared to birds and mammals. Some might say that reptiles and amphibians are "cold blooded" and birds and mammals are "warm blooded." If no one suggests these terms or other related terms, ask them if they have heard of "cold blooded" and "warm blooded" animals. Then tell the students that the lizard like the one in Figure 6.1 can have a body temperature nearly as warm as their own even when the air temperature is near zero. Ask the students if they can figure out how that happens. Use their responses to lead into a discussion about heat from the Sun. Ask them how heat can come from the Sun, through empty space, and reach Earth and warm the lizard.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the student book and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review.

Using the Did You Know, p. 174

The Did You Know? feature will support the discussion about heat from the Sun by describing the species of lizard that can warm their bodies to as high as 30°C just from absorbing radiant energy from the Sun.

USING THE ACTIVITY

Find Out Activity 6-1A

Currents in a Pie Pan, p. 175

Purpose

- Students will observe convection currents and convection cells in a solution that is heating in a pie pan on a hot plate.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Obtain pie pans, liquid soap, and food colouring. Test the activity to find the level of heat on the hot plate that will give the best results.	For each group: – aluminum pie pan – hot plate (not a coil burner) – stirring rod – liquid hand soap (or shampoo) that has a pearly appearance – food colouring – water

Time Required

- 20–30 min

Safety Precautions

- Students should be extremely careful with the hot items. Do NOT handle the aluminum pie pans when they are hot. They can collapse and cause serious burns.
- Do not touch the electric plug with wet hands.

Expected Results

The soap solution should show many small convection cells. The hand soap should have shadowy lines that show the motion of the solution. Food colouring will enhance the lines. If the conditions are ideal, the convections cells will be hexagonal.

Activity Notes

- Students should work in groups of four.
- You might choose to do this activity as a demonstration, and let students gather around the demonstration, four at a time. You could also use the flex camera to present the images to the class as a whole.
- Be sure that the students stir the water and liquid soap mixture thoroughly but gently, so it does not have any foam.
- The solution should be very still and free of disturbances that could cause motion before turning on the hot plate.
- Be sure that the hot plates are not set so hot that the solution begins to boil.

Supporting Diverse Student Needs

- You might need to carefully point out the individual convection cells and the direction of motion of the solution to some students.

What Did You Find Out? Answers

1. The solution will form currents in which it will be rising in places and then falling in other places. It will form an “up and down” circular motion. Ideally, the circular motion will form “donuts without holes.”
2. As the bottom of the solution warmed, the warm parts became less dense and rose. The cooler solution on top was more dense and dropped to the bottom, where it began to warm. Meanwhile, the warm parts of the solution on the top would cool, and the cycle would continue.
3. When the Sun heats the surface of Earth, the air close to the surface absorbs heat from the surface. As the air becomes warm, it expands and, because it is less dense, it rises. The cooler air above then drops near to the ground and begins to warm. Convection currents just like those in the pie pan form in the air.

TEACHING THE SECTION, pp. 176–187

Using Reading

Pre-reading—Know, Want to Know, Learned (K-W-L)

Write each of the titles of the subsections on the board. Ask the students what they know about each of these topics. Summarize their comments under the headings. Then ask the students what questions come to their minds about each of the topics. Record their questions on the board. Have the students record the questions in their notebooks.

During Reading—Note-taking

Have the students look for answers to all of the questions that they recorded in the pre-reading exercise. Ask them to take notes on all of the answers that they find. Also, tell them to make notes on any items in the reading that are unexpected or surprising.

After Reading—Reflect and Evaluate

With the class, go back over the “Know” statements that you summarized and check to see if they were correct. Make special note of any statements that were not correct. Evaluate their understanding of each subtopic. In some cases, they might need a more detailed verbal explanation.

Reading Check Answers, p. 177

1. The two objects must be in contact so that the energetic particles of one object can collide with the particles in the other object.
2. Conduction occurs mostly in solids.
3. When the particles on one side of a solid are hotter (have more kinetic energy) than the particles on the other side of that same solid, the energetic particles collide with the particles right beside them, giving them more kinetic energy and thus making them hotter. These particles then collide with the particles on the other side, passing the kinetic energy on. This process occurs all the way through the solid until the heat is evenly distributed throughout the solid object.

Reading Check Answers, p. 179

1. In convection, the energetic particles themselves move from one place to another, carrying energy with them.
2. Convection cannot occur in a solid because the particles are not free to move from one place to another.
3. Some might say that wind is a form of convection. When water is heating up, convection occurs. Accept all reasonable answers.

Reading Check Answers, p. 185

1. You can make waves in water or another liquid by moving your hand up and down or back and forth. The waves will carry the energy to anything that is floating on the water and make it move. The motion is caused by kinetic energy that the object received from the water waves.
2. Electromagnetic waves can carry energy through empty space.
3. An object must absorb the waves in order to receive the energy and become warmer.

USING THE ACTIVITIES

- Activity 6-1B on page 179 of the student book is best used at the end of the subsection on convection on page 178.
- Activity 6-1C on page 182 of the student book is best used after completing the discussions on conduction, convection, and radiation.
- Activity 6-1D, the Core activity on page 184 of the student book is best used after the discussion on absorbing radiant energy.
- Activity 6-1E on page 188 of the student book is best used just after introducing convection on page 178.
- Activity 6-1F on page 189 of the student book is best used at the end of the subsection on convection.

Detailed notes on doing the activities follow.

Find Out Activity 6-1B

Displaced Drops, p. 179

Purpose

- Students observe convection currents in water.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Purchase or make ice cubes. Leave a sample of water in the classroom overnight so it will reach room temperature.	For each group: – dropper – 250 mL beaker of room-temperature water – 100 mL of coloured ice-cold water – 100 mL of coloured very hot water

Time Required

- 15–20 min

Safety Precautions

- Safety glasses should be worn throughout the activity.
- Remind students to use caution when handling the beaker of very hot water.
- The coloured water will stain clothing. Students should be careful to prevent spills.

Science Background

Cold water is more dense than room-temperature water, so it should drop down through the room-temperature water. Hot water is less dense than room-temperature water, so it should rise or remain on top of room-temperature water. The rising of warmer fluids and dropping of cooler fluids is the source of convection currents. Students will probably not fully comprehend the concept of density, so you might need to explain the concept in a different way. (It will be covered in Science 8 in the Fluids unit.) When a fluid heats, it expands and takes up more space. Each unit of space therefore contains fewer particles, and thus it is lighter. Light objects float on heavier objects.

Activity Notes

- Divide the students into groups of three or four.
- Have students draw pictures of the two beakers and illustrate the paths taken by the coloured drops of water.
- In order to get the best results, students should use only a very small drop of water from the dropper. They should not let it splash into the water in the beaker. They should let it drop from a position just barely above the surface of the water in the beaker.
- When the activity is complete, discuss the explanations of what they observed to ensure that they understand the science and do not just memorize “cold water sinks, hot water rises.”

Supporting Diverse Student Needs

- You might need to demonstrate the steps of the procedure for students with reading difficulties.

What Did You Find Out? Answers

1. Cold water is more dense than room-temperature water. Therefore, a drop of cold water is heavier than a drop of room-temperature water. Thus the cold water will sink. Most students will find that their predictions were verified.
2. As water is heated, it expands. Therefore, a drop of hot water is lighter than a drop of room-temperature water. Light things float. Most students will find that their predictions were verified.

Think About It Activity 6-1C

Energy Transfers and Home Heating Systems, p. 182

Purpose
- The students analyze the diagram of a room heated by a hot water baseboard heater.

Advance Preparation

None

Time Required
- 25–30 min

Activity Notes
- Students should work in pairs and discuss the diagram and paragraph that describes the diagram.

Supporting Diverse Student Needs
- You may need to guide Pathway 3 students through the activity, discussing each step with them.

What to Do Answers

4. The students should have listed most of the points below.
   - The fire in the burner heats the outside of the boiler tank mostly by radiation. However, conduction in the heated air will carry the heat to the boiler tank, then conduction between the hot air and the outer surface of the tank will also heat the tank.
   - Heat will be transferred through the walls of the tank by conduction.
   - The inner walls of the tank will heat the water in contact with the walls by conduction. The hot water in contact with the walls of the tank will distribute the heat throughout the entire tank of water by convection.
   - As the hot water passes through the baseboard radiator, it will heat the metal by conduction.
   - The heat will be distributed through the metal, including the fins, by conduction.
   - The hot metal will heat the air in contact with the metal by conduction. The hot air will then distribute heat throughout the room by convection.

What Did You Find Out? Answers

1. Student should say at least five places.
2. The fins on the baseboard radiator pipes create a much larger surface area of hot metal so it is in contact with much more air.
3. Hot air is less dense (each unit of hot air is lighter), therefore it rises. If radiators were at the top of a room, the heat would stay near the ceiling.
4. The air in contact with the windows is cool and will tend to drop. The rising hot air from the radiators will mix with the cool air and heat it before it moves farther into the room.
5. Even if the walls are insulated, the outside walls are still somewhat cooler than the inside walls in the winter. If you place the heaters near the outside walls, the air in contact with those cooler walls will be warmed before it gets farther into the room.

Find Out Activity 6-1D

Absorb That Energy, p. 184

(Core Lab)

Purpose
- Students determine how an object's surface characteristics affect its absorption of radiant energy.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
2 weeks before	Begin gathering, or ask students to gather, empty pop cans. You will need two cans per group.	For each group: – 2 thermometers – incandescent light bulb (at least 100 W) – ruler – 2 empty pop cans – dark- and light-coloured cloth or black and white paint – aluminum foil – 200 mL cooking oil – tape or elastic bands

Time Required
- 30–45 min

Safety Precautions
- Remind students that the light bulb will become hot so they need to be careful when they are near it.

Science Background

What we see as colour is the part of the visible spectrum that was not absorbed by an object. The colour of an object is white if no light is absorbed and it is all reflected. Black is the "colour" when all light has been absorbed. Although the absorption of infrared waves (the waves in solar radiation and radiation from light bulbs that are most responsible for transmitting heat) is not identical to absorption of visible light, it is quite similar. Therefore, black surfaces tend to absorb most infrared waves, and white surfaces tend to reflect infrared waves. Also, shiny surfaces reflect light whereas dull surfaces absorb it. Thus, dull, black surfaces will absorb much more of the energy in the infrared waves, and the absorbed energy will heat the objects much more than white or shiny surfaces.

Activity Notes

- If you use painted cans instead of dark- and light-coloured cloth, ask for student volunteers to help do the painting a few days in advance of the day of the activity.
- Ensure the lamp is directed at the side of the cans as shown in student text and not at the top.
- Plasticine or modelling clay could be used to fill in the pop can openings to prevent accidental spills.
- After each reading, the oil should be gently swirled to mix the oil and achieve a more uniform heating.
- Divide students into groups of two to four.
- At the completion of the activity, challenge students to observe and record everyday examples of dark-coloured surfaces absorbing more energy than light-coloured surfaces.
- Discuss practical applications of this knowledge.

Supporting Diverse Student Needs

- Rather than having learning challenged students decide which criteria to test, give them the cans and ask them which will get hotter.

What Did You Find Out? Answers

1. The oil in the dark-coloured and/or dull cans has a higher temperature than the oil in the light-coloured and/or shiny cans.
2. Have students compare their results. Most likely, they will agree.
3. Light-coloured and shiny cans do not absorb heat as well as dark-coloured and dull cans.
4. The actual temperature of the cans (not necessarily the differences between cans) can be affected by the distance from the light, the power of the light bulb, the air temperature, whether a breeze was blowing on the cans, or many other factors.
5. (a) The dark-coloured surface radiates energy better than the light-coloured surface and cools more quickly.
   (b) The dull surface radiates energy better than the shiny surface and cools more quickly.

Conduct an Investigation 6-1E

Blowing in the Wind, p. 188

Purpose

- Students will observe convection currents in air.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Obtain an aquarium with a screen top and a piece of cardboard larger than the aquarium top.	For one demonstration: – aquarium with screen top – 100 mL beaker – 1000 mL beaker – Petri dish – scissors – cardboard larger than aquarium lid – ice – short, fat candle – matches – paper towels – tape

Time Required

- 20–30 min

Safety Precautions

- If students handle the matches, be sure they are careful.
- The person who handles the beaker with the burning paper should wear thermal gloves.
- Long hair should be tied back when working with the matches, burning paper, or a burning candle.

Science Background

Cold air is dense and drops to the bottom of any container. The cold air will spread around the surface just like water would. If warm air is present, the cold air will move in and push the warmer air upward.

Activity Notes

- The activity is probably best done as a demonstration. You could have different students help with tasks such as cutting the hole in the cardboard, putting ice in the Petri dish, placing the ice and candle, lighting the candle (after it is placed in the aquarium), and placing the lid and cardboard on the aquarium.
- While the air in the aquarium is cooling over the ice and warming over the candle, ask the students to predict the path of the smoke.
- Be sure that all students can observe the aquarium clearly.
- Ensure that the students are patient and watch the smoke in the aquarium long enough to observe a full cycle of motion.
- After the students understand what is happening in the aquarium, discuss the way that wind is very similar to the motion of the air in the aquarium.

Supporting Diverse Student Needs

- Be sure that learning challenged students get a front row seat and give them a clear and detailed explanation of what they are seeing.

Analyze Answers

1. The smoke should be dropping over the ice, flowing from the ice to the candle, rising over the candle, and moving across the top from above the candle to above the ice.
2. The ice cools the air around it, making the air more dense (heavy) so that it stays on the bottom of the aquarium.
3. The candle heats the air around it, making the air less dense (lighter) and, consequently, the air will rise.
4. Same as #1.

Conclude and Apply Answers

5. Air is moving from the ice to the candle. On a much larger scale, wind is often moving from cooler parts of Earth's surface to warmer parts.
6. Parts of Earth's surface are warmer than other parts, similar to the candle and the ice. The air over the cooler parts of Earth's surface are dense and spread out, pushing warmer, less dense air upward. A circular convection current is occurring on Earth, but it is only the surface part of the circle that we notice as wind because we are unaware of the motion of the air high above us.

Conduct an Investigation 6-1F

Convection in Water, p. 189

Purpose

- Students observe convection currents in water.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Obtain glass baking dish (or dishes if you are letting students do the investigation in groups). The glass must be able to withstand direct heat from a hot plate. Obtain wood block(s) the same height as the hot plate that you plan to use.	For one demonstration or for each group: – hot plate – block of wood same height as hot plate – large clear-glass baking dish – water – food colouring

Time Required

- 25–30 min

Safety Precautions

- Food colouring will stain skin and clothing. Instruct students to be very careful in order to prevent spills.
- Be sure to use glass dishes that can go directly on a burner.

Science Background

Warm water is less dense than cold water. Cold water spreads out at the lowest level possible and pushes less dense, warmer water up.

Activity Notes

- This investigation is probably best done as a demonstration.
- Let the students drop the food colouring into the water. After observing the motion of the coloured water that was dropped over the hot plate, you might want to drop food colouring into the water over the wood block.
- Be sure to make observations for at least 15 min to see the complete motion of the water.

Supporting Diverse Student Needs

- Be sure that learning challenged students get a front row seat so they can clearly see the details of the demonstration. Ask them to describe to you the motion of the coloured water.

Analyze Answers

1. The coloured water moved along the top of the water toward the other end of the dish, away from the hot plate. Then it dropped down to the bottom of the dish and moved back toward the hot plate.
2. The overall motion was a long oval that was vertical in the dish.

Conclude and Apply Answers

3. As the water in the dish that was above the hot plate warmed, it expanded and became less dense (lighter). The room-temperature water in the other end of the dish was more dense (heavier) than the warm water, so it spread out across the bottom of the dish and pushed the warm water up. The warm water spread across the surface by going toward the end of the dish above the wood block. The water above the block now falls and the process continues.

USING THE FEATURE

Science Watch: Earth's Energy Budget, p. 190

Use the feature to show how the three forms of energy transfer work together and are critical to the existence of life on Earth. Go through the illustration in the first column. Point out each form of energy transfer and how it contributes to keeping Earth within the proper range of temperatures that sustain life. Refer back to the wide range of temperatures in the universe that the students learned about in Chapter 4 to re-emphasize that temperatures on Earth are in a relatively small range.

If you want to bring in global warming, discuss the fact that humans are burning more fossil fuels and releasing more carbon dioxide than Earth can store by making fossil fuels. The formation of fossil fuels takes many thousands of years.

Science Watch Answers

1. The radiation that heats the air is the infrared radiation that is emitted by Earth and water after each has absorbed solar energy. The air does not absorb light from the Sun, but solid ground and water do.
2. If Earth did not emit as much heat as it absorbs, the temperature would continue to rise indefinitely. Eventually, it would be too hot for living things to survive.
3. As the levels of carbon dioxide in the atmosphere increase, more infrared radiation from the ground is absorbed by the air and less is radiated back out to space. More energy is being absorbed by Earth than it is releasing back to space, and the temperature is rising.

SECTION 6.1 ASSESSMENT, p. 191

Check Your Understanding

Checking Concepts

1. Heat is distributed throughout a solid object by conduction.
2. In convection, the energetic (hot) particles move from one place to another. In conduction, only the energy moves. Energetic particles collide with those beside them and pass the energy on without leaving their original position.
3. In conduction, energetic (hot) particles collide with the neighbouring particles and pass energy to them. In this way, the energy moves, but the particles do not.
4. Different parts of Earth's surface are at different temperatures because they absorb different amounts of radiation from the Sun. The surface of Earth heats the air in contact with it by conduction. The warmed air distributes the heat by convection. The air over the warmer parts of the surface will become warmer and rise. Cooler air over cool parts of the surface will move under the rising warm air. This motion of the cooler air replacing the rising warmer air is wind.
5. Energy can be transferred through empty space by electromagnetic waves or radiation. The energy is in the form of electric energy and magnetic energy that needs no particles to transfer from one place to another.
6. Visible light and infrared rays are forms of electromagnetic waves.
7. When a solid object absorbs infrared rays, the energy is converted into kinetic energy of the particles.

Understanding Key Ideas

8. The air above the burning candle is very warm, so it rises up the chimney. Air is drawn down the chimney on the left to replace the air that rose, bringing the smoke with it. The smoke would then move with the air toward the candle and back up the chimney on the right.
9. The hand in the figure is not touching the hot coil on the hot plate, but the hand can feel the heat because the hot coil is emitting radiant energy. Heat is being carried from the coil to the hand by radiation. The hot coil is heating the bottom of the pot by conduction. The heat is being spread through the bottom of the pot by conduction. The inside bottom of the pot is heating the water in contact with it by conduction. The heat is being distributed throughout the water by convection.
10. Move your hand up and down, thereby making the rope move up and down. Each part of the rope causes the next part to move up and down, passing the energy along the rope. When the part of the rope to which the bell is attached moves up and down, the bell will move up and down and it will ring. The kinetic energy of your hand is being transferred by the rope to the bell. The motion of your hand creating a wave in the rope can be likened to creating electric and magnetic energy in the form of electromagnetic waves. Just as the bell is "absorbing" energy from the rope, a solid object can absorb electromagnetic energy from the electromagnetic waves.

Pause and Reflect Answer

The copper coil absorbs and conducts heat away from the flame so efficiently that it cools the air around the wick to below the kindling temperature of the wax in the wick, making the flame go out. Since the coil is open, plenty of oxygen reaches the wick, so lack of oxygen is not the reason that the flame goes out. This would be an excellent demonstration because if the coil is removed quickly enough, the flame will reappear and the candle will continue to burn.

Other Assessment Opportunities

- Look through the list of BLMs for those that might be used when teaching this section.

6.2 CONDUCTORS AND INSULATORS

BACKGROUND INFORMATION

All materials conduct heat, but some conduct heat much more efficiently than others. These materials are called conductors. Conductors typically have particles that have a great deal of freedom of movement and can carry kinetic energy from one place to another very quickly. Since the electrons in metals are quite free to move about within the material, metals are good conductors of heat. (Note: For the very same reason, metals are good conductors of electric current.)

Materials that conduct heat extremely poorly are called insulators because they inhibit the movement of heat. If there are no particles at all to collide with others and pass kinetic energy along to, this would be the ultimate insulator. For this reason, a vacuum is the best insulator.

COMMON MISCONCEPTIONS

- The terms “conductor” and “insulator” are applied to both heat and electric current. Although good conductors of heat are usually also good conductors of electric current, you cannot assume that this is always true. The same is true for insulators. Just because a certain material acts as an insulator for heat, it cannot be assumed that it is an insulator for electric current.

ADVANCE PREPARATION

- For Activity 6-2A, for each group, in addition to typical laboratory items, you will need plastic from a pen, long iron nails, and wooden craft sticks or pencils for each group.
- For Investigation 6-2B, you will need a heat conductivity apparatus that includes copper, iron, and aluminum rods. If rods of other metals are available, that would enrich the investigation. For each group, you will also need a glass rod, a long candle, and matches.
- For Investigation 6-2C, for each group, you will need six identical, empty, metal coffee cans with plastic lids. At the beginning of the term, ask the students to start collecting these coffee cans. You will also need ice cubes, foam pellets such as “peanut” foam pellets, poured insulation, plastic bubble wrap, wood shavings, aluminum foil, and sealable plastic bags.
- For Investigation 6-2D, for each group, you will need two glass jars with metal lids, wood chips, plastic bags, wool blankets or scarves, aluminum foil, newspapers, foam pellets, duct or electric tape, and string.

INTRODUCING THE SECTION, pp. 192–193

Using the Text

The student book introduces the concepts of conductors and insulators of heat by using a familiar example—touching hot pans on the stove. Discuss with the students what types of pots and pans get hot and why handles are often made of plastic. Ask why hot pads are made of cloth. Guide the discussion to the rate at which heat seems to travel through different materials.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the student book and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review.

Using the Did You Know, p. 192

Explain that when any spacecraft has been in orbit and then re-enters the atmosphere, it is moving at an extremely high speed. When the spacecraft hits the atmosphere at this speed, the friction creates tremendous amounts of heat. If the heat reached the inside of the craft, the temperatures inside the craft would be too high for the astronauts to survive. Space agencies have developed special tiles that can withstand excessive temperatures to prevent the heat from penetrating into the spacecraft. The hot tiles radiate the heat back out into space.

USING THE ACTIVIY

Find Out Activity 6-2A

The Super Stirrer, p. 193

Purpose

- Students determine which materials conduct heat the fastest and the slowest.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Gather the materials. The greater the selection, the better the results will be.	For each group: – equal-length pieces of: copper wire long iron nails wooden craft sticks (or wooden pencils) plastic from pen – very hot water
1 day before	Using the available samples, complete the activity to make sure you know the proper ranking.	

Time Required

- 15–20 min

Safety Precautions

- The water should be very hot for this activity so remind the students to handle the cup or beaker with an oven mitt.
- Safety glasses should be worn throughout this activity.

Expected Results

The copper should conduct heat the fastest. Iron will be second. The plastic and the wood will follow.

Activity Notes

- The students should work in groups of two or three.
- The test will be most accurate if the length and diameter of all of the objects are as similar as possible.
- The activity works best if the water is almost boiling hot. You might want to boil water in an electric kettle and pour it for the students and instruct them not to touch the beaker.
- Before the students carry out the test, ask them what properties a stir stick should have.
- After completing the activity, record each group's results on the board. If all groups do not agree, discuss what might have caused any disagreement.

Supporting Diverse Student Needs

- Learning challenged students might want to draw pictures of the samples and describe how quickly each one became hot.

What Did You Find Out? Answers

1. (a) Most students will probably say that stir sticks should be made of wood because it took the longest time to become hot. Depending on the size and shape of the wood and plastic, some students might say that plastic is best for a stir stick.
   (b) The bottom of a frying pan should be copper because it became hot the quickest.
   (c) The handle of a frying pan should be wood or plastic. You might mention that frying pans are likely to be put in the dishwasher. Ask them which material would hold up to being in a dishwasher many times. They will probably choose plastic.
   (d) A container for delivering pizza should be wood or plastic. (In a sense, delivery boxes are made from wood because they are paper.)
2. The particles in a conductor are more free to move and vibrate and thus collide with neighbouring particles.

TEACHING THE SECTION, pp. 194–198

Using Reading

Pre-reading—Know, Want to Know, Learned (K-W-L)

In separate discussions, ask the students what they know about cookware, home heating radiators, automobile radiators, and home insulation. Ask them to think of questions about these items that they might be able to answer when they learn more about conductors and insulators.

During Reading—Elaborative Interrogation

While the students are reading, ask them "Why" questions. For example, "what is cookware made of?" When they say copper or steel or any other metal, ask them, "Why?" Do the same for insulation. Encourage them to ask themselves "Why?" while they are reading.

After Reading—Reflect and Evaluate

After students have completed the reading, go back to the questions they created in the pre-reading exercise. Have them answer as many questions as they can.

Reading Check Answers, p. 195

1. Copper is one of the best conductors of heat. It will transfer heat to the food efficiently.
2. Metals are usually the best conductors of heat.
3. Radiators should be made of metal so that they transfer the heat efficiently from the water inside to the air. They should have a large surface area so there is a lot of air in contact with the hot metal.
4. Some possible answers are: household radiators bring heat into the home, car radiators take heat out of the car engine. Both types of radiators pump hot water through the radiator, and the large surface area of the metal releases heat into the air.

Reading Check Answers, p. 198

1. A vacuum is a good insulator because there are no particles present to collide with other particles, pick up kinetic energy from another particle, or give kinetic energy to another particle. As well, there are no particles to move from one place to another and distribute heat.
2. Air does not conduct heat well, but air can undergo convection and carry heat from one place to another by picking up heat from one place and moving to another place where it can release heat.
3. There might be places that are hard to reach with insulation in the form of batts or solid sheets, but insulation can be sprayed into these places. Also, there might be places where heat can escape very easily and extra foam could be sprayed there. The extra cost of the insulation is often recovered in reduced heating costs.
4. A single pane of glass has an R-value similar to a layer of drywall, but drywall is never the only material between the inside and outside of a wall. There are always many more layers. Glass, however, is the only layer in a window.

USING THE ACTIVITIES

- Activity 6-2B on page 199 of the student book is best used after the discussion of conductors on page 195.
- Activity 6-2C on page 200 of the student book is best used after introducing insulators on page 196.
- Activity 6-2D on page 202 of the student book is best used at the end of the section on page 198.

Detailed notes on doing the activities follow.

Conduct an Investigation 6-2B

Heat Conductivity Rate, p. 199

Purpose

- Students investigate the conduction rate of heat through various substances.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Assemble the equipment.	For each group: – Bunsen burner – 2 clamps – glass rod and metal rods of equal diameter and length – heat conductivity apparatus – 2 laboratory stands – timing device – ruler – matches – candle

Time Required

- 45–60 min

Safety Precautions

- Caution the students about working with hot candle wax. It can cause burns.
- Lighted Bunsen burners should be sitting on a desk or table and not be moved.
- Long hair should be tied back.

Science Background

Each substance has its own specific coefficient of thermal conductivity. For objects that are identical in size and shape, the coefficient of thermal conductivity will tell you the order of the rates in which the objects will conduct heat. Metals, including alloys, conduct heat most rapidly, but there is still a significant difference in thermal conductivity within metals and alloys of metals. There are many types of glass but, in general, its thermal conductivity is much lower than that of metals.

Activity Notes

- Students should work in groups of no more than four.
- If you have only one conductivity apparatus, you might want to do a demonstration more than once. Some student groups could do the comparison of metal and glass while others watched the demonstration. The groups could then switch and do the opposite part of the activity.

- Before the students observe the conductivity apparatus, have them make a table, such as the one below, so they can record their observations.

MATERIAL	TIME TO MELT WAX

Supporting Diverse Student Needs

- Observe the group(s) that includes Pathway 3 students. Point out each rod and state what material it is.

Analyze Answers

1. Transfer of heat occurs faster through metals and slower through non-metals.
2. If the materials used are those in the list, the order should be: copper, aluminum, iron, glass. Thermal conductivities of other substances can be found in chemistry handbooks and on the Internet.

Conclude and Apply Answers

3. Most students will correctly predict that metal conducts heat faster than glass. The information on the metals is in the text, but they might not connect the reading with the activity and get the metals in the wrong order.
4. You would want a fast transfer of heat for pots and pans, stove burners and oven coils, irons, hair dryers, etc. You would want slow transfer of heat in any kind of handle, oven mitts, walls, sides of refrigerators or freezers.

Conduct an Investigation 6-2C

Keep It Cool, pp. 200-201

Purpose

- Students will determine what materials make the best insulators.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Collect materials not usually found in the school. – coffee cans: ask staff/students to collect them – foam pellets and bubble wrap: these might be available free at electronics or computer stores – poured insulation: available at a local hardware store – wood shavings: check with the school's woodworking shop or local pet stores – ice cubes: buy a bag or make in ice-cube trays	For each group: – scale or balance (1 for every 2 groups) – 6 coffee cans with lids – large basin (must hold 6 coffee cans at once) – thermometer – ice cubes of similar size and shape – resealable plastic bags – paper towels – foam pellets – wood shavings – aluminum foil – poured insulation – plastic bubble wrap
2 days before	Check to see that all materials are put aside and ready for use.	

Time Required

- 45–60 min

Safety Precautions

- Use care when handling coffee cans. Some might have some sharp edges.

Science Background

Air is a good insulator when it cannot move very far and, thus, undergo convection. The best insulators will have air trapped in a very large number of very small openings. The material itself that is trapping the air should be a non-metal. Plastics and polymers are good materials for insulators.

Activity Notes

- Students should work in groups of about four.
- Supply the students with, or have them make, a data table like the one below.

INSULATION MATERIAL	ICE CUBE		
	INITIAL MASS (g)	FINAL MASS (g)	MASS LOST (g)
wood shavings			
foam pellets			
bubble wrap			
poured insulation			
aluminum foil			
empty can			

- Tell the students to be sure to label the sealable bags clearly so that when they remove them, it will be clear as to which can the bags were in.
- If it isn't possible to collect enough identical coffee cans, it might be necessary to use alternative containers. It is critical, however, that all six containers used by any one group are the same.
- The cans are likely to float in the water bath in the basin. In these cases, put something heavy such as a book or piece of wood on top of the cans.
- Start directly into the investigation at the beginning of class. When the cans are sitting in the water bath, there will be a 30 min wait. Have class discussions on topics such as the following:
  – the meaning of R-value
  – review the meaning of dependent, independent, and controlled variables such as:
    - amount of insulation
    - the way the insulation is packed
    - where the ice cube is placed in the can; is it surrounded by insulation?
    - the position of the can in the water bath
- Alternatively, since the investigation might take longer than one class period, you might have the students prepare the cans with everything but the ice cubes, during one class, and then continue the investigation during the next class."

Supporting Diverse Student Needs

- Be sure that learning challenged students are in a group with a student leader who will help them and make them a part of the process.

Analyze Answers

1. The ice in the control (empty) can should melt the most. Usually, the ice in the can with the poured insulation or foam pellets should melt the least. This will, of course, depend on how the packing was done.
2. Many students will say it is the one in which the ice melted the least (answer to #1). However, some students might take into consideration availability, cost, ease of obtaining, packing, etc., to choose an answer.
3. The "empty can" is not a valid answer because it was the control that had no insulation. Most likely, the answer will be the aluminum foil.

Conclude and Apply Answers

4. Students will most likely say the poured insulation or foam pellets.
5. This answer should include items about ease of obtaining insulation, ease of carrying, or minimizing the cost.

Conduct an Investigation 6-2D

When You're Hot…., p. 202

Purpose

- Students use their knowledge of heat transfer and insulators to design and make an insulated jar.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Begin collecting materials. Ask students/colleagues to help find materials.	For each group: – plastic bags – wool blankets or scarves – aluminum foil – newspapers – foam pellets – duct or electricians' tape – string
1 day before	Organize and set up materials in the lab.	

Time Required

- 40–60 min

Safety Precautions

- Caution students to be careful when working with very hot liquids.

Science Background

Insulators resist the transfer of heat in any direction. The insulators that prevent heat from getting into a container also prevent it from getting out of a container. As discussed in the previous investigation, air is a good insulator when it cannot move very far and, thus, undergo convection. The best insulators will have air trapped in a very large number of very small openings. The material itself that is trapping the air should be a non-metal. Plastics and polymers are good materials for insulators.

Activity Notes

- The size of the jars should be limited to a size that would be practical to carry as a thermos.
- Students should work in pairs.
- The two jars that any pair of students use should be as nearly identical as possible.
- Students should submit their labelled diagrams and explanations of insulation properties before building and testing.
- If the activity is done early in the day, the procedure for measuring the temperatures four hours later, as described in the student book,will be practical. However, if the activity is done late in the day, it might be best for students to design and build their container in one day. The next day, the teacher could pour the hot water in all of the jars, measure the temperatures, and seal the jars four hours before class. Then the students could measure the final temperatures in class.

- Consider having students present their jars to the class and describe one good feature and one poor feature of their jar.

Supporting Diverse Student Needs

- Some students might not know what a Thermos® jug is. Bring one to class and discuss it before students embark on their projects.

Evaluate Answers

1. Answers will depend on the success of the individual students' results.
2. Some students might say that the insulation must be secured better because it started to come apart. Some students might say that the lid needed better insulation.

USING THE FEATURES

Career Connect: Ask an Expert, p. 203

This feature offers an opportunity to discuss the idea that insulation must be appropriate for the task. Poured insulation or foam pellets might be very good insulators, but they would not be practical for a sleeping bag. Discuss appropriate insulators for other applications such as refrigerators and stoves that involve electric current or burning fuel.

Ask students to think of other careers that require knowledge about insulators.

www science: Animal Insulation, p. 204

This feature might appeal to students who are more interested in living things than artificial objects. Some students might want to learn more about each of the animals. They could do this as a project. Also, ask the students if they can think of any other animals that have unique methods for coping with very cold weather. How did early humans who lived in the arctic insulate their bodies?

You might also ask the students if they have seen the movie *March of the Penguins.* This movie shows one of the greatest challenges to living creatures surviving in the cold.

SECTION 6.2 ASSESSMENT, p.205

Check Your Understanding Answers

Checking Concepts

1. Plastic is a good insulator and will not transmit the heat from the hot pan to the cook's hand.
2. Copper and aluminum both react with chemicals in some food and contaminate the food. Stainless steel is not as good a heat conductor as aluminum or copper, but it does not react with food and, therefore, is safe to use in contact with food.
3. The purpose of radiators is to transmit heat to the room. Metals are much better heat conductors than non-metals so they will conduct the heat from the hot water (or electric element) inside the radiator to the air in the room.
4. A car radiator removes heat from the engine and releases it to the outside air.
5. A Thermos® bottle has a plastic outer container to hold and protect the inner glass lining. The glass is a double walled vessel with a vacuum sealed between the two glass walls. The walls are also silvered to reflect away any possible radiant heat. A plastic or rubber top seals the opening inside the glass where hot or cold liquids are held.
6. All forms of home insulation have tiny pockets of air trapped all through the material. It is this air that provides the best insulating properties.
7. Windows can contain two layers of glass with a layer of air or other gas sealed in between the layers. The trapped layer of air acts as an insulator.
8. The R-value tells you how well the material resists the transfer of heat.

Understanding Key Ideas

9. The best conductors will allow the heat in the rods to be rapidly transferred into the cold liquid nitrogen. The rod becomes extremely cold very rapidly. Because the rod is cold, moisture from the air deposits on it, making frost. The rod with the most frost (upper right) is the best conductor of heat. As the thermal conductivity decreases, the amount of frost decreases. The rod with the least amount of frost (centre left) is the poorest conductor of heat.
10. The R-value would be 9.36.
11. While in the oven, all items will be at the same temperature. When you take them out of the oven, the metal pan will cool the quickest because it will conduct heat away fastest. The glass will remain hot longer. If you do not remove the cake from the glass baking dish immediately after taking it out of the over, the glass dish might stay hot long enough to burn the cake.

Pause and Reflect Answer

One possible design might be a cardboard box lined with pieces of poured foam. It is quite possible to have the solid foam around the house because so many items are packed in it. You might also line the inside with aluminum foil. Accept all reasonable answers.

Other Assessment Opportunities

- Look through the list of BLMs for those that might be used when teaching this section."

6.3 TEMPERATURE VERSUS HEAT

BACKGROUND INFORMATION

The difference between temperature and heat is sometimes confusing. As was explained in Chapter 5, temperature is a measure of the *average* kinetic energy of the particles of a substance. The average of two sets of data can be the same even if the data sets are of different sizes. The average kinetic energy of the particles, and thus the temperature, can be the same if there is one gram of a substance or one tonne. However, the total energy does depend on the amount of substance present.

For example, it takes a lot more heat to bring the temperature of a bathtub full of water up to 30ºC than it does a cup of water.

The amount of heat necessary to raise the temperature of 1 g of one substance by 1ºC is also different than the amount of heat necessary to raise the temperature of 1 g of a different substance by 1ºC. The heat added to a substance is used for more than just raising the kinetic energy of the particles. Some of the energy from the heat is used for increasing the vibrations within particles (molecules) and rotation of particles. Since the nature of particles of different substances is different, the amount of energy that is used for vibrations and rotations is different also. The only way to determine how much heat is required to raise the temperature of 1 g of a given substance by 1ºC is to measure it experimentally. The amount of heat required to raise the temperature of 1 g of a given substance by 1ºC is called the specific heat capacity of the substance. Water has an exceptionally high specific heat capacity. This property of water has a great influence on weather and climate on Earth.

COMMON MISCONCEPTIONS

- Many people think that the temperature of an object is a measure of the amount of "heat" in an object. However, when heat enters an object or substance, the energy is used in a variety of ways. It goes into vibrations and rotations of particles or into breaking bonds between particles. It is important to emphasize that temperature is directly related to only one property of particles — the kinetic energy of the particles. It is not related to any of the other forms of energy contained in an object.

ADVANCE PREPARATION

- For Activity 6-3A, in addition to typical laboratory items, you will need vegetable oil and alcohol.
- For Investigation 6-3B, in addition to typical laboratory items, you will need paraffin oil, mineral oil, or motor oil. You will also need glass marbles, sand, steel shot, and vegetable oil.
- Look through the list of BLMs for those that might be used when teaching this section.

INTRODUCING THE SECTION, pp. 206–207

Using the Text

The significance of this introductory text is that large bodies of water moderate the temperatures of the region. To emphasize the contrasting temperatures, you might make another comparison. For example, the average high and low temperatures in Regina, Saskatchewan in January are –10ºC and –22ºC, and in July they are 26ºC and 11ºC. In Vancouver, British Columbia in January, the average high and low temperatures are 6ºC and 0ºC. In July, they are 22ºC and 13ºC. The winters are colder and the summers are warmer in Regina, in the prairies than in Vancouver, on the coast. The students should recognize the importance of the properties of water and heat.

Using the Key Terms and Section Summary

At the beginning of each section in the student book are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the terms listed in the Key Terms by scanning the student book and using the glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are useful for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review.

Using the Did You Know, p. 206

The Gulf Stream and its related ocean currents are a striking example of the ability of water to transfer heat. The equatorial currents absorb heat from the Sun and combine with other currents in the Gulf of Mexico to create the Gulf Stream. The Gulf Stream carries the heat to northern Europe where it is called the North Atlantic Drift. The heat from the Gulf Stream makes northern Europe much warmer than other parts of the world at the same latitude. For example, Calgary, Alberta and London, England are at the same latitude; the average temperature in Calgary in January is –9ºC. In London it is +4ºC.

USING THE ACTIVITY

Find Out Activity 6-3A

Mix It Up, p. 207

Purpose

- The students will discover that when water is mixed with other liquids, the original temperature of the water has a greater effect on the final temperature than does the temperature of the other liquid.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Obtain vegetable oil and check to be sure that the other materials are available.	For each group: – 3 (50 mL) beakers – 25 mL graduated cylinder – laboratory thermometer – stirring rod – ice water – room-temperature water – room-temperature alcohol – room-temperature vegetable oil
1 day before	Leave water, alcohol, and vegetable oil out in the lab so they are all at room temperature when it is time to carry out the activity.	

Time Required

- 20–30 min

Safety Precautions

- Use care when handling the alcohol.

Expected Results

Water has a higher specific heat capacity than does alcohol or vegetable oil. Therefore, when equal volumes of water and either the alcohol or oil, are combined, the final temperature of the mixture will be closer to that of the original temperature of the water. The temperature of the water has a greater influence on the final temperature than alcohol and oil. The effect will be greater with oil than with alcohol.

Activity Notes

- The students should work in pairs.
- The 20 mL volumes need to be measured accurately to get good results.
- The students should NOT stir with the thermometers.
- When measuring the temperature of the solutions, the thermometers should not touch the side or bottom of the beaker.

Supporting Diverse Student Needs

- Some of the students might not understand what they are measuring. Tell them that they are checking to see if the final temperature is exactly in the middle of the two liquids that were mixed or if the final temperature is nearer to one of the original liquids.

What Did You Find Out? Answers

1. The final solution with the highest temperature was the water. The next was the mixture of alcohol and water, and the mixture of oil and water was last.
2. This implies that the water has a greater effect on temperature than does the alcohol or vegetable oil. The water must have contributed more heat to the solutions than the alcohol or the vegetable oil.

TEACHING THE SECTION, pp. 206–211

Using Reading

Pre-reading—Key Word Concept Maps

There are some new terms in this section as well as some everyday words used in technical ways. Have the students write the terms "kinetic energy of particles," "average kinetic energy," "sum of the kinetic energies," "temperature," and "heat." Have them use a concept map to predict how these terms are related.

Have the students write the terms "specific," "heat," and "capacity," and write the meanings in everyday terms. Then, as they read, they should find out how the terms fit together.

During Reading—GIST (general idea)

As the students read the section, they should get the GIST of the relationships between:

- average kinetic energy and temperature
- sum of kinetic energies and heat
- specific heat capacity and temperature increase

- large bodies of water and climate

After Reading—Reflect and Evaluate

When the students have completed their reading of the section, have them reflect on their original concept map and evaluate how well it fit with what they learned while reading the section.

Reading Check Answers, p. 211

1. The specific heat capacity of a substance is the amount of heat that is required to raise 1.0 g of the substance by 1.0ºC.
2. If you combined four samples of water that each had a temperature of 4ºC, the final temperature would be 4ºC and not 16ºC because temperature is related to the *average* kinetic energy of the particles of the water. Since the temperature in each sample was 4ºC, the average kinetic energies in each sample were the same. When you combine samples for which the averages are the same, the final average will be the same as the original averages of each sample.
3. The kinetic energy of the particles influences both heat and temperature of a substance. However, it is the *average* kinetic energy that influences the temperature and the *sum* of all of the kinetic energies that influences the amount of heat in the substance.
4. Heat is related to the SUM of the kinetic energies of the particles in a substance, and temperature is related to the AVERAGE of the kinetic energies of the particles in a substance.

USING THE ACTIVITY

- Activity 6-3B on page 212 of the student book is best used after the discussion of absorbing and losing heat on page 209.

Detailed notes on doing the activity follow.

Conduct an Investigation 6-3B

Keeping it Cool, pp. 212-213

Purpose

- Students investigate whether liquids and solids absorb thermal energy at the same rate.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Obtain any materials not available at school: motor oil (or alternative), vegetable oil, marbles, steel shot. (Shot is available in hardware stores.)	For each group: – hot plate – 500 mL beakers – graduated cylinder – thermometer – retort stand – thermometer clamp – stopwatch – balance and masses – stir sticks
1 day before	Set aside a container of water (500 mL per group) to be at room temperature when the investigation begins. Assemble equipment for groups and set it out. Set up a station for pouring oil.	– room-temperature water – 250 mL oil (mineral oil, paraffin, or motor oil) – 250 mL vegetable oil – glass marbles – sand – steel shot – oven mitts – masking tape

Time Required

- 45–60 min

Safety Precautions

- Handle all containers of hot substances with care.
- Inform students of first aid procedures. If hot oil or water touches their skin, they should hold the burned area under a stream of cold water for several minutes and have a fellow student inform you at once of the incident.
- Wash hands thoroughly at the end of the investigation.
- Explain to the students that hot oil sticks to skin. Use extreme caution!
- Caution students and post a sign to the effect that *oil is not to be heated above 60ºC.*
- Explain that hot oil droplets on a burner can ignite.
- Introduce the oil-pouring station.

Science Background

The intent of this investigation is to demonstrate the difference in specific heat capacities of different liquids and solids. The variables are temperature and amounts of heat. However, it is not possible to directly measure the amount of heat that enters a substance. Therefore, it is necessary to assume that the same amount of heat enters the material during equal units of time while the material is sitting on a hot plate. By making this assumption, you can use time as a variable. This assumption is not totally correct, but it is close enough to allow the student to determine which materials have higher or lower specific heat capacities.

Activity Notes

- Students should work in pairs for this investigation.
- Handling oils can be messy. Therefore, it is best to keep the mess in one place by having a pouring station for oils. Spread plastic sheets or newspapers in the oil-pouring area.
- The procedure described in the textbook, in which the hot plates are cold when the timing begins, makes handling of materials less difficult. However, it adds tremendously to the time required. As well, the time during which the hot plates warm up adds a significant amount of error to the measurements. It would be more accurate and take much less time if the hot plates were warmed before the beakers were placed on them. If you choose to do the investigation this way, you need to caution the students to use extreme care when assembling the set up and when removing the beakers from the hot plates. Watch the students very closely as they handle their beakers.
- Clamping the thermometers to retort stands ahead of time will prevent students from using them as stirring sticks.

Supporting Diverse Student Needs

- Students with any type of disability should be paired with a very responsible partner or you should work directly with them.

Analyze Answers

Part 1

1. Water took much more time to increase in temperature by 30ºC.
2. The two types of oil took about the same time to increase in temperature by 30ºC and much less time than the water. The properties of the oils are very similar.

Part 2

3. The glass and sand took much more time to increase in temperature by 30ºC.
4. Glass and sand took about the same time to increase in temperature by 30ºC. Glass is made out of sand. Although they look quite different, they are very similar chemically.

Conclude and Apply Answers

5. (a) Yes, some types of materials require much more heat than others to increase in temperature by the same amount.
   (b) The amount of time is the information that gives the answer. For every minute a sample remains on the hot plate, more heat enters the material. Therefore, if it takes longer for the temperature of a material to increase in temperature by a certain amount, it means that more heat was required to cause that increase in temperature.

USING THE FEATURE

www science: Sea and Land Breezes, p. 214

Many different topics that the students have learned about are demonstrated by sea breezes and land breezes. You might suggest that students look for references to the different topics as they read the article. You might give them hints by telling them to look for effects of conduction, convection, and radiation; specific heat capacity of water versus land; the expansion of substances (air) with an increase in temperature; and warm air rising and cool air moving below the warm air.

SECTION 6.3 ASSESSMENT, p. 215

Check Your Understanding Answers

Checking Concepts

1. You would expect Regina to be warmer in the summer and cooler in the winter than Vancouver because Vancouver is on the ocean and large bodies of water absorb and release heat, preventing large changes in temperature.
2. The average kinetic energy of the particles in a substance is related to the temperature of the substance.
3. The sum of the kinetic energies of all of the particles in a substance is related to the amount of heat in the substance.
4. Heat depends on the amount of a substance but temperature does not.
5. The iron would have the greatest change in temperature. It takes less heat to increase the temperature of iron by 1ºC so a given amount of heat would raise the temperature more than it would for aluminum, which requires more heat to cause an increase in temperature by 1ºC.
6. Water has a higher specific heat capacity than soil. Sunlight penetrates further into water, thus spreading the heat around to a larger amount of water.

Understanding Key Ideas

7. (a) Beaker B requires more heat to achieve the stated results.
   (b) Beaker B requires more heat to achieve the stated results.

(c) Beaker A requires more heat to achieve the stated results.

8. A certain amount of water can absorb much more heat than vegetable oil for the same increase in temperature.
9. Sand has a much lower specific heat capacity than water so it heats up much more than water when the same amount of sunlight is absorbed. When there is no sunlight, the temperature of sand drops more than the temperature of water when both materials give off the same amount of heat.
10. (a) A possible answer would be that the milk bottle has a larger capacity than the glass. Accept all reasonable answers.
    (b) A possible answer would be that the specific heat capacities of metals are much lower than the specific heat capacity of water. Accept all reasonable answers.
    (c) In everyday language, you usually think of capacity in terms of volume. For example, how much liquid a container can hold. The word “capacity” in “specific heat capacity” refers to an amount of energy that cannot be measured in terms of a volume or amount of mass or any of the tangible units of measurement.

Pause and Reflect Answer

The heat would first be absorbed by the water in heating it to the boiling point and then the temperature would not change as the liquid water turns into water vapour. This would prevent a lot of the heat from going directly into the skin on the feet.

Other Assessment Opportunities

- Look through the list of BLMs for those that might be used when teaching this section."

CHAPTER 6 ASSESSMENT, pp. 216-217

PREPARE YOUR OWN SUMMARY

Student summaries should incorporate the following main ideas:

1. Conduction, Convection, and Radiation
   - Conduction is the process of heat transfer in which particles with a large amount of kinetic energy collide with neighbouring particles and pass some kinetic energy to them.
   - Convection is the process of heat transfer in which particles with a large amount of kinetic energy move from one place to another carrying the energy, and thus heat, with them.
   - Radiation is the process of heat transfer in which energy is carried from one place to another by electromagnetic waves.
2. Wind and Convection
   - Wind is a form of convection current.
   - Wind is caused by uneven heating of Earth’s surface.
   - Where the surface is warm, air becomes warmer and rises. Cool air flows in and replaces the warm air.
3. Waves and Radiation
   - Radiation is the transfer of heat from one place to another, carried by electromagnetic waves.
   - All waves transfer energy.
   - Electromagnetic waves do not need matter to carry energy.
   - For an object to receive heat from an electromagnetic wave, the object must interact with the wave and absorb the energy.
4. Thermal Conductivity
   - All materials conduct heat, but some do so with much more efficiency than others.
   - The thermal conductivity of a substance indicates how well it conducts heat.
   - Metals are, in general, the best heat conductors.
5. Insulators
   - Insulators conduct heat extremely poorly.
   - A vacuum is the best insulator.
   - Air is an excellent insulator if it is trapped and cannot undergo convection.
6. Specific Heat Capacity
   - Different materials require different amounts of heat to increase their temperature by the same amount.
   - The specific heat capacity of a substance is the amount of heat required to increase the temperature of one gram of the substance by one degree Celsius.
   - Water has a large specific heat capacity.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. (a) Radiation: In the “wave,” each individual in the crowd stands up and puts their hands up, then sits back down. Their motion is up and down, but the individuals never leave their seat. From a distance, however, the motion appears to move around the stadium. This resembles wave motion.

(b) Conduction: The falling motion, or kinetic energy, of each domino causes it to collide with the next domino, giving it kinetic energy. The sequence of the dominos, however, does not change. Each one is still beside those that it was beside originally.

(c) Convection: When each skier is at the top of the hill, he or she moves down the hill with kinetic energy. Each individual carries that kinetic energy with them.

2. Radiation: When lizards bask in the Sun, they absorb the radiant energy from the Sun, and it causes their body temperature to rise to a temperature well above that of the surrounding air.
3. The coffee in the shiny metal cup will stay warm longer because a shiny surface does not radiate heat as well as a dull, black surface.
4. Metals conduct heat efficiently, whereas most non-metals are good insulators. The non-metals prevent the heat from the pan from being transferred to the hand of the cook.
5. (a) There is only one layer of materials in windows, and it (glass) has a low R-value, whereas walls have many layers of materials, including insulation. Doors are thinner than a wall and often contain air that is not trapped in small spaces.

   (b) Windows can be made of two panes of glass with air sealed between the panes. Not only does this double the amount of glass in a window, but the air also acts as an insulator. Insulation can be added to the inside of some doors.
6. (a) You would use a wooden spoon. The plastic spoon might begin to melt.

   (b) You would be preventing conduction because a metal spoon would transmit the heat to your hand by conduction very efficiently. Wood is a reasonably good insulator.
7. Temperature is directly related to the *average* kinetic energy of the particles of a substance, and heat is directly related to the *sum* of the kinetic energies of the particles of a substance.
8. The wood shavings have many pockets of air trapped in between them, whereas there is almost no air in the solid wood. Air is a better insulator than wood.
9. The copper pot heats more quickly because copper conducts heat more rapidly than iron.

Understanding Key Ideas

10. (a) No, convection cannot occur in solids because, in order for convection to occur, particles of the substance must move from one place to another.

    (b) Conduction can and does occur in liquids because particles are always colliding with each other and transferring kinetic energy. However, convection will be occurring at the same time and is more effective in transferring heat in liquids.
11. Many students will probably suggest something similar to Investigation 6-1E, Blowing in the Wind. To avoid using smoke and fire, they might suggest using a lightweight string or yarn between the ice and the candle. Accept all reasonable answers.
12. (a) Your hand would feel heat due to convection.

    (b) Your hand would feel heat due to radiation.

    (c) Your hand would feel heat due to conduction.
13. Edmonton, Alberta is on the prairies and Amsterdam, the Netherlands is nearly surrounded by the ocean. As well, the Gulf Stream/North Atlantic Drift current brings heat from the equator to the waters of the ocean near Amsterdam.
14. More insulation is put in attics because warm air expands and rises. More heat is likely to escape through the ceiling than the walls.
15. (a) The foil on the outside reflects heat back to where it came from by radiation. The vacuum in the cells in the foam prevents heat loss by conduction. Since there are no particles that can move from one place to another, the vacuum also prevents heat loss by convection.

    (b) If the foil became torn, air would get back into the foam and the R-value would drop.
16. Limestone has the larger specific heat capacity because it would take more heat to raise the temperature of the limestone to the same extent as the granite.

Pause and Reflect Answer

Yes, sitting a metal spoon in a cup of coffee would help it to cool faster. The metal spoon would conduct heat out of the coffee into the handle of the spoon. The handle would transfer heat to the air by radiation and by conduction with the air that is touching the handle. Then that warmed air would carry the heat away by convection.

UNIT 2 ASSESSMENT

PROJECT

Water Heater, p. 220

Purpose

- The students will use their knowledge of heat transfer and insulation to design and build a candle-powered water heater.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 month before	Begin to collect nonflammable containers, fasteners, and insulation. Ask students to begin to do the same.	For each group: – thermometer – birthday candle – 100 mL room-temperature water – nonflammable containers, fasteners, and insulation – matches
2 days before	Remind students to bring in the nonflammable materials that they have collected.	

Time Required

- 120–200 min
  – Steps 1 and 2: 40–60 min
  – Step 3: 50–90 min
  – Step 4: 30–50 min

Note: This project could take large amounts of construction time and storage space. Consider allowing after-school time to complete the construction. Be sure that you have a secure area in which to store the works-in-progress, especially if several classes use the same room.

Safety Precautions

- Be sure that all materials are nonflammable.
- Safety glasses must be worn at all times during the project.
- Review, with the class, the safety precautions required when working with an open flame.
- The apparatus will be hot during and after heating. Remind students to handle it with care.

Science Background

Review background information sections for heat transfer and for insulators.

Activity Notes

- Short, fat tea light candles could be used instead of birthday candles because they do not need a holder and are more stable.
- Ideas for nonflammable materials include tin cans, such as tuna cans or soup cans; aluminum foil; foil tart pans; or baby food jars.
- Groups of four students might work best for this project.
- Discuss the Criteria with the students.
- Remind students to keep records of the initial and final temperatures of the water in their final demonstration for their reports.
- If you have a large number of groups and a complete demonstration would take too much time, have each group show and describe their device. Then, have each group measure the temperature of their water. Have all groups ready to light their candle. Give the students a signal to go and start timing. After three minutes, tell everyone to blow out the candle and measure the final temperature of their water. Have students submit their data.

Supporting Diverse Student Needs

- Pathway 3 students might need a more detailed explanation than the other students.

Report Out Answers

1. You may choose whether to have demonstrations or have students submit reports.
2. Accept all reasonable answers.
3. Accept all reasonable answers.

Other Assessment Opportunities

- Look through the list of BLMs for those that might be used when teaching this section.

INTEGRATED RESEARCH INVESTIGATION

Building Codes and Insulation, p. 221

Purpose

- Students develop research skills by searching for building codes involving insulation in their local area.

Advanced Preparation

- When you first begin to study insulation, tell students about the project and encourage them to start gathering information.

Activity Notes

- If possible, bring in a local contractor to speak to the class and guide them to sources of building codes.
- Discuss different presentation formats with the students.
- The Internet has many resources for information about insulation. Students may start their search at www.discoveringscience.ca.

Supporting Diverse Student Needs

- Pathway 3 students will probably need more detailed explanations about the Research Investigation than other students.
- Students with weak language skills should be paired with students who have strong language skills.

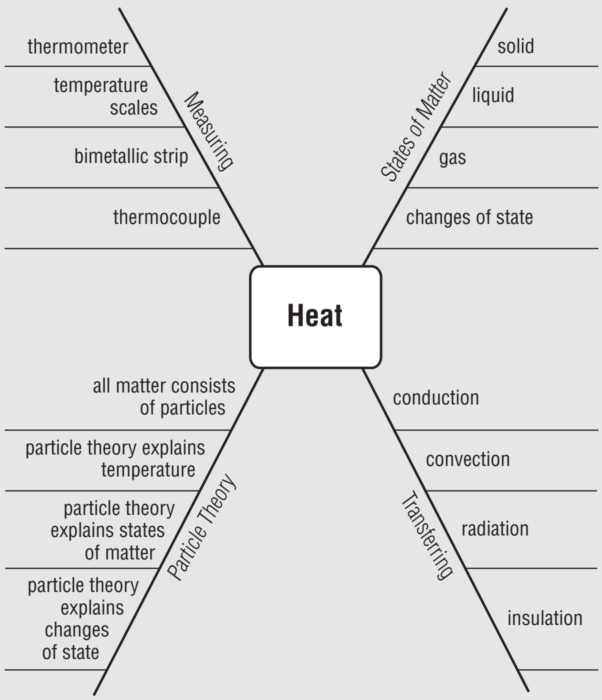
Other Assessment Opportunities

- Look through the list of BLMs for those that might be used when teaching this section."

UNIT 2 REVIEW ANSWERS, PP. 222–225

Visualizing Key Ideas

1.



Using Key Terms

2. (a) False: The Celsius scale is defined to make the freezing point of water equal to 0ºC. OR The Kelvin scale is defined to make absolute zero equal to 0 K.
   (b) False: Body temperature is 37ºC. OR Comfortable room temperature is between 20ºC and 23ºC.
   (c) False: Zero degrees on the Fahrenheit scale is the coldest temperature that Fahrenheit could produce in the laboratory in a mixture of ice, water, and salt. OR Zero degrees on the Celsius scale is the freezing point of water.
   (d) True.
   (e) False: Condensation is the reverse process of evaporation. OR Deposition is the reverse process of sublimation.
   (f) False: Thermal contraction occurs when the temperature of an object decreases. OR Thermal expansion occurs when the temperature of an object increases.
   (g) True.
   (h) False: Wind is a form of convection.
   (i) True.
   (j) False: The specific heat capacity of a substance is the amount of heat required to raise the temperature of 1.0 g of the substance by 1.0ºC.

Checking Concepts

3. (d)
4. The following are possible answers:
   (a) 18ºC
   (b) 40ºC
   (c) 22ºC
   (d) 40ºC
5. A thermoscope does not have a numerical scale, whereas a thermometer does.
6. A temperature of 273.15 K is 0.00ºC.
7. To calibrate a thermometer means to experimentally find at least two points on the thermometer when it is exposed to two substances that have a known temperatures and then use those points to complete the temperature scale. The known temperatures are often 0ºC, which is the freezing point of water and 100ºC, which is the boiling point of water.
8. A bimetallic strip bends when its temperature changes. They are used in thermostats.
9. The kinetic energy of an object is determined by its mass and speed.
10. If the temperature of an object increases, the *average* kinetic energy of its particles increases.
11. Solids have a fixed shape. Liquids assume the shape of the container and form a surface inside the container. Gases assume the shape of the container and fill the container.
12. According to particle theory, the attractive forces between particles in a solid are so strong that the kinetic energy of the particles cannot pull them apart. In a liquid, the particles have enough kinetic energy for one particle to pull away from the others, but new attractive forces form immediately with nearby particles.
13. When gases are heated, the kinetic energy of the particles increases. The particles then collide with each other and with the walls of the container more frequently and harder. If the walls are flexible, they will move out as a result of the increased force and frequency of the collisions.
14. If a solid such as steel or concrete expands even a few millimetres, it can cause bending of the steel or cracking of the concrete, making the structure unstable.

15. Pure water cannot be used as a coolant in a car radiator because it freezes at 0°C and temperatures in Canada always go below freezing in the winter. Radiators and even engines would be cracked if the coolant froze.
16. Sublimation is the change in state from a solid directly to a gas.
17. If a substance has very high melting and boiling points, it means that the bonds between particles are very strong.
18. When particles absorb heat, their kinetic energy increases. Then they collide with neighbouring particles more frequently and with a greater force. When they collide, they pass some of their kinetic energy to the particle with which they collided. This process continues and conducts heat throughout a solid.
19. When gases and liquids are heated, they expand and the particles spread out. The number of particles in a given volume decreases, thus that unit volume is lighter than it was before. Gravity pulls down the heavier parts of the gas or liquid, which then push up the lighter parts of the gas or liquid.
20. Convection cannot occur in solids because, in convection, particles must move from one place to another. Particles are fixed in place in a solid.
21. Electromagnetic waves carry energy through empty space.
22. When an object absorbs radiant energy, the particles have an increase in kinetic energy.
23. Two possibilities are: an iron or, an electric frying pan. Accept all reasonable answers.
24. Radiators used in hot-water heating in homes must efficiently conduct heat from the water to the air, so they must be made of a good conductor. This is typically a metal. The metal must have a large surface area so it is touching the air over a large area.
25. A vacuum is a good insulator because there are no particles that can carry out conduction or convection.
26. Heat is related to the *sum* of the kinetic energies of the particles, and temperature is related to the *average* kinetic energy of the particles.
27. Water has a much larger specific heat capacity than soil, so a given amount of heat will cause a greater increase in temperature of the soil in the ground than it will to water. Also, sunlight penetrates deeper into water than it does into the ground. The energy of the sunlight is spread around to more water than it is to soil in the ground. Also, any motion will mix surface water with water at lower depths and thus spread the heat to an even larger volume of water.

Understanding Key Ideas

28. Some items that might have thermostats are coffee makers, toaster ovens, stove burners, and dishwashers. Accept all reasonable answers.
29. Possible answers include:
    (a) Students might walk around in random directions very slowly, looking very weary.
    (b) Some students might be running or jumping rapidly. These students might bump (gently) into students who are walking very slowly and then that student would start running or jumping.
    (c) Students would all be running and jumping around very rapidly.
30. (a) Only the particles with the highest speeds can escape from the surface of the drop.
    (b) The particles with slower speeds remain in the water droplet.
    (c) As the higher speed (energy) particles leave the drop, the average kinetic energy of the remaining particles is lower. Therefore the temperature of the water in the droplet is lower.
    (d) The change of state of the water is evaporation.
31. (a) If you cool carbon dioxide down to below –78.5°C, it will become a solid.
    (b) No. If you heat solid carbon dioxide up above –78.5°C, it will become a gas. (At standard atmospheric pressure, carbon dioxide is never a liquid. It can only become a liquid under much higher pressures.)
32. In hot water, the particles are farther apart than they are in cold water. Therefore, a specific volume of hot water has fewer particles than the same volume of cold water and each unit of volume of hot water is lighter than that of cold water. As a result, the lighter hot water will float on the heavier cold water.

Thinking Critically

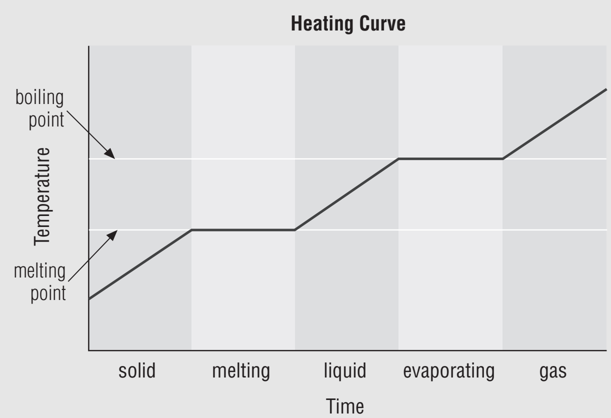
33. (a) No, sand is not a liquid.
    (b) Each grain of sand is a piece of a solid with a very large number of particles attached together by very strong attractive forces. Each grain of sand can move past other

grains of sand, but it is the same idea as a box of tennis balls being dumped into another box. To be a liquid, each individual particle must be able to move past every other particle.

34. (a) A bimetallic strip (coil) would be best because something has to move to turn a switch on and off.
 (b) A bimetallic strip (coil) that is attached to a pen that writes on a chart. When the temperature changes, the coil moves and causes the pen to move while it is writing on a chart.
 (c) An infrared detector could detect the heat of a forest fire from a long distance away.
 (d) A thermocouple would be best because it can withstand much higher temperatures than other types of thermometers.
 (e) An infrared detector could detect the heat in the wheel bearings of a train when it passed.
 (f) A bimetallic strip (coil) as described in (b).
35. When the temperature dropped in the winter, the wires would undergo thermal contraction and the lines would move up. If the lines were installed in the summer and were pulled tightly between power poles, there would be no room for them to contract. In the winter, when the wire in the lines underwent thermal contraction, the lines might break.
36. When an aerosol can is used up, the gas in the can is at the same pressure as the outside of the can. If an aerosol can was heated, the gas in the can would try to expand. Because it is sealed, the can could not expand and the gas particles would collide with the sides harder and harder and much more frequently. If the can got too hot, it would explode.
37. If the glass in the window is extremely cold and very hot water hits it in a small area, that area would expand quickly while other parts of the glass did not expand. If the expansion was great enough and quick enough, it could distort the glass so much that it would crack. Students might suggest that the glass already had a small crack. This is a valid suggestion. The hot water would cause the crack to enlarge.
38. (a) If the concrete and steel have the same amount of expansion and contraction when heated or cooled, they will expand and contract together.
 (b) If the metal bars did not expand and contract by the same amount as the concrete, the bars would exert pressure on the concrete when one expanded or contracted more than the other. The concrete would crack and eventually begin to crumble.

Developing Skills

39. (a) Graph B shows the volume of the water in a pot on a stove when the burner is turned on. The water is initially cool. Its volume is low because cold water is more dense than warm water. There is little change in volume for a while because the burner was just turned on and it takes time for it to become hot and begin to heat the water. As the burner heats the water, the water becomes less dense causing the volume to increase. When the temperature reaches its maximum value, as controlled by the cook, the volume of the water ceases to increase.
 (b) Graph A shows the volume of a jug of water that was just placed in a refrigerator. The water is initially at room temperature so its density is lower that that of cold water. Since the density is low, the volume is high. As soon as the water is placed in the refrigerator, it begins to cool. As it cools, it becomes more dense causing the volume to decrease. Eventually, the water reaches the temperature of 4∞C, the temperature at which the refrigerator is set. At 4∞C, the water is at its maximum density and thus at its lowest volume. Since the temperature no longer changes, the volume remains the same.
40.



Pause and Reflect Answer

When water around the hot electrical probe begins to heat up on Earth, the hot water expands and becomes “lighter” than the water around it. Gravity pulls the cooler water down, which pushes the lighter water up. This motion is called a convection current. In zero gravity in a spacecraft, gravity does not act on the cooler water. Therefore, there is no movement of water and thus no convection. Gravity is necessary for convection to occur.

The situation is similar for the gas bubbles that form when the water begins to boil. On Earth, the water in contact with the hot probe eventually turns from a liquid to a gas, forming bubbles. The gas is much lighter than the liquid water, so gravity pulls the water down, which pushes the gas up. The gas bubbles float to the top of the water, and the gaseous water moves out into the air. On the spacecraft, when the water in contact with the hot probe becomes a gas, gravity cannot pull on the water so there is no motion. The gaseous water just stays where it is, beside the hot probe.