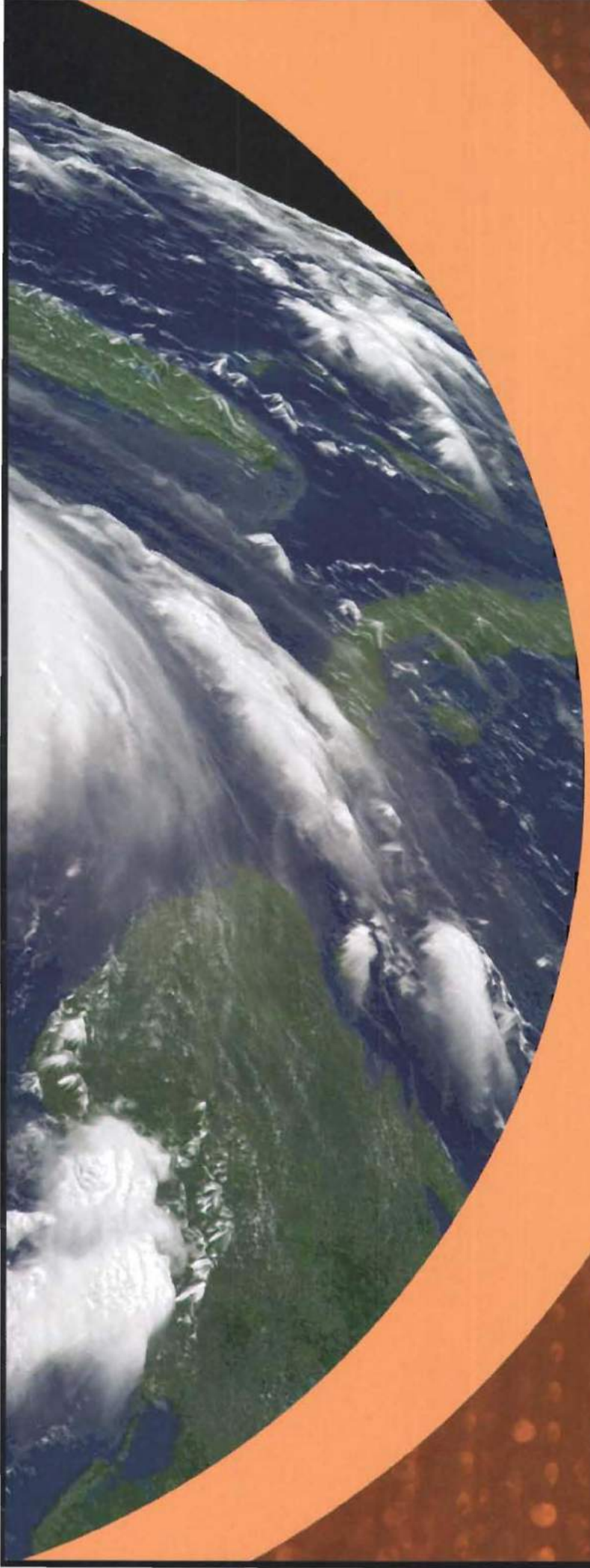
11.0 Heat plays an important role in nature.

The beautiful image of Hurricane Katrina from space does not suggest the destruction that Katrina caused on Earth.



What You Will Learn

In this chapter, you will:

- identify the layers of Earth's atmosphere
- describe the effects of radiant energy on large bodies of water and land
- explain the relationship between heat, the water cycle, and weather patterns

Skills You Will Use

In this chapter, you will:

- use appropriate equipment and tools
- record and organize data
- analyze patterns and report results

Why This Is Important

Natural events affect human lives. Learning about Earth's structure and environmental processes will help you understand the events and changes that influence your life and the lives of people in your family and community.

Before Reading

Thinking Literacy

Asking Questions

Asking questions before starting to read helps readers set a purpose for reading, as well as get more involved with the text. Scan the pictures, diagrams, and summary boxes in this chapter to get a sense of the heat and weather topics being covered. Develop some questions you have about these topics. Revisit your questions during reading to see which ones have been answered in the text.

Key Terms

- atmosphere
- ocean current
- volcano
- water cycle
- wind
- rock cycle

Heat plays an important role in nature.

11.0 Getting Started

Figure 11.1 Severe storms can cause great damage to natural and mechanical systems.

August 2, 2006, was a day that many Ontario residents will remember for a long time. That day, much of Ontario was hit by severe thunderstorms and high winds, resulting in floods and outages of the electricity supply. The violent weather came after three days of extreme heat and humidity over southern and central Ontario. Trees were uprooted and power lines brought down, causing power outages in an area from Toronto north to Bracebridge and east to Tweed (Figure 11.1). About 150 000 customers were affected. It took several days to restore power to all the homes and businesses.

Minden was the area most affected by the storm, but the Tweed area, Barrie, Orillia, Huntsville, Newmarket, Peterborough, Kingston, Walkerton, Simcoe, Guelph, and Orangeville also felt the effects of winds up to 120 km/h (Figure 11.2). A tornado was reported in the middle of the afternoon in the area of Highway 401 and Highway 6.

You might wonder what causes such violent storms to happen. Scientists who study how heat affects the atmosphere also ask this question because heat is an important part of the environment and can affect weather events.

Humans produce and use a large amount of heat in their activities. The production of heat adds a variety of chemical pollutants to the environment. Canadians are among the groups of people around the world who are concerned about how these pollutants affect the environment, the living things that are part of the environment, and themselves.

Figure 11.2 The August 2006 storm covered a large area of southern and eastern Ontario.

D22 Quick Lab

Cycling Water and Heat

The Sun controls natural systems on Earth, including the water cycle and the weather. A model is a design, object, or idea used to explain or visualize something difficult to see. In this activity, you will create a model to show how heat plays a role in the water cycle.

Purpose

To create a model of Earth's water cycle

Materials & Equipment

- hot plate and beaker (or kettle)
- water
- ice cubes
- cake pan
- oven mitts

Figure 11.3 Set-up for Quick Lab

CAUTION: Steam is very hot. Wear oven mitts. Do not allow the steam to touch your skin.

Procedure

1. Place the beaker of water on the hot plate or fill and plug in the kettle.
2. Place the ice cubes inside the cake pan. Wait a few minutes.
3. When the water is boiling, use the oven mitts to hold the cold cake pan over the beaker.
4. Observe the bottom of the cake pan.

Questions

5. Describe what you saw on the bottom of the cake pan when you held it over the beaker of boiling water.
6. Draw and label a diagram to illustrate the materials and equipment and your results.

11.1 Heat Affects the Air Around Us

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

- Human activities depend on the atmosphere.
- The atmosphere has five layers; humans live in the troposphere.
- Weather on Earth depends on heat transfer from the Sun.

Quick: take a deep breath, then breathe out. While you are reading this page, you are breathing easily. You probably realize you cannot do that just anywhere — in other words, you need to be somewhere where clean air is available.

Have you considered what it is that you are breathing and that surrounds you? It is called Earth's **atmosphere** — the blanket of gases that surrounds Earth. Whether you are reading this page at school, at home, or somewhere else, the atmosphere surrounds you.

The atmosphere includes the air humans need to live. It also includes a mixture of dirt, dust, and other substances — including some that human activities release into the air as pollution. When you breathe, you take air and a mixture of these other substances into your lungs. One of the gases in air, oxygen, is the gas that animals (including you) require to live.

D23 Starting Point

Skills A C

Coming Up for Air

Figure 11.4 shows situations where humans must be aware of the constant need for fresh air. By yourself or with a partner, give each photograph a title. Record the letter and title for each. Briefly, provide information about what is happening in each photograph. Add any personal connections that you may have to these activities.

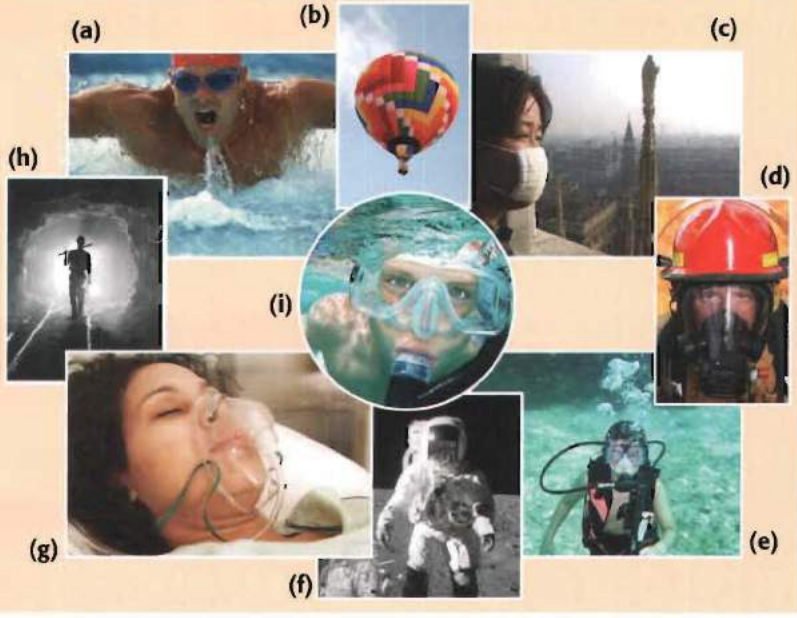


Figure 11.4 Humans need fresh air in all situations.

D24 During Reading

Thinking Literacy

Question Types

When readers ask questions and look for answers as they read, they are interacting with the text in a meaningful way. There are different types of questions readers can ask:

- literal or "on the line" questions. The answer is found in the text.
- inferential or "between the lines" questions. The reader interprets information from the text along with background knowledge to answer.
- evaluative or "beyond the lines" questions. The answer may not be in the text at all. Readers need to use their background knowledge and experiences to answer.

Revisit the questions you developed at the beginning of this chapter. Use the information above to determine whether each of your questions is literal, inferential, or evaluative. Where will you find the answers to each of your questions?

Learning about Layers of Air

Wherever you go above the surface of land or above the oceans, you are surrounded by the mixture of gases that make up Earth's atmosphere. Humans live in the bottom layer of the atmosphere. Of course, many types of birds, such as the peregrine falcon, and other animals who live in trees spend some of their time in the atmosphere at a higher level than humans. Trees like the eastern white pine (Figure 11.5) extend many metres up into the atmosphere.

Conditions in the atmosphere, including rain, wind, and temperature, all affect human life. Think about thunderstorms and blizzards. Also think about sunny days at the lake, and plants growing in the spring. All of these examples show how changes in the atmosphere above Earth's surface are important not only to scientists but also for everyday life.

Scientists who study the atmosphere divide it into five main layers according to the changes in temperature as you go higher above Earth's surface (Figure 11.6 on the next page):

- the troposphere — from 0 to 20 km
- the stratosphere — from 20 to 50 km
- the mesosphere — from 50 to 85 km
- the thermosphere — from 85 to 690 km
- the exosphere — from 690 to 10 000 km

Figure 11.5 The eastern white pine is the provincial tree of Ontario. It is the tallest tree in eastern North America. The record height for this species is more than 60 m.

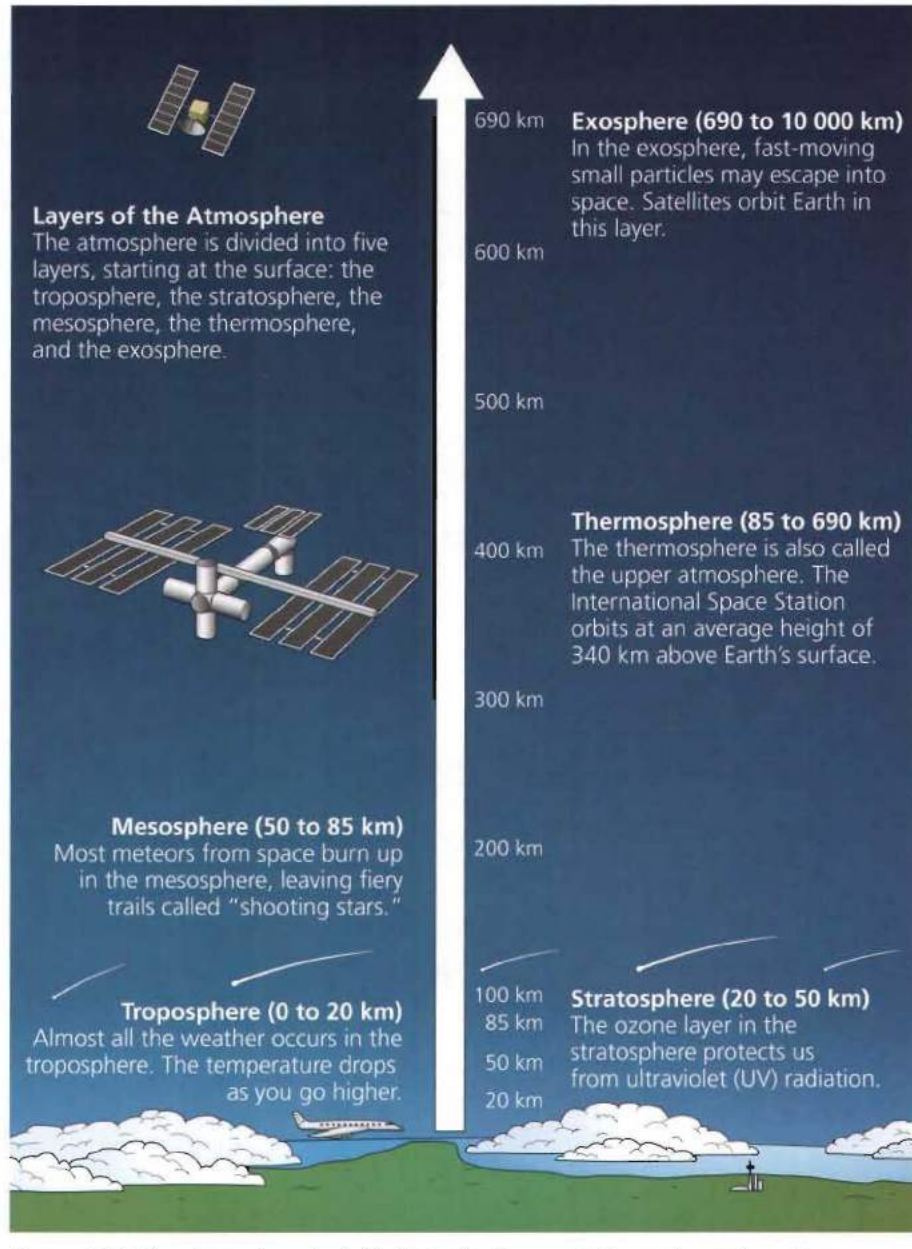


Figure 11.6 The atmosphere is divided into five layers, starting at the surface: the troposphere, the stratosphere, the mesosphere, the thermosphere, and the exosphere. Data are from National Oceanic and Atmospheric Administration (NOAA), U.S. Dept. of Commerce.

The Troposphere

WORDS MATTER

Troposphere: The word troposphere comes from *tropo* (turning, changing) and *sphere* (ball-shaped).

Meteorology: The word meteorology comes from a Greek word meaning the discussion of things that happen in the sky.

Humans live in the lowest level of Earth's atmosphere — the **troposphere.** Almost all human activity, including air travel, goes on in this layer. As the word troposphere suggests, constant changes occur in the troposphere. In fact, it is the layer of the atmosphere in which Earth's weather occurs. But what is weather? **Weather** refers to the conditions of Earth's atmosphere at a particular time and in a particular place. The study of weather and weather patterns is called **meteorology**.

Heat Transfer and Earth's Weather

What causes changes in our weather? For the answer, you have to consider not only Earth but also the source of much of Earth's energy — the Sun. The energy from the Sun that reaches Earth contributes to changes in Earth's weather systems and affects the weather in your local area.

Although it is an average-sized star, our Sun is the source of a huge amount of energy. Only a small fraction of it reaches our planet. Even so, the amount of energy reaching Earth's surface every day is more than 6000 times the amount of energy used by all humans on Earth in a day. Are you wondering what happens to this energy? Study Figure 11.7 to find out.

Take It Further

Scientists have learned a lot more about Earth's atmosphere. You can, too! Begin your search at ScienceSource.

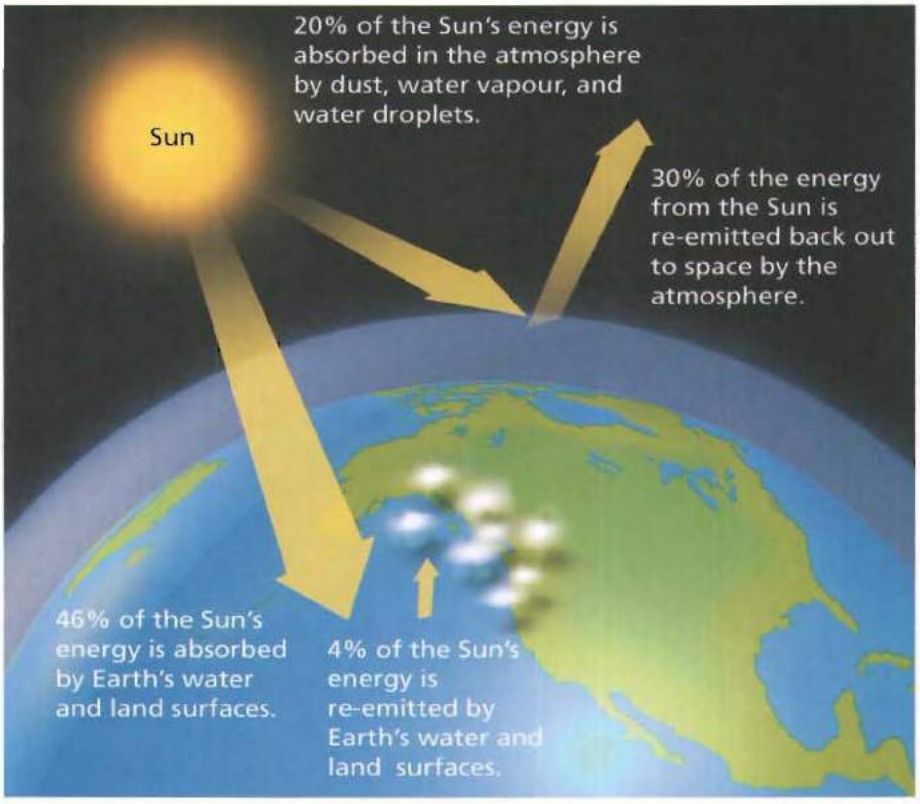


Figure 11.7 Scientists estimate that less than one-billionth of the Sun's total energy output each day actually reaches Earth. Even this small portion represents a huge amount of energy.

D25 Learning Checkpoint

Reflecting on the Sun

Draw a two-column chart in your notebook as shown in Table 11.1. Refer to Figure 11.7 to complete the table. Summarize what happens to the energy that reaches Earth.

Table 11.1 The Sun's energy

What Happens to the Sun's Energy?	Percent of the Sun's Energy

SKILLS YOU WILL USE
- Recording and organizing data
- Analyzing patterns

Curious Candle

Air contains a mixture of gases, including oxygen. How long can a candle burn inside a closed container? How does the size of the container affect the time for a burning candle to go out? In this activity, you will use several beakers to observe the effect of heating different volumes of air inside the beakers of different sizes.

Question

How long can a candle burn under beakers of different sizes?

CAUTION: Do not touch the hot beaker after the candle has gone out.

Materials & Equipment

- pie plate
- small candle
- matches
- beakers of different sizes
- oven mitts
- modelling clay
- water
- clock or stopwatch

Hypothesis

Suggest how the size of a beaker might affect the time a candle can burn inside it. Record your answer.

Procedure

1. Copy Table 11.2 into your notebook.
2. Place a small piece of modelling clay onto the centre of the pie plate.
3. Stand the candle upright in the modelling clay.
4. Fill the pie plate with water.
5. Your teacher will light the candle.
6. As you place the smallest beaker over the candle, start timing. Closely observe the spout of the beaker and record your observations.
7. When the candle goes out, record the time in minutes and seconds in your table.
8. Use an oven mitt to lift the beaker out of the pie plate. Do not let water drip on the candle.
9. Repeat steps 5–8, replacing the small beaker with the middle-sized beaker.
10. Repeat steps 5–8 using the largest beaker.

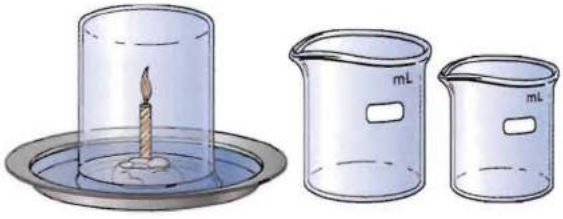


Figure 11.8 Set-up for activity

Table 11.2 Effect of beaker size

	Size of Beaker (mL)	Time That the Candle Lasted (min and s)
smallest beaker		
middle-sized beaker		
largest beaker		

Analyzing and Interpreting

11. Compare the three results you recorded in your table. Record your comparison.
12. Why did you need to start this activity by adding water to the pie plate?

Skill Builder

13. Predict how long the candle flame would last under a beaker twice as large as the largest beaker you used in step 10.

Forming Conclusions

14. What effect does the size of the beaker have on how long the candle will burn?

11.1 CHECK and REFLECT

Key Concept Review

1. Define "atmosphere" in your own words.
2. Name two locations where humans need technology to breathe.
3. Name the five layers of the atmosphere in order, starting from Earth's surface.
4. In which layer of the atmosphere do we find the most human activity?
5. What percent of the Sun's energy that reaches Earth is absorbed by Earth's water and land surfaces?

Connect Your Understanding

6. A friend tells you: "The atmosphere is just a bunch of gas." Do you agree with this statement? Defend your answer.
7. Invent a mnemonic sentence for the five layers of the atmosphere using the letters T — S — M — T — E.
8. The word atmosphere comes from *atmo* (vapour, smoke) and *sphere* (ball-shaped). Why is this a suitable name for the blanket of air that surrounds you?
9. A simile is a comparison that uses the words "like" or "as." Write sentences to compare something in your life with the layers of the atmosphere. Refer to the description of the atmosphere in this section. Start with the sentence: "The atmosphere is like a _____ because _____."
10. Scientists estimate that less than one-billionth of the Sun's total energy output each day reaches Earth. What do you think happens to the rest? (**Hint:** Consider the size of Earth.)

Practise Your Skills

11. Draw a bar graph of the data for the Sun's energy, shown in Figure 11.7. Use graph paper, a ruler, and coloured pencils.
12. Create a mini-poster using your mnemonic sentence from question 7. On your poster, include your mnemonic sentence along with the names of the matching five layers of the atmosphere. Add a colourful illustration for each layer. Give your mini-poster an original, creative title.

For more questions, go to ScienceSource.

D27 *Thinking about Science and the Environment*

Mapping the Atmosphere

You have learned what happens to the Sun's energy that reaches Earth. Human activity adds gases and small particles to the air that can trap heat and warm the atmosphere. Create a consequence map with the central question, "What are the consequences of humans adding gases and other substances to Earth's atmosphere?" The first level of your map will be the positive and negative consequences you think will result. The second and third levels of your map will provide more information for each positive and negative consequence.

11.2 Heat Affects Water

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

- Water is continuously moving and changing states in nature.
- Heat creates the water cycle and affects weather.
- The water cycle and ocean currents depend on convection.

Figure 11.9 Water is an important consideration for farmers.

Air and water are valuable resources that humans need and use every day. The health of your family and the success of many businesses depend on these important natural resources. Just like air, water on Earth is a shared resource. How we use water or misuse it can affect people and human activities far away from us. Think about all the ways you use water or depend on water every day. It is a long list.

Water is important for farmers everywhere (Figure 11.9). A farm cannot exist without water for crops and animals. At one time, farmers may have been less concerned about the amount of water they used. Today, with technology like computers and satellites, farmers are able to monitor and closely control their water use. In addition, new farming techniques mean that farmers may need less water to grow crops.

Water use in Ontario and in all locations on Earth is influenced by the **water cycle** — the movement in nature of water from the surface of Earth to the atmosphere and back. How farmers use and recycle water affects how much water sinks into the ground, how much water flows over the surface, and even how much water evaporates from their cropland.

D28 *Starting Point* Skills A C

Wonderful Water

It's time for some quick writing. Grab a pen or pencil. Record the title of this activity. Then, write non-stop for two or more minutes. The topic is: "How Do I Depend on Water?" Ready? Set? Write.

Heat Flow in the Water Cycle

The energy of the Sun is directly responsible for three very important natural systems that affect life on Earth — the water cycle, weather patterns, and ocean currents. Think about the water cycle. You have seen that adding heat to water by boiling causes the water to change from a liquid to a gas. But it is not necessary to boil water to cause this change of state. Adding a smaller amount of heat has the same result; it just happens more slowly. Figure 11.10 shows one example of this idea.

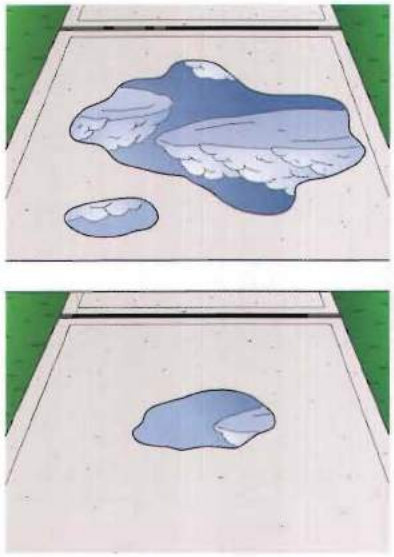


Figure 11.10 There is enough heat in the air on a warm day to evaporate the water in a puddle.

Water in a puddle slowly seems to disappear, even on a cloudy day. In fact, it evaporates — turning into invisible water vapour. On the other hand, when hot steam touches a cool surface, it condenses, changing from water vapour to liquid water that can cover or drip from the surface (Figure 11.11).

These observations indicate a **cycle**, a continuous movement of materials in nature that repeats. The mist on the bathroom mirror is a home version of part of Earth's water cycle — the movement in nature of water from the surface of Earth to the atmosphere and back (Figure 11.12).

Figure 11.11 The mist is caused by water vapour that condensed on the cool mirror.

Water in the atmosphere is not always invisible. When the temperature high above Earth starts to decrease, water droplets join together. Slowly, the smaller droplets become larger droplets, forming a cloud that we can see. As the water droplets grow even larger, they also become heavier and will begin to fall as rain, also called **precipitation**.

Puddles of water evaporate due to heat. As the temperature drops, water droplets in clouds join together and fall as rain. You can see that heat plays a role in the two changes of state in the water cycle:

- evaporation (liquid water on Earth absorbs heat and changes into water vapour)
- condensation (invisible water vapour in the atmosphere cools down and changes back into drops of water that fall as rain).

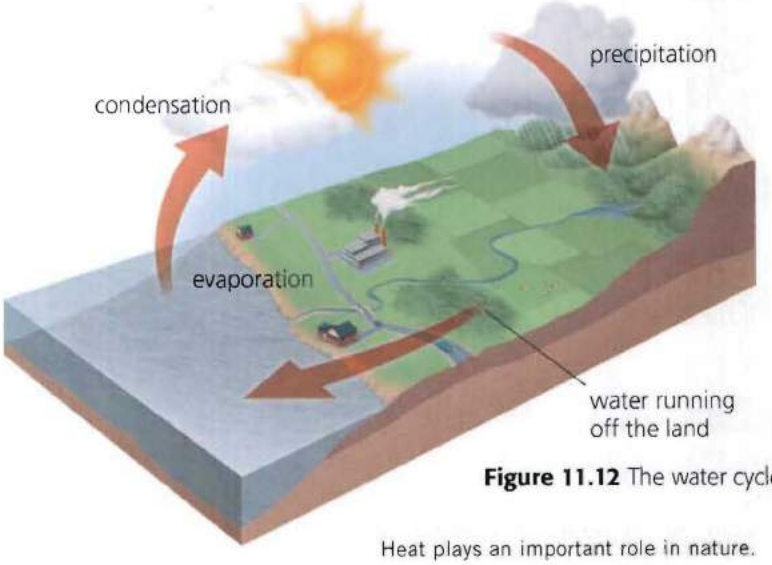


Figure 11.12 The water cycle

D29 Learning Checkpoint

Weather and the Water Cycle

Draw a chart in your notebook as shown in Table 11.3. In column A, print or write the three questions to consider. In column B, try to answer these questions. After reading "Weather and the Water Cycle," complete column C.

Questions to Consider

1. How does the Sun shine down on different parts of Earth?
2. What causes ocean currents?
3. How do ocean currents affect life in the oceans?

Table 11.3 Weather and the water cycle

Column A Questions about Weather and the Water Cycle	Column B What I Know before Reading	Column C What I Know after Reading

Weather and the Water Cycle

Since Earth is roughly a sphere the Sun's radiant energy does not fall evenly on Earth's land and seas (Figure 11.13). All year round, even though Earth is moving through space, the Sun shines more directly down on the land and ocean at and near the equator, heating them more strongly.

Ontario and the rest of Canada are north of the equator. This means that in Canada the Sun's rays fall less directly than at the equator. The same amount of heat is spread over a larger area on Earth's surface. Also, in winter, Canada receives far less sunlight, making most of Canada cold and snowy.

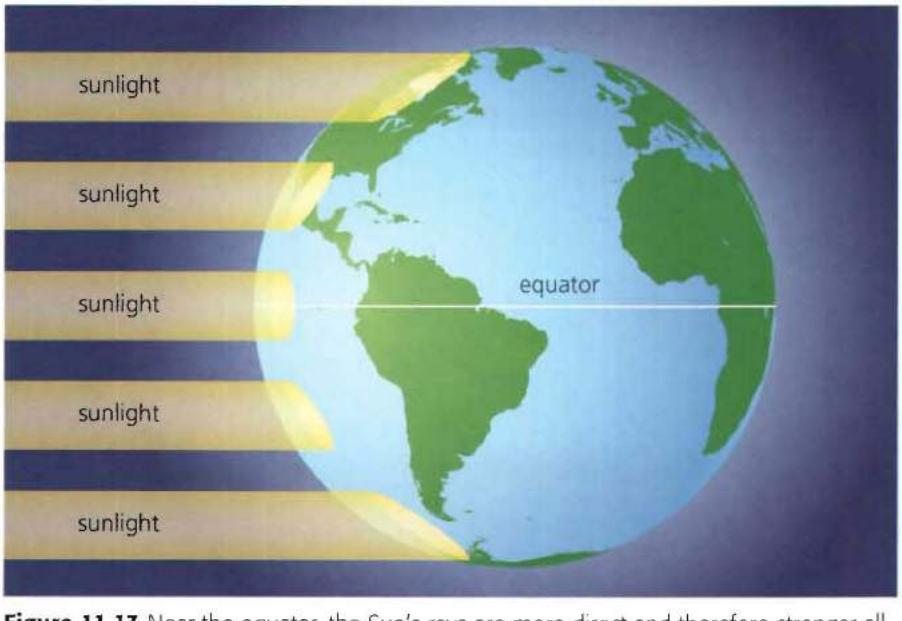


Figure 11.13 Near the equator, the Sun's rays are more direct and therefore stronger all year round.

The differences in temperature between regions near the equator and northern and southern regions set in motion a continuous movement of air across Earth. This movement distributes heat from the Sun across the planet. The movement of air in the troposphere is called **wind**.

When air in one region is warmer than the surrounding air, it becomes less dense and begins to rise, drawing more air in underneath. A convection current is set up. For example, during the day, land heats up more than water. The air above the land near large lakes or an ocean heats up and rises. Cooler air from above the water rushes in, creating a cool sea breeze. At night, when the land cools down more quickly than the water, the opposite is true. Warm air above the water rises while cooler air from the land takes its place, creating a cool land breeze.

All the while, air is carrying water vapour and water droplets that circulate from Earth into the atmosphere and back again in giant convection currents. The water cycle is one of several factors that influence the weather in your region of Ontario and around the world. In one location, the weather may be warm and sunny; only a few kilometres away, it could be raining and windy.

Take It Further

Be an amateur weather watcher! Track Canada's weather patterns yourself. Environment Canada posts weather maps for regions in Canada on the Internet. You can find 5-day forecasts for your region of Ontario as well as any region in Canada. Begin your search at ScienceSource.

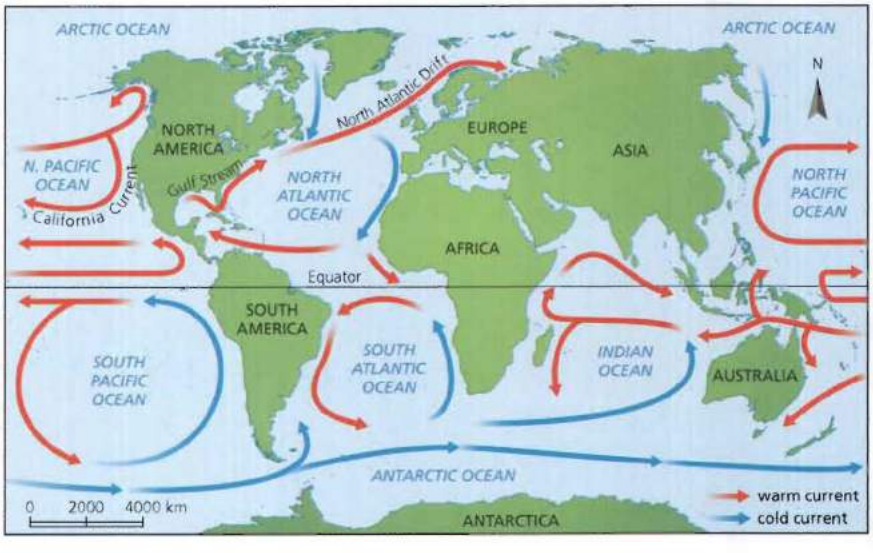
Heat and Ocean Currents

An **ocean current** is a pattern of movement of the water in a large region of the ocean. Ocean currents contribute to the movement of thermal energy from the warm regions of Earth near the equator to the colder regions in the Arctic and Antarctic. In effect, these convection currents partially balance the extremes of temperature on Earth's surface.

An ocean current is like a river of warm or cold water moving in a more or less circular pattern. This pattern influences the **climate**. The climate is the long-term weather conditions over large areas of Earth. Ocean currents affect the land areas that form Canada's western, eastern, and northern coasts, as well as the routes taken by ships carrying products and people (Figure 11.14).

Ocean currents flow in convection patterns that depend on wind, the minerals dissolved in the water, the shape of the ocean floor in different locations, heat from the Sun, the pull of the Moon's gravity, and even Earth's rotation (spin).

Figure 11.14 Major ocean currents



Scientists have discovered more than 50 different ocean currents. Ocean currents and their patterns are of interest in studies of Earth's air and water systems and changes in climate.

Keeping It Warm, Keeping It Cool

Ocean currents flow in a circular pattern — clockwise in the northern hemisphere, where Canada is found, and counterclockwise in the southern hemisphere, south of the equator. There are three categories of ocean currents (Table 11.4).

Table 11.4 Categories of ocean currents

Category of Current	Ocean Layer	Flow Direction	Factors That Drive Current
warm surface current	at and near surface	from near equator toward north and south poles	wind spinning of Earth
cold surface current	at and near surface	from polar regions toward equator	mainly wind
deep ocean current	deep ocean	form at poles; flow toward equator and rise to surface	density of water differences in temperature between layers

Ocean currents influence life in the oceans. The ocean is layered: warmer on top, cold at the bottom. The range of water temperatures in each layer controls which organisms can live there. Ocean organisms are sensitive to changes in temperature. A change in temperature of even a few degrees may be enough to cause these organisms to change their location. Other organisms that depend on them for food must also move or die of starvation.

Figure 11.15 A tornado may form as the result of a thunderstorm, at the boundary between warm, moist air and hot, dry air.

Spinning Systems

The moving atmosphere and oceans circulate continuously. The results are wind and storms in the troposphere and currents in the oceans. Strong winds can be very destructive and may produce **hurricanes** and **tornadoes.** A hurricane is a strong, spinning weather system over the ocean that has continuous winds exceeding 119 km/h. Hurricanes form and grow stronger as they pick up heat from warm tropical ocean water. Tornadoes are strong, spinning columns of air in contact with the ground. They are unpredictable, usually local, and last only a short time (Figure 11.15).

D30 *Inquiry Activity* Toolkit 2

SKILLS YOU WILL USE
- Analyzing patterns
- Reporting results

Bottled Weather — Teacher Demonstration

A 2-L plastic bottle with some smoke particles inside can provide a model of a common event that occurs every minute in the atmosphere.

Question

How can you model cloud formation?

Materials & Equipment

- 2-L or smaller colourless plastic bottle with cap (remove the label)
- warm water
- booklet of matches
- black paper

CAUTION: Be careful when using matches.

Figure 11.16 Set-up for activity

Hypothesis

Predict what might happen when you squeeze a 2-L bottle that is filled with smoke and water vapour.

Procedure

1. Place just enough warm water in the bottle to cover the bottom. Replace the cap.
2. Shake the bottle vigorously for one minute.
3. Light a match and let it burn for a few seconds. Blow out the match and immediately place the head of the match into the bottle. Let the smoke fill the bottle. Remove the match.
4. Observe that, after a few seconds, the smoke will seem to disappear.
5. Screw the cap on the bottle, being careful not to let too much smoke escape.
6. Hold the bottle over a dark surface such as a dark counter top or black paper. Quickly squeeze the sides of the bottle really hard, then release. Do this six or seven times (more squeezing may be necessary). Hold the last squeeze for a few seconds, and then quickly release it. As soon as you release the squeeze, look for a change inside the bottle.

Analyzing and Interpreting

7. Do you think that there was invisible water vapour inside the bottle before you placed the head of the match into the bottle? Suggest how you know this.
8. Interpret the changes that occurred quickly after squeezing and releasing the bottle.
9. Why do you think you needed to squeeze the bottle several times?

Skill Builder

10. Use drawings to illustrate the steps in the procedure. Include your observations of changes inside the bottle. Number each drawing with the matching step in the procedure.

Forming Conclusions

11. Suggest how your observations in this activity could help explain the formation of clouds in the atmosphere.
12. Suggest conditions in the atmosphere that might lead to more clouds forming.

11.2 CHECK and REFLECT

Key Concept Review

1. Why is the name water cycle suitable for the movement of water on Earth?
2. How does heat cause ocean currents?
3. Suggest a reason why the oceans near the equator are warmer than the oceans closer to Earth's poles.

Connect Your Understanding

4. List two examples of ways human activity influences the water cycle.
5. Compare the steps in the water cycle to another cycle of events in daily life. You can start your comparisons with a statement such as : "The water cycle is like _____ because _____."

Practise Your Skills

6. Design, draw, and label your own illustration of the water cycle. Alternatively, plan a physical activity to represent the water cycle.
7. Design, draw, and label a series of illustrations to represent the six factors that influence ocean currents. (See page 325).

For more questions, go to ScienceSource.

D31 *Thinking about Science and the Environment*

Monitoring the Oceans – Argo

The International Argo Project (or Argo) is a global network of 3000 free-drifting floats that measure the temperature and salt content of the upper 2000 m of Earth's oceans (Figures 11.17 and 11.18). For the first time, scientists can continuously monitor several characteristics of the water in the upper regions of the oceans, including temperature, direction, and speed. All data are sent via satellites to centralized computers.

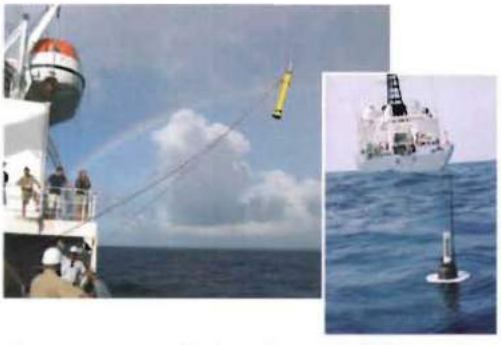


Figure 11.17 A ship installing Argo floats

Figure 11.18 This image shows where many of the Argo floats were located on one particular day.

Consider This

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

1. What four categories of data do the Argo floats collect?
2. Why are the data gathered by Argo important to meteorologists?

11.3 Heat Affects Land

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

- Earth is made of several layers.
- Many of Earth's features were and are formed by heat.
- The rock cycle helps us understand how heat causes changes in Earth.

The dramatic announcement "Vancouver! Vancouver! This is it!" was made by vulcanologist David Johnston over the radio link from Coldwater Observation Post, north of Mount St. Helens in Washington State, on Sunday morning, May 18, 1980. A few seconds later, Mount St. Helens exploded (Figures 11.19 and 11.20).

Hot gases and ash shot 19 km into the sky. The top and northern side blew away, reducing the height of the mountain by about 400 m. The temperature reached 350°C, and the blast was so loud it could be heard across the Canada–United States border in Vancouver, British Columbia. For days, ash was carried east by winds, settling on cars, buildings, and houses in Calgary, Regina, and as far as Winnipeg — a distance of over 2200 km.

Volcanic eruptions grab our attention. People wonder how hot, melted rock deep in Earth can flow upward and onto the surface. But below the surface, Earth is constantly changing every day — changing due to heat.

Figure 11.19 Mount St. Helens erupting on May 18, 1980

Figure 11.20 Mount St. Helens is south of Vancouver in Washington State.

D32 Starting Point

Skills A C

Earth's Mysterious History

The many changes in Earth's long history are closely tied to heat. It is like a mystery story. Changes on and below Earth's surface occur but we do not understand all of them. For example, heat causes mountains to form on land and on the ocean floor. Think about, and then discuss with a classmate, several reasons why scientists are interested in studying how heat causes changes on Earth. You could also describe what you know about *how* scientists research these changes.

D33 During Reading

Thinking Literacy

Facts-Questions-Responses

Volcanoes and earthquakes are an interesting topic, but some information may be complex and detailed. An FQR chart can help readers interact and make sense of information while taking notes. Create an FQR chart in your notebook. Label the first column "Facts," the second "Questions," and the third "Responses." (See Figure 11.21.)

As you read the information on volcanoes and earthquakes on pages 329-333 (up to Rocks and Minerals), pause to record facts that are presented. For each fact, record a question you have about it. In the last column, you can record your response to the fact or a connection or reaction you had. Not all facts need both a question and response. Once you have completed reading, share some of your facts, questions, and responses with the class.

Facts	Questions	Responses
Mt. St. Helen's erupted May 18, 1980	*Did this affect our weather in Ontario?*	

Figure 11.21 FQR chart

Questions about Earth

Humans live on the outside skin of Earth. For hundreds of years, we have asked questions similar to those you might ask before tasting a new piece of fruit (Figure 11.22). How thick is Earth's skin? Are there layers inside? What would we find at the centre? Several models for Earth are shown here (Figures 11.23–11.25). Which would you choose as a model of Earth? Why? Keep reading to see how your choice compares with the scientific evidence.

Figure 11.22 An unusual fruit

Earth — The Inside Story

You live on Earth's surface. But what about the ground beneath your feet? Scientists divide Earth into four layers. Using Figure 11.26, let us travel through these layers, starting at the surface, in an imaginary vehicle, the *Earth Explorer*.

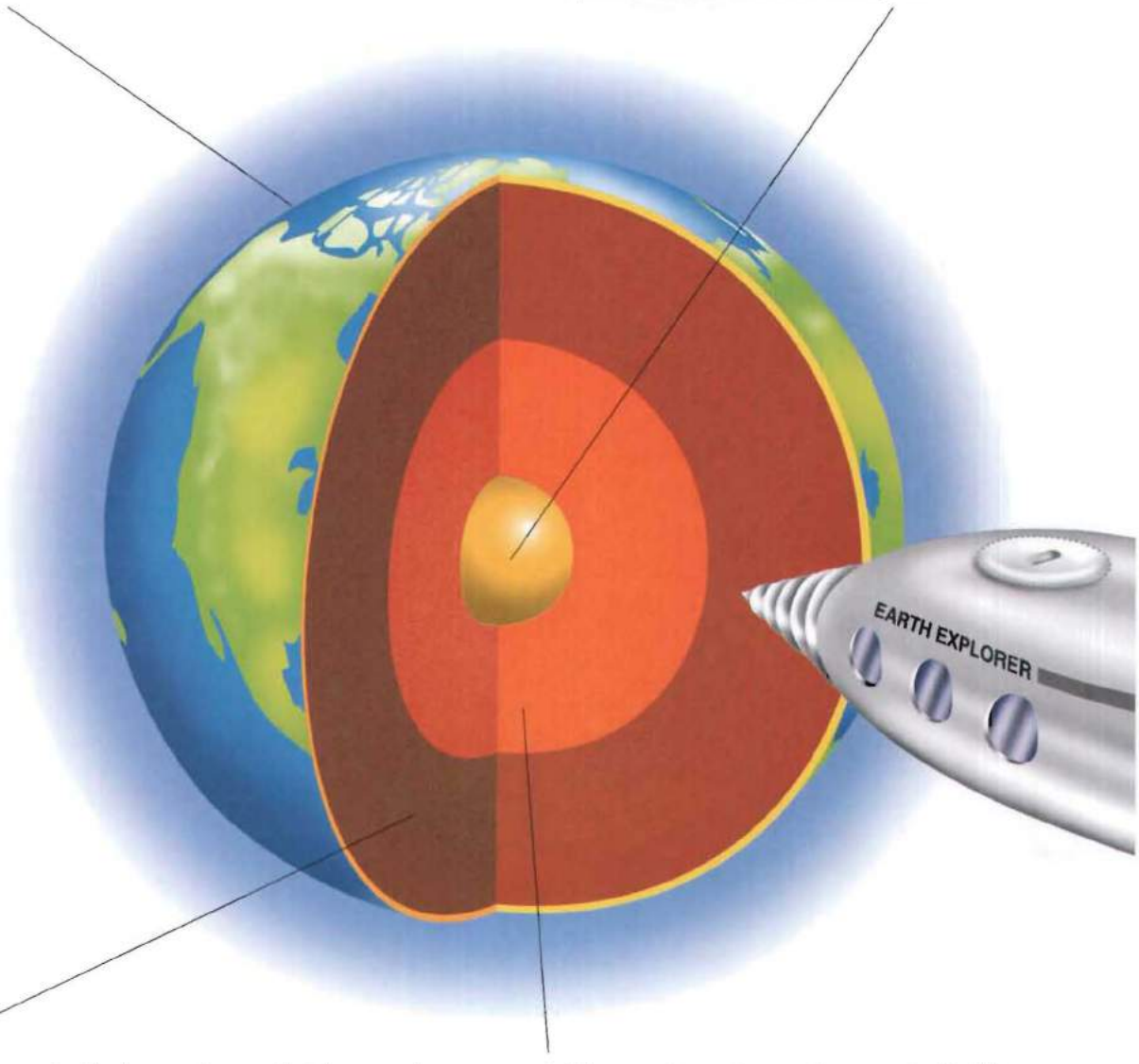
Figure 11.23 Model 1

Figure 11.24 Model 2

Figure 11.25 Model 3

1 Earth's outer layer is the **crust**. All the features we see around us—mountains, valleys, plains, hills, plateaus—are part of the crust. You will start your trip through Earth from the bottom of the ocean because the crust is thinnest here—only about 6 km thick.

4 Finally, you reach the **inner core**. This layer is solid, even though it is very hot. The weight of the other layers has pressed the inner core into an extremely hard ball. There are still another 1250 km to the centre of Earth. But the inner core is so hard that even your special vehicle cannot drill through it.



2 Now you are inside the next layer, called the **mantle**. The mantle is about 2900 km thick, but it is not the same all the way through. The upper part of the mantle is solid, like the crust. Below the solid upper part of the mantle, the temperature and pressure are higher. However, your vehicle can move more easily through this lower layer of the mantle because the rock is partly melted. This rock can flow very slowly.

3 When you leave the mantle, you enter Earth's molten **outer core**. The temperatures are so high here that the rock is completely liquid. Even though the rock is molten, it still takes you a long time to get to the inner core because this layer is also very thick–about 2200 km.

Figure 11.26 Earth's four layers

New Crust Forms All the Time

Suggested Activity
D35 Quick Lab on page 336

Earth's crust is constantly changing. The three types of heat transfer (conduction, convection, and radiation) all play their part in the continuing story of the changes on and beneath Earth's surface. Conduction occurs in the solid inner core. Heat is transferred to the neighbouring molten outer core. This molten (melted) rock below Earth's surface is called **magma**. The magma in the outer core and the deeper part of the mantle is hotter than the magma in the upper part of the mantle near Earth's crust. This difference in temperature creates convection currents in the molten rock in the mantle. Hot, molten rock rises toward the top of the mantle and moves to the side (Figure 11.27). Heat is also transferred during this sideways movement by conduction and radiation. Sometimes, molten rock sinks back down toward the outer core and the cycle continues.

Earth's crust sits on large, thick sections of rock called **plates**. Because the mantle is made of hot, molten rock, these large rock plates can move apart or move together. Sometimes, the movement allows magma, ash, and gases to shoot upward toward the crust through cracks, producing rumbling in the ground and a lighting of the night sky as a **volcano** erupts (Figure 11.27). At other times, the shifting of the plates produces shaking and sliding in the crust as an **earthquake** takes place.

WORDS MATTER

Molten: The word molten means fused or liquefied by heat, from an older form of English, *melten*, meaning to melt.

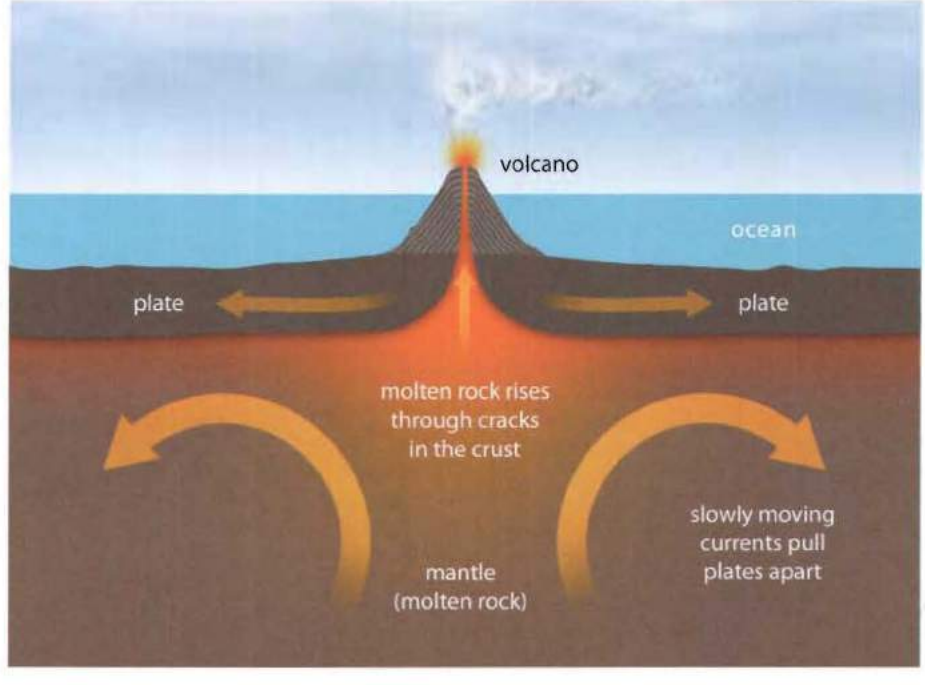


Figure 11.27 When the plates of rock that float on the mantle move apart, molten rock can shoot upward and onto Earth's surface, forming a volcano.

Deep under the oceans, hot magma may squeeze upward where rock plates are moving apart. The hot magma is released onto the ocean floor as **lava** (Figure 11.28). When it meets the cold ocean water, the lava begins to cool, spreads out, and then forms new crust.

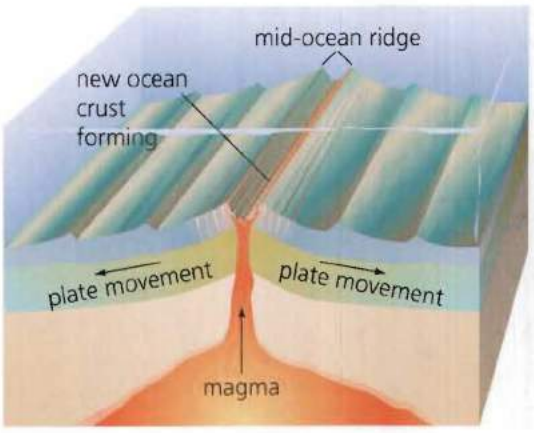


Figure 11.28 Deep under the oceans, new crust is forming continuously as hot lava reaches the ocean floor, begins to cool, spreads out, and then hardens.

Rocks and Minerals

Earth's crust is made up of rocks of different kinds. **Rocks** are naturally formed solid material made up of one or more minerals. **Minerals** are naturally occurring solid pure substances. The first step in identifying a rock is to look at the minerals it contains. There are over 4000 known minerals. **Crystals** are the special shapes of minerals found in rocks made from molten rock (magma) that cooled slowly. Each type of mineral has a special crystal shape (Figure 11.29).

Figure 11.29 Minerals have unique crystal shapes.

Three Classes of Rocks — Igneous, Sedimentary, and Metamorphic

Just as students in school are grouped into different classes, so too are rocks placed into different classes. Scientists have named three large classes (families) of rocks.

Igneous rock is the class of rock that forms from molten rock that has cooled and hardened. There are many different kinds of igneous rock. Rock that forms when magma cools slowly often contains large crystals. If the magma reaches Earth's surface, it is called lava. Lava cools quickly when it is exposed to the air or water. Lava contains small crystals or no crystals at all. Figure 11.30 shows three examples of igneous rocks. Obsidian and pumice form from lava. Granite forms from magma.

Sedimentary rock is the class of rock that forms from small pieces of rock, shells, or other materials that pile up in layers. The bottom layers pack together from the pressure of the layers above them, like snow at the bottom of a snowbank compressing from the weight of the layers of snow above it. The layers of rock at the bottom harden, forming sedimentary rock, like snow at the bottom of several layers turning to ice. Just as there are many different kinds of minerals that can pile up, there are many different kinds of sedimentary rock.

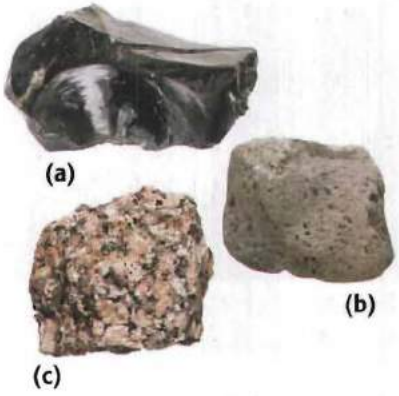


Figure 11.30 Igneous rocks (a) obsidian, (b) pumice, (c) granite

Table 11.5 Rock types

Name of Rock	Class (Family) of Rock	Name of Metamorphic Rock That It Changes To
granite	igneous	gneiss
sandstone	sedimentary	quartzite
limestone	sedimentary	marble
shale	sedimentary	slate

Metamorphic rock is formed from igneous or sedimentary rocks that have been changed from their original form by heat (from Earth) or by the pressure of the rocks above them. As there are many different minerals that make up igneous rocks and sedimentary rocks, there are also many different types of metamorphic rocks. Examine Table 11.5 to find out the names of several types of metamorphic rocks. Two rocks can contain exactly the same set of minerals but look very different because they formed in different ways. The ways the minerals in the rocks are arranged and the sizes of the crystals can all give clues to how the rock was formed.

Suggested Activity
D36 Inquiry Activity on page 336

D34 Learning Checkpoint

How Rocks and Minerals Form

Match the following descriptions with the new terms you have learned.

1. the class of rock formed from layers of particles, shells, plants, or animals piled up
2. the class of rock that forms when molten rock cools and hardens
3. molten rock beneath Earth's surface
4. molten rock that reaches Earth's surface
5. the special shapes of minerals found in rocks that are made from molten rock that cools slowly
6. an opening in Earth's crust through which solid and molten rock, ash, and gases escape

Figure 11.31 High-quality diamonds, sold as Polar Bear Diamonds™, are mined, cut, and polished in Canada's Northwest Territories.

What Are Gemstones?

Gemstones (or gems) are minerals that are valuable because of their exceptional beauty, colour, and rarity. Their main physical properties are colour, lustre (shininess), how light passes through them, and hardness. Gemstones are often made into jewellery. Some common gemstones, like quartz and amethyst, are fairly inexpensive. Others, like ruby, emerald, sapphire, and diamond, can be very valuable. Many gemstones have important uses in manufacturing and electronics.

How and Where Are Diamonds Formed?

Diamonds, with all their beauty and sparkle, are a form of carbon (Figure 11.31). According to geologists, diamonds were first formed underground more than 2.5 billion years ago. They were crystallized in the mantle below Earth's crust at great depths, usually more than 150 km down. Here is how we believe this happens. Rocks in Earth's upper mantle were carried deeper into the mantle where they melted. These rocks contained carbon, and on melting released carbon particles. The carbon particles formed crystals under the very high pressure from the molten rock above. Under the right conditions of heat and pressure, diamond crystals formed. The diamonds were carried toward the surface by volcanic eruptions of flowing magma in the mantle. Below the volcano, carrot-shaped deposits of rock (called kimberlite pipes) formed. These deposits contain diamonds, volcanic rock, and fragments of the mantle.

Take It Further

The newest rocks on Earth are found around active volcanoes. Find out where these rocks are forming and what they are made of. Begin your search at ScienceSource.

The Rock Cycle

During an Ontario spring, it is common for ice to melt during the day and then freeze back into ice overnight. The next day, the ice can melt again and freeze again. This back-and-forth behaviour is an example of a cycle.

Rocks also go through cycles. The **rock cycle** is the repeating pattern in which one family of rock changes into a different family. Figure 11.32 shows the role that heat plays in the rock cycle. The rock cycle occurs because of the heat produced, stored, and released inside Earth. Earth is not the unchanging planet it might appear to be. Old rock is continuously being pushed into the mantle, where it melts. Hot magma reaches the crust, cools, and forms new rock. Rocks change constantly. For example, pressure from the weight of layers of rock pushing down may change one form of rock into another. Water, wind, chemicals, and even living things, lead to **weathering**, or wearing away, of rock. This is the first stage of **erosion** — the breakdown and movement of rocks and soil by wind, water, or ice.

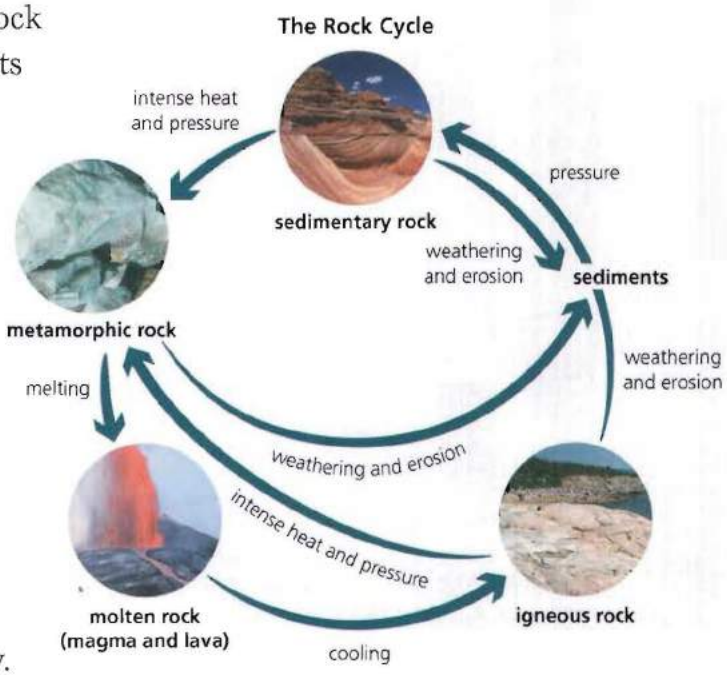


Figure 11.32 The rock cycle

D35 *Quick Lab*

Colour in a Beaker

Purpose

To create a model of the convection currents that cause molten rock to move in Earth's mantle

Materials & Equipment

- large beaker
- hot plate
- water
- food colouring
- long medicine dropper

Figure 11.33 Set-up for Quick Lab

Procedure

1. Add water to the large beaker until it is half full.
2. Set the beaker on the hot plate. Allow the water to become still.
3. Use a long medicine dropper or hollow glass tube (with your thumb on the end) to pick up some food colouring. Place the food colouring inside the beaker so that it forms a layer of colour at the bottom (Figure 11.33).
4. Slowly heat the beaker of water. Observe what happens to the food colouring.

Questions

5. What did you observe in the beaker as it was heated? Illustrate your answer with labelled "before" and "after" drawings of the beaker and food colouring to show the changes that occurred.
6. Compare the results of this activity with the information you have learned about convection currents in Earth's mantle. How is this activity similar? How is it different?

D36 *Inquiry Activity*

Toolkit 2

SKILLS YOU WILL USE

- Using appropriate equipment
- Reporting results

Crystallize Your Thinking

What happens when molten rock from deep in Earth's mantle travels upward toward the crust? It cools – in two different ways, depending on where it stops flowing. In this activity, you will observe both types of cooling by using a common element – sulphur.

Question

What happens when molten rock cools quickly or slowly?

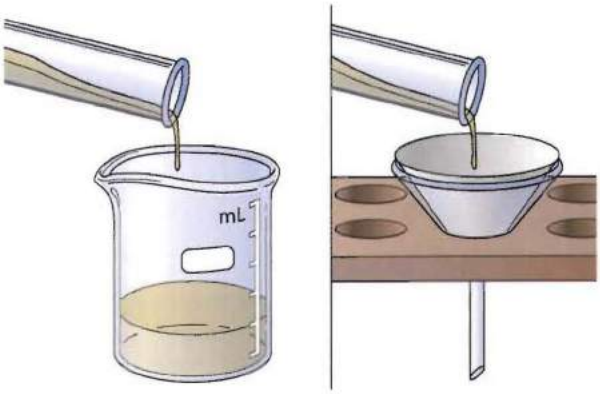


Figure 11.34 How does quick cooling affect the appearance of solid sulphur?

CAUTION:
- Use a fume chamber or adequate ventilation.
- Be careful when using a hot plate or Bunsen burner.
- Place the glass funnel upside down so that it will not roll off your lab surface.
- Do not remove any powdered or solid sulphur from the classroom.

Materials & Equipment

- powdered sulphur
- metal scoopula
- test tube holder
- 2 test tubes
- hot plate or Bunsen burner
- 400-mL beaker (if using a hot plate)
- 250-mL beaker of cold water
- circle of filter paper
- glass funnel
- test tube rack
- paper towel
- water

Hypothesis

When molten sulphur cools quickly, it will look like...
When molten sulphur cools slowly, it will look like...

Procedure

Part 1 — Quickly! Quickly!

1. Using the metal scoopula, add powdered sulphur to a test tube to about 6 cm depth.
2. Gently melt the sulphur following your teacher's directions.
3. When the sulphur has melted, quickly pour it into the 250-mL beaker of cold water.
4. Cool the test tube in the test tube rack.
5. When the sulphur has cooled, pour off the water from the beaker and place the solid sulphur on a piece of paper towel.

Part 2 — Slow as Can Be

6. Fold a piece of filter paper to form a cone.
7. Fit the filter paper into the glass funnel. Add a few drops of water to stick the paper to the glass. Place the funnel into the test tube rack.
8. Using the metal scoopula, add powdered sulphur to a test tube to about 6 cm depth. Melt the sulphur.
9. When the sulphur has melted, quickly pour it into the filter paper. Allow the sulphur to cool slowly.
10. Place the test tube into the rack to cool.
11. Compare the two samples of cooled sulphur. Break them open and observe the inside of each piece. Record your observations.
12. Clean up. Leave all pieces of sulphur in your classsroom.

Skill Builder

13. Compare the insides of the solid sulphur samples from Parts 1 and 2. Draw and label a diagram of each sample of cooled sulphur.

Analyzing and Interpreting

14. Suggest reasons to explain any differences between the sulphur samples from Parts 1 and 2.

Forming Conclusions

15. Consider your answers to points 13 and 14. Suggest how your observations in this activity might explain differences in rock formed in the mantle and at the surface of Earth.

11.3 CHECK and REFLECT

Key Concept Review

1. Name the four layers of Earth in order, from the outside to the centre.
2. Why is the term "crust" suitable for the layer of Earth where you live?
3. What are the names of the three classes of rocks?
4. What are the differences between magma and lava?
5. Suggest reasons why scientists are interested in studying Earth's layers.
6. A classmate suggests that heat is involved in producing all three classes of rock. Do you agree or disagree? State reasons to support your answer.
7. Suggest reasons to explain why garnet, opal, and topaz are considered to be gemstones.
8. Describe two differences between Earth's inner core and Earth's outer core.

Connect Your Understanding

9. Schist, shown on the right, is a type of rock formed when certain minerals are changed by heat and pressure. Which of the three classes of rock includes schist?

10. Compare the rock cycle to a cycle of events in your daily life. How are they similar? How are they different?

Practise Your Skills

11. On Page 330, three possible models are shown for Earth. One of these models is an accurate comparison. Which one is it? Explain the reason for your choice. Then, choose two or more additional examples that you could use to explain the layers of Earth to a friend.
12. Figure 11.32 on page 335 illustrates the rock cycle. Explain how weathering, erosion, heat, and pressure all cause changes in rocks. Design and draw a separate illustration for each part of your explanation.

For more questions, go to ScienceSource.

D37 *Thinking about Science and the Environment*

A Volcano in the Neighbourhood

People in many parts of the world (like Hawaii) live on or near an active volcano. Suggest several reasons to explain why people choose to do this. List the costs and benefits of such a life choice. Share your ideas with a partner, a group, or the whole class. Your teacher may ask you to research communities where people live close to volcanoes. Add the results of your research to your cost-benefit analysis.

Hurricane Katrina

Figure 11.35 A hurricane is a strong, spinning weather system over the ocean that has continuous wind speeds exceeding 119 km/h. Hurricanes form and grow stronger over tropical regions of the ocean as they pick up heat from the warm ocean water. This photograph shows Hurricane Katrina in August 2005.

At the end of August 2005, a devastating hurricane, Katrina, destroyed portions of the U.S. coast from southeast Louisiana to Alabama (Figure 11.35). Katrina was one of the worst natural disasters in North American history. Katrina's journey began in south Florida. While moving northward toward the central Gulf coast, Katrina strengthened into a Category 5 hurricane. Category 5 means continuous wind speeds greater than 250 km/h.

Katrina's winds became weaker before she touched down. But they were still strong enough to cause a near-record storm surge of ocean water. The winds and water caused widespread destruction and loss of life. The city of New Orleans was particularly hard hit when the dikes surrounding the city broke. Large sections of the city were flooded. Over 80 percent of the city and many areas of neighbouring communities were under water for weeks.

At least 1836 people lost their lives in Hurricane Katrina and in the flooding. Damage to buildings and farmland due to the storm is estimated to have been more than $80 billion (Figure 11.36).

Questions

1. You have read about the destruction caused by Hurricane Katrina. Propose at least three questions about the storm and damage. Record your questions in your notebook.
2. Hurricanes rarely strike Ontario. But on October 16, 1954, Hurricane Hazel, one of the most notable hurricanes in history, moved into Ontario as a powerful storm from the United States. Flash flooding from Hazel in Canada destroyed 20 bridges, killed 81 people, and left more than 2000 families homeless. Suggest several ways Ontarians can protect themselves from such powerful storms.
3. Imagine that you are a radio, television, or newspaper reporter. Write a script in which you describe the effects of a powerful hurricane on your community. Include the names of landmarks, cities, towns, and events that are affected by the hurricane you are describing.

Figure 11.36 Some of the flooding in New Orleans caused by Hurricane Katrina

11.0 Chapter Review

Assess Your Learning

After Reading Thinking Literacy

Reflect and Evaluate

Revisit your original questions from the beginning of the chapter. Have they all been answered? Summarize what you have learned about the value of asking questions as you read using the following organizer:

3-2-1 Review

- 3 things I learned about the comprehension strategy of asking questions
- 2 ways this strategy helped me as a reader
- 1 question I still have about asking questions

Share your 3-2-1 Review with a partner and discuss similarities and differences. Try to answer each other's final question.

Key Concept Review

1. Suggest three ways in which human activities depend on the atmosphere. K
2. The atmosphere is a mixture of materials. Name two of them. K
3. What is the name of the layer of the atmosphere in which we live? K
4. Which of the following would be a more accurate statement? Provide reasons for your answer. (a) The weather in Sudbury is warm and cloudy. (b) The weather in Ontario is warm and cloudy. C
5. What is the main source of Earth's energy? K
6. Name the two changes of state that are part of the water cycle. K
7. A classmate tells you that a meteorologist studies meteors (chunks of rock that travel through space). Explain why this statement is not accurate. C
8. Do the Sun's rays fall more directly on Ontario or on Florida? Explain your answer. Include a drawing with labels. C
9. How is heat distributed across Earth? Suggest two ways. K
10. How is weather different from climate? K

Connect Your Understanding

11. Name and describe two situations or machines in which it is important to filter air before it is used. You may want to use some of the items shown on this page in your answer. A
12. Ocean currents flow in patterns. Name three factors that influence these patterns. C

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

13. A chart of numbers, similar to the one below, can help you summarize new information. Draw your chart and fill it in, using information in this chapter. You may include more than one set of information in each box. The first box has been filled in for you. C

Number	New Information and Descriptions
2	two types of melted rock: magma (underground) and lava (on the surface)
3	
4	
5	

14. Summarize the three categories of ocean currents. Copy the chart below into your notebook. K

Type of Ocean Current	Description
warm surface currents	
cold surface currents	
deep ocean currents	

Practise Your Skills

15. Design and create a chart for the activities you have completed in this chapter. In your chart, include:

- each activity's number
- each activity's name
- a brief description of each activity
- a summary of your observations for each activity C

Unit Task Link

Driving cars, producing consumer goods, using electronic devices: all these use energy. Using energy releases heat into the air and into the bodies of water. Improved insulation in buildings would prevent or reduce heat loss. This would reduce the amount of energy used. Go to ScienceSource to research systems of insulation used in homes, schools, and office buildings.

D38 Thinking about Science and the Environment

S T E

Disaster Preparedness

Think about several ways that families and local communities can prepare for disasters such as hurricanes, ice storms, and wind storms.

What to Do

1. Draw a four column chart with the following column titles: Type of Emergency or Disaster, How Can My Family Prepare? How Can My Community Prepare? and, Why Is It Important?
2. Fill in the chart for several types of emergencies and disasters.

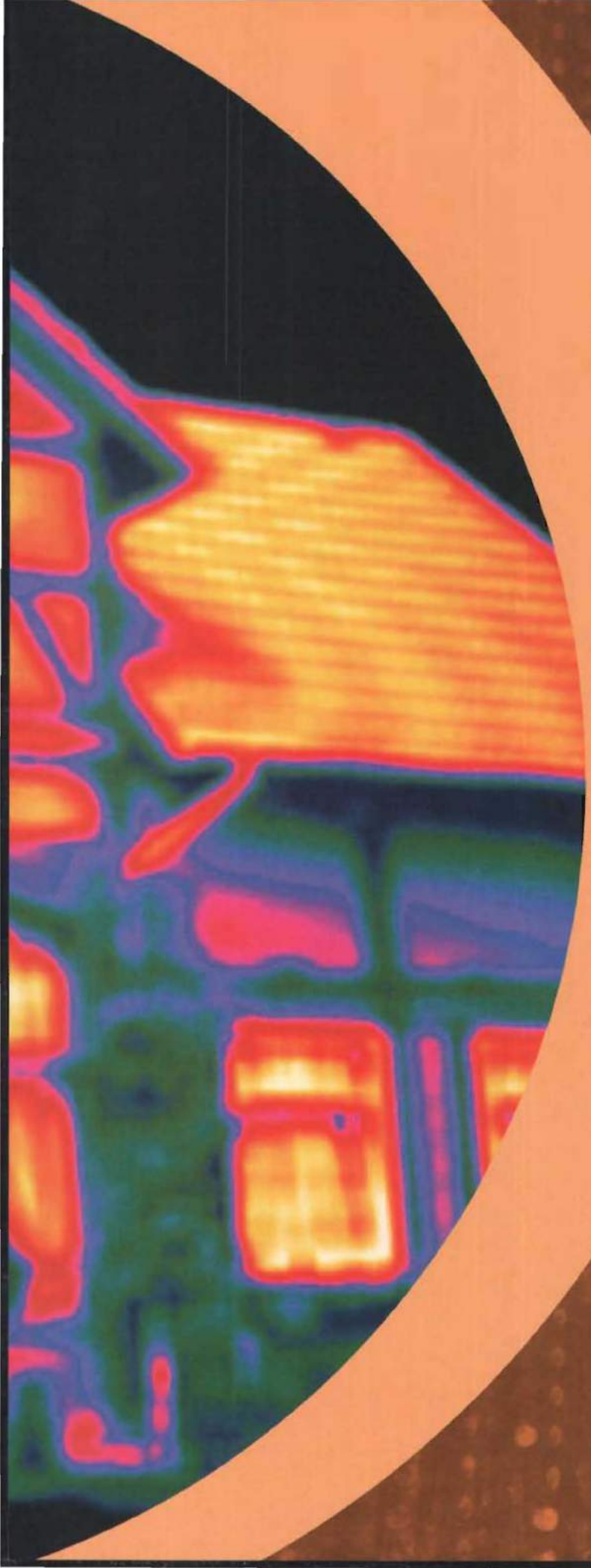
Consider This

Share your chart with a classmate. Add information to all four columns. Then, share your chart with a group or the whole class. Your teacher may ask you to prepare a poster so that other students can learn more about disaster preparedness.

Use the Internet to learn more about preparing for disasters and emergencies. Begin your search at ScienceSource.

12.0 Heat technologies offer benefits and require choices.

This photograph is a thermogram. It shows the distribution of heat over the surface of a house. White to yellow areas are warmest. Red to purple and green are coolest. The thermogram shows that the roof and windows of the house are poorly insulated, while the better-insulated walls lose less heat to the environment.



What You Will Learn

In this chapter, you will:

- demonstrate energy transformations that involve heat
- determine how you can reduce your use of energy
- discuss ways to decrease global warming

Skills You Will Use

In this chapter, you will:

- use scientific inquiry/experimentation skills to investigate heat transfer
- use a variety of ways to communicate with audiences

Why This Is Important

Heat has both positive and negative effects on the environment. Each of us has an important role to play in protecting the global environment. Canadians should be able to understand how technology can reduce heat loss. By reducing energy use, we make fewer negative changes in the world.

Before Writing

Thinking Literacy

Cause and Effect Pattern

Writers of non-fiction text use a variety of patterns to provide a structure for expressing their ideas clearly. Cause and effect pattern is one way to organize information. Think about what you know about cause and effect and look through this chapter for headings that might fit with this pattern. What other subject texts use this pattern for writing?

Key Terms

- energy converter
- heat island
- global warming
- heat pollution
- greenhouse gases
- climate change

12.0 Getting Started

Figure 12.1 These electrical transmission towers, and hundreds of others, were destroyed in the ice storm in 1998.

Ice storms are a common experience in most parts of Canada. They are especially common from Ontario to Newfoundland. The danger that an ice storm presents depends on the amount of ice that builds up and how long the storm lasts. The ice storm that lasted for five days in January 1998 was the worst ever recorded in Canada. From January 5 to 10, freezing rain, ice pellets, and a bit of snow fell — 85 mm in Ottawa, 73 mm in Kingston, 108 mm in Cornwall, and 100 mm in Montreal.

Without question, the storm directly affected more people than any previous weather event in Canadian history. The damage in eastern Ontario and southern Quebec was so severe that major rebuilding, not repairing, of the electrical system had to be undertaken (Figures 12.1 and 12.2). What it took human beings half a century to construct took nature a matter of hours to knock down.

Figure 12.2 The ice storm also caused problems for people living in big cities.

Farmers were especially hard hit. Dairy and hog farmers were left without electricity needed to keep animal shelters warm and to run milking machines. Many Quebec maple syrup producers lost the entire supply of their sugar bush.

What caused such a severe storm? Canadian scientists think that a worldwide weather pattern called El Niño may have played a role in the ice storm of 1998.

Winter disasters such as the ice storm disrupt the delivery of energy that we use to heat our homes and places of work. This use of heat is very important for daily life, business, and industry. Being prepared for such disasters is therefore an important part of life in Canada.

D39 Quick Lab

Keep Your Cool

If it's not protected from warmer temperatures, ice will melt quickly. There are different ways to prevent melting.

Purpose

To compare ways of preventing ice from melting

Materials & Equipment

- 10 ice cubes
- plastic cooler
- tote cooler
- newspaper
- paper towel
- towel
- triple-beam balance or kitchen scale

Figure 12.3 These pictures offer four ways to protect ice from the heat of the Sun and the air.

Procedure

1. Divide the class into five groups to test four possible ways to prevent melting of ice cubes.
   A: a plastic cooler B: a tote cooler
   C: a towel D: three sheets of newspaper
   E: no protection for the ice cubes
2. In groups, find mass #1 of two ice cubes, using the triple-beam balance or a kitchen scale. Record the mass.
3. Depending on your group letter, place the ice cubes in a cooler, or wrap them in the towel or the sheets of newspaper, or leave them sitting on paper towel.
4. Wait 30–45 min. Then dry the ice cubes with the paper towel.
5. Find mass #2 of the ice cubes using the triple-beam balance or scale.
6. Calculate the percent of ice remaining, using the following formula.

$$\%\ \text{ice remaining} = \left(\frac{\text{mass \#2 (g)}}{\text{mass \#1 (g)}} \right) \times 100\%$$

Questions

7. Which method was most effective in preventing the ice from melting?
8. How was heat transferred in this experiment?

12.1 Energy Transformations and Heat Pollution

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

- Heat is often released to the environment when energy is transformed.
- Producing energy can release heat and gases into the environment.
- Heat pollution of land, water, and the atmosphere affects the environment.

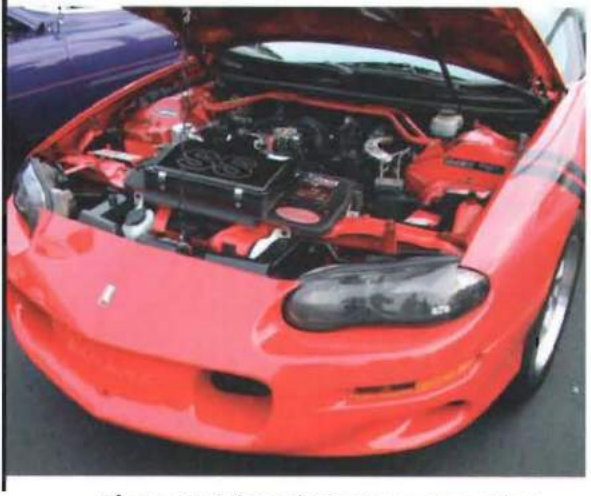


Figure 12.4 Sometimes energy conversions, like those in this vehicle, produce a lot of heat that is released into the environment.

Any device that transforms energy from one form to another is called an **energy converter**. The engine in your family car, a hair dryer, a computer hard drive, and a light bulb are all examples of energy converters (Figure 12.4). Energy converters can be much larger than these items. For example, the power plant that produces energy for your region is a very large energy converter.

Depending on where you live in Ontario, your community may obtain its electrical energy mainly from a thermal power plant that burns a fuel, such as coal or natural gas; a nuclear power plant that uses the energy stored in atoms; or a hydroelectric power plant that uses the energy of falling water.

D40 *Starting Point*

Skills A C

Go with the Flow

Since the 1970s, Canadians have been paying close attention to the energy we use (Figure 12.5). In 1973, the Organization of Petroleum Exporting Countries (OPEC) dramatically raised the price of oil by cutting back production. This caused the price of gasoline to jump in a few weeks from about 9 cents per litre to about 13 cents per litre. Compare that with today's prices and you will see that energy costs a lot more today! Starting at ScienceSource, collect and prepare a collage of images to illustrate the uses we have for fuels.

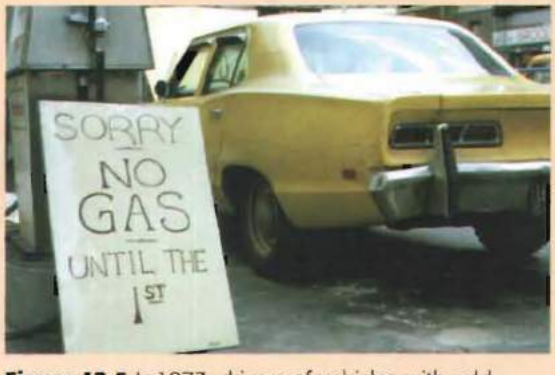


Figure 12.5 In 1973, drivers of vehicles with odd-numbered licence plates could buy gasoline only on odd-numbered days of the month. Even-numbered licence plates were limited to even-numbered days.

Hidden Costs of Power Plants

Each method of producing electricity has disadvantages. All of Ontario's power plants that burn coal may soon be closed or rebuilt to reduce air pollution and heat pollution (Figure 12.6). Nuclear power plants such as the Pickering, Darlington, and Bruce Nuclear Power Generating Stations use the energy stored in uranium atoms to produce electricity without air pollution (Figure 12.7). But there are other problems with nuclear energy. The disposal of heated waste water and how and where to store the nuclear waste that these plants produce are problems that need long-term solutions.

Ontario has more than three dozen hydroelectric generating stations. Hydroelectric power generation does not create air pollution (Figure 12.8). However, hydroelectric projects that include large dams may affect conditions in surrounding ecosystems. The hidden costs of power plants have led to the search for alternative sources of energy that have a less damaging impact on the environment.

Figure 12.6 The Nanticoke coal-fired power plant on Lake Erie burns coal to produce electricity. It is Ontario's worst-polluting power plant.

Figure 12.7 The Pickering Nuclear Power Generating Stations

Figure 12.8 The Lac Seul Generating Station, a hydroelectric power plant in northwestern Ontario

D41 *Learning Checkpoint*

Energy Conversion

1. What is the purpose of an energy converter?
2. Name three energy converters that you or your family use regularly.
3. Name three kinds of power plants that produce electricity in Ontario.
4. Describe the method of energy production for each of the three types of power plant you suggested.

Human Activities Produce Heat

You have learned that, in most energy transformations, the end result is the production of heat. A large quantity of heat may be produced, as in the engine of a car, or a small quantity, as in a student running a race. In all cases, the heat that is produced during an energy transformation is released into the environment.

Some human activities produce and release very large amounts of heat. This is particularly true in factories. Ontario manufacturers produce and ship hundreds of billions of dollars' worth of products every year. Most of this activity is found in the production of automobiles, metal, plastic and rubber products, computer products, chemical and petroleum products, machinery, and foods and beverages (Figure 12.9).

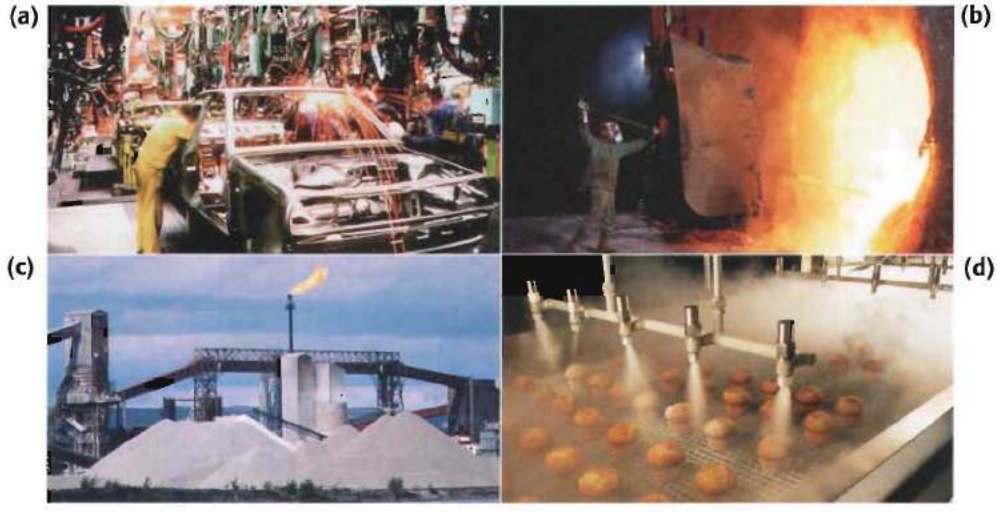


Figure 12.9 Manufacturing products for human use produces a lot of heat. **(a)** An auto assembly line **(b)** The blast furnace in a steel plant **(c)** Crushed limestone stockpiled for use in iron ore smelting **(d)** A baked-goods assembly line

Take It Further

Think about the different ways in which people produce energy to run our cities and farms. Then, use the Internet to gather information on the energy transformations that occur. Begin your search at ScienceSource.

Adding Heat to the Atmosphere

Ontario has many factories. The easiest way to cool down a factory is to release hot air directly from the building into the environment. This is done by bringing fresh air into the building with large fans, circulating it, and sending the warm air back outside the building (Figure 12.10).

A second method is to use an air-conditioning system. This allows control over the indoor temperature. A third method for cooling buildings and machines is to circulate cool water from a water system such as a river. The cool circulating water absorbs the heat of the building. The hot water then circulates outside, releasing the stored heat into the air. Sometimes, the hot water is released into water systems, as in the nuclear power generating stations described earlier.

Figure 12.10 Large fans such as these remove hot air from some buildings.

Adding Heat to Natural Water Systems

Heat from human activities is added to the environment. If the release of heat has negative effects on an ecosystem, the added heat may be described as **heat pollution**. Living things are very sensitive to changes in temperature. Adding heat to a river or lake may cause a big problem for organisms that live in the water and cannot easily find another place to live.

Adding heat to a water system poses another problem. Organisms in water systems breathe oxygen, just like you do. Adding even a small amount of heat to a water system causes less oxygen to be available in the water for the organisms that depend on oxygen for survival. The result is that the organisms can suffer from a lack of oxygen and may die (Figure 12.11).

Figure 12.11 Fish and other organisms die when there is not enough oxygen in a river or lake.

D42 *Quick Lab*

Heat Transfers Between Containers

Purpose

To measure and record changes in temperature between warmer and cooler liquids

Materials & Equipment

- two 400-mL beakers or small containers
- pail or large container
- thermometer
- warm water and cool water

Procedure

1. Add warm water to the pail to a depth of several centimetres. Half-fill the beaker with cool water.
2. Draw a data table to record the temperature (every minute for 20 min) of the warm water in the pail and the cooler water in the beaker.
3. Predict how the temperature of the water in the pail and in the beaker will change over 20 min. Record your predictions.
4. Use the thermometer to measure the starting temperature of the water in each container. Record your results in your data table.
5. Use the second beaker to add cool water to the pail and warm water to the beaker.
6. Measure and record the temperature in each container every minute for 20 min.
7. Draw and label a graph to show the change in temperature of the water in the pail. Colour your line. On the same graph paper, use a different colour to draw a graph to show the change in temperature of the water in the beaker. Include a legend and a title.

Questions

8. What happened to the thermal energy of the warm water added to the beaker?
9. Describe what happened to the temperature of the water in the pail.

12.1 CHECK and REFLECT

Key Concept Review

1. What happens to the heat that is produced during an energy transformation?
2. Name two or more ways in which buildings can be cooled.

3. What are two of the disadvantages of using coal as a fuel in power plants that produce electricity in Ontario?

Connect Your Understanding

4. How does a hair dryer act as an energy converter?
5. Name several energy transformations that release heat into the environment.
6. Describe two ways in which adding heat to water systems can be harmful to fish and other organisms that live in the water.
7. Why do you think Canadians have become concerned about gases and heat that are released into the environment every day?

Practise Your Skills

8. Draw a Venn diagram to compare and contrast the kind of fuel used and the kind of energy released by the three plants shown in Figures 12.6, 12.7, and 12.8 on page 347.

For more questions, go to ScienceSource.

D43 *Thinking about Science and the Environment*

Extra Energy

You have learned that human activities produce heat that ends up in the environment. This release of heat can affect living things.

Canada's population increases every year. How might this increase affect the amount of energy used and the amount of heat produced?

Consider This

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

1. In what ways can Canadians reduce their personal use of energy?
2. How can individual Canadians and communities be encouraged to use less energy? Suggest several ways.

12.2 Heat, Gases, and the Atmosphere

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

- Heat islands influence local weather conditions.
- Human activities release gases that might contribute to global warming.
- Climate changes are occurring in the environment.

Hot summer days can be a big problem for some city dwellers. In North America, more than 1000 people die each year due to high environmental temperatures. Many more are rushed to hospitals, suffering from heat-related illness.

Each year, the Toronto Public Health Department issues Heat Alerts and Extreme Heat Alerts. For example, in 2007, from May through August, 15 of these alerts were issued. To prepare for and respond to these serious situations, Toronto has developed the Hot Weather Response Program.

Figure 12.12 Help in the heat

D44 Starting Point

Skills A C

Heat Islands

In large cities, human activity can add a significant amount of heat to the environment. However, the way a city is built also has a big influence on the temperatures in and around it.

Look at Figure 12.13. Compare the rural areas, suburbs, and parks with the downtown areas. Suggest three or more reasons for the temperature differences that you observe.

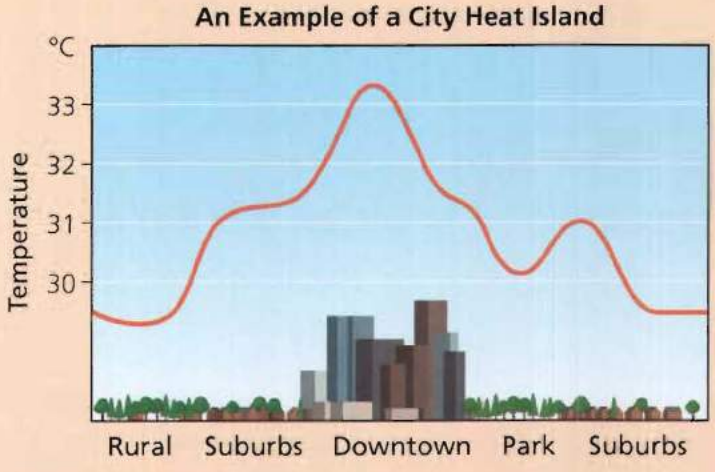


Figure 12.13 This graph shows how a typical city is warmer than the surrounding areas. Air temperatures are usually measured about 1.5 m above the ground.

Heat Islands

A **heat island** is a region of a city that has higher air and surface temperatures than its surroundings. The temperature difference is usually greater at night than in the day and greater in winter than in summer. It is most obvious when winds are weak.

Heat islands form as cities grow and replace natural land cover with buildings and pavement (roads and sidewalks). The increase in temperature in and above a heat island depends on an area's natural weather and climate, closeness to water bodies like lakes and oceans, and land forms like nearby mountains and valleys.

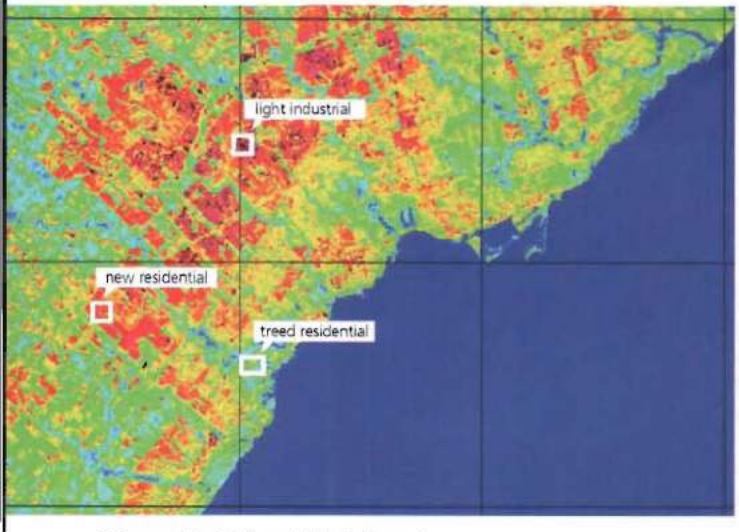


Figure 12.14 A satellite infrared image of Toronto. Yellow and red colours indicate higher temperatures.

Climate scientists use infrared satellite photographs to measure the size of heat islands (Figure 12.14). This information allows city planners to prepare for heat emergencies during hot summers, to determine regulations for building sizes and heights, and to gauge how much parkland and green spaces a city needs.

Heat islands also affect the surrounding areas. For example, scientists have found that partly as a result of the heat island effect, monthly rainfall is about 28 percent greater in areas 10–20 km downwind of some cities compared with upwind. In the winter, some cities in cold climates may benefit from the warming effect of heat islands. In general, the harmful summertime effects from heat islands are greater than the wintertime benefits.

D45 *During Writing*

Thinking Literacy

Cause or Effect or Both?

Cause and effect writing gives reasons for why something happened or is happening. You have just read about heat islands. What features of cities cause heat islands to form and grow in size? Develop a simple graphic organizer to show the cause and effect relationship between heat islands and their causes.

Extend your thinking further. Can heat islands also be a cause for something else? In another organizer, show some of the effects of heat islands on local weather conditions. Reread the last paragraph on heat islands to find signal words the writer used. Can you think of other signal words a writer might use in cause and effect pattern?

Monitoring Gases in the Atmosphere

Each time you breathe out, you release carbon dioxide and other gases. Each time your family drives you to school or a shopping centre, the family car releases carbon dioxide and other gases. One person, one family, and one automobile may not seem to be a problem. However, each of us adds many thousands of litres of carbon dioxide to the atmosphere every year. Millions of Canadians with millions of automobiles and billions of people on Earth add billions of litres of carbon dioxide to the atmosphere each year.

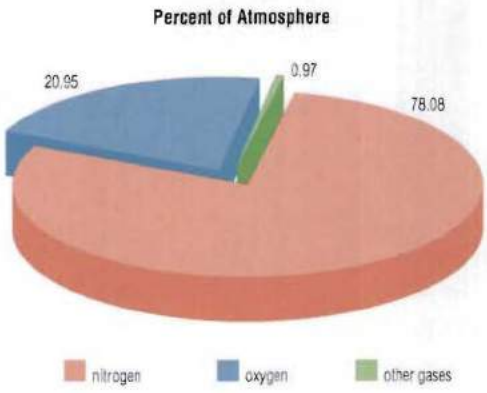


Figure 12.15 The main components of the air we breathe

You might wonder if this large amount of additional carbon dioxide affects the planet. You would not be alone. Scientists in many countries are investigating this question.

Earth's atmosphere contains many gases, including nitrogen, oxygen, and argon. These three gases make up about 99 percent of the air we breathe (Figure 12.15). Carbon dioxide normally makes up only 0.037 percent of air. Because carbon dioxide is naturally present in air, it is not considered to be a pollutant. But the amount of carbon dioxide that humans are adding to air has become a concern for scientists, governments, and citizens in many countries, including Canada.

What Is the Greenhouse Effect?

If you place a sealed glass container in sunlight or under a strong light, the air inside the container quickly becomes hot. This is like the inside of an automobile becoming hotter than the air outside on a cold, sunny day in winter (Figure 12.16). It is also like a greenhouse, where the glass sides and roof allow the Sun's radiation to enter, trapping the heat, warming the air, and helping plants to grow.

In some ways, our planet also acts like a greenhouse. Earth's atmosphere is like the glass sides and roof of the greenhouse or the glass windows of an automobile. The atmosphere allows radiation from the Sun to reach Earth's surface. Several of the gases in the atmosphere, like carbon dioxide, trap this heat, warming the land and oceans (Figure 12.17 on the next page).

Figure 12.16 The air inside this automobile is much warmer than the air outside.

Figure 12.17 The greenhouse effect. Some of the radiant energy from the Sun is trapped near Earth's surface by gases in the atmosphere that act like the glass in a greenhouse.

Some of the energy that reflects back into the atmosphere from the land and oceans also warms the air. Gases in the atmosphere that trap heat are called **greenhouse gases**. Water vapour, carbon dioxide, methane, and nitrogen oxides are all examples of greenhouse gases.

The **natural greenhouse effect** is the natural range of temperatures that Earth experiences because the greenhouse gases in the atmosphere trap energy from the Sun. Without these gases, heat would escape back into space and Earth's average temperature would be about 16°C colder.

The Enhanced Greenhouse Effect

Human activities, such as burning non-renewable fuels like gasoline and coal release greenhouse gases into the atmosphere. Most scientists who study climate support the theory that these activities are contributing to an **enhanced greenhouse effect** (Figure 12.18). This effect is due to the build-up in the atmosphere of higher than normal amounts of greenhouse gases.

Table 12.1 shows some of the common sources of greenhouse gases, natural and related to human activity. It also shows some ways of reducing emissions of these gases.

Take It Further

What is Canada doing to meet its commitments under climate change agreements such as the Kyoto Protocol? Begin your search at ScienceSource.

Figure 12.18 The enhanced greenhouse effect: Human activities are adding more greenhouse gases to the atmosphere. Many scientists agree that this causes more heat to be trapped, causing Earth's temperature to rise. This is called global warming.

Table 12.1 Greenhouse gases

Greenhouse Gas	Common Ways the Gas Is Released into the Environment	Possible Ways to Reduce Emissions
Water vapour (H_2O)	• Through the water cycle	• Reduction of water vapour is not needed.
Carbon dioxide (CO_2)	• When humans and other animals breathe out • When non-renewable fuels are burned in power plants and in vehicles	• Decrease use of non-renewable fuels, and increase alternative methods of energy production. • Use alternative fuels to power vehicles.
Methane (CH_4)	• From natural sources: wetlands, termites • When grazing animals digest food • When non-renewable fuels are extracted from deep underground by drilling	• Decrease use of non-renewable fuels, and increase alternative methods of energy production. • Develop ways to use natural methane.
Nitrogen oxides (NO_x)	• From natural sources in soils • From fertilizers on farms • When gasoline is burned in vehicles	• Use alternative fuels to power vehicles. • Reduce fertilizer run-off.

Global Warming

Scientific data indicate that Earth's climate has become warmer over the past 150 years. This worldwide average increase in temperature of Earth's atmosphere, land, and oceans is called **global warming**. The warming has been increasing more quickly over the past 20 years. This change in the climate has become a concern for Canadians and for citizens in many countries.

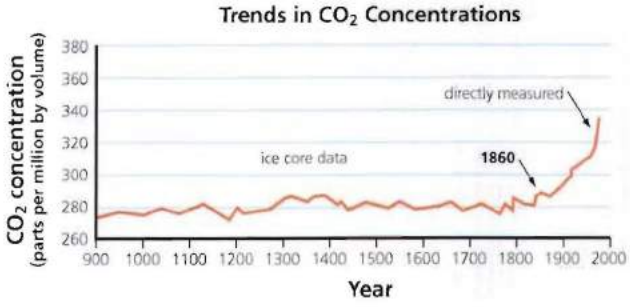


Figure 12.19 Changes measured for carbon dioxide gas in Earth's atmosphere

Most scientists agree that the rise in average temperature is related mainly to increases in greenhouse gases in the atmosphere over the same period, since about 1860 (Figures 12.19 and 12.20). These scientists believe that we must quickly and significantly decrease or change human activities that release greenhouse gases or that prevent nature from controlling the gases.

Figure 12.20 Scientists use ice cores from the Arctic and Antarctic to obtain information about carbon dioxide levels in the atmosphere over hundreds of years. They analyze gases in air bubbles trapped in the ice.

What Are We Doing? What Needs to Be Done?

Most Canadians, as well as citizens around the world, believe we must take action now. Agreements like the **Kyoto Protocol** (1997), which has been signed by more than 160 countries, call for countries such as Canada to reduce greenhouse gas emissions from all sources. Unfortunately, the levels and deadlines that have been agreed to will be very difficult for countries, including Canada, to meet.

D46 *Inquiry Activity* Toolkit 2

SKILLS YOU WILL USE
- Recording and organizing data
- Analyzing patterns

Make Your Own Greenhouse

Question

What happens to the temperature inside a sealed glass container when a strong light shines on the container?

CAUTION: Do not tap the glass thermometers against other objects.

Materials & Equipment

- 2 large Erlenmeyer flasks
- 1-holed rubber stopper to fit the flask
- thermometer to fit the hole in the rubber stopper
- second thermometer
- watch or timer

Hypothesis

Suggest what might happen when sealed and unsealed flasks are placed in a strong light. Then, propose a reason to explain your statement.

Procedure

1. Your teacher will provide you with a rubber stopper for one of the flasks. A thermometer has been carefully pushed through the hole in the stopper.
2. Gently push the rubber stopper onto the neck of one flask. The thermometer should be several centimetres above the inside bottom of the flask.
3. Leave the second flask open (Figure 12.21).
4. Prepare a data table similar to Table 12.2. Measure the temperature of the air inside the sealed flask. Ask a partner to check the measurement, and then record the temperature in your data table.

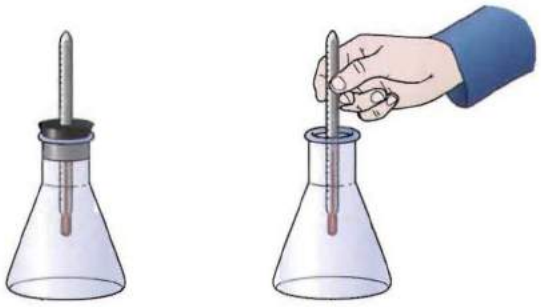


Figure 12.21 Set-up for activity

5. Hold the second thermometer so that it is not touching the inside surface of the open flask. Measure the temperature of the air inside the open flask. Ask a partner to check the measurement. Record the temperature in your data table.
6. Place the two flasks in a safe place under a strong light or in sunlight for two minutes.
7. Repeat steps 4 and 5, without moving or shading either flask.
8. Take further measurements until your data table is complete.

Table 12.2 Temperature in two flasks

Time (min)	Temperature of Sealed Flask (°C)	Temperature of Open Flask (°C)
0 (starting)		
2		
4		
6		
8		
10		

Skill Builder

9. Follow your teacher's directions for drawing a graph for the data you have collected.

D46 *Inquiry Activity* (continued)

Analyzing and Interpreting

10. Describe the pattern(s) shown by the two lines on your graph.

11. Compare this activity with the description of the greenhouse effect earlier in this section. How are they similar?

12. Compare this activity with the description of the greenhouse effect earlier in this section. How are they different?

13. Suggest a reason for using the open flask in this activity.

Forming Conclusions

14. Suggest one or more reasons to explain the two patterns in temperature measurements that you have observed in this activity.

D47 *Decision-Making Analysis*

Toolkit 4

SKILLS YOU WILL USE
- Gathering information
- Summarizing information

Reduce, Re-use, Recycle, Recover

Issue

To find personal choices that might affect greenhouse gas emissions. To consider ways to use fewer products, reduce waste, and decrease energy use.

Background Information

Every day, Canadians buy, use, and throw away huge amounts of material in all types of useful products and the packaging that comes with them. Heat is involved in manufacturing, packaging, transporting, and storing these products. And then we must deal with what we throw away. For example, Ontario produces more than 9 million tonnes of garbage per year. The City of Toronto alone produces more than 1 million tonnes of garbage per year.

1. Use a mind map or chart to brainstorm examples of how we produce garbage. Set up four categories: at home, at school, in the workplace, and in leisure activities.

2. Draw a two-column chart. Print titles for each column: column A: Examples of Garbage; column B: Methods to Reduce Garbage.

3. Transfer your brainstorm ideas to column A using the four categories. Leave several blank lines at the end of each category.

4. Use column B to suggest how individuals, families, businesses, and institutions, such as your school, can reduce waste.

Analyze and Evaluate

5. Share your chart with a classmate or group. Use a checkmark to indicate which of your ideas were also listed by other students. How many of your ideas from column A or column B were listed by others?

6. Using the lines you left blank, add more ideas for each category to your columns.

7. With your group, select several of the ideas from column B. Prepare a short class presentation in which each member of your group plays a role in explaining and demonstrating the points your group has selected. In your presentation, include pictures, samples, or video clips of products that you are describing.

12.2 CHECK and REFLECT

Key Concept Review

1. Suggest ways in which heat islands contribute to city temperatures.
2. How do heat islands affect the surrounding regions?
3. Which three gases make up most of Earth's atmosphere?
4. Name four greenhouse gases in Earth's atmosphere.
5. What do scientists measure to estimate global warming? You may have several answers to this question.
6. How is the enhanced greenhouse effect different from the greenhouse effect?

Connect Your Understanding

7. Suggest reasons why rural areas (away from cities) cool off faster than cities.
8. How is a greenhouse a good model for Earth and its atmosphere?
9. Unlike humans, dogs do not sweat. How can we help dogs to stay cool when outdoor temperatures rise?
10. Planners estimate that, by the year 2025, two-thirds of the world's population will live in cities. What effects do you think this will have on urban heat islands?
11. If carbon dioxide makes up only 0.037 percent of Earth's atmosphere, why are scientists so concerned about the amount of carbon dioxide that humans add to the atmosphere each day?

Practise Your Skills

12. Create a diagram that compares the natural greenhouse effect with the enhanced greenhouse effect.

For more questions, go to ScienceSource.

D48 *Thinking about Science and the Environment*

Read All about It

In this chapter, you have read how human activities add heat and greenhouse gases to the atmosphere. Now it is time to find out how this information has been reported to the public. Begin your search for "greenhouse gases" at ScienceSource. Select at least three websites.

Read as much as you can and, using your own words, summarize the information. Record the names and URLs of all the websites you have selected. Be prepared to discuss your summary in class.

12.3 Managing Heat Issues

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

- Global warming and climate change affect the environment.
- Wise use of heat and other forms of energy helps the environment.
- Ontario is developing a variety of alternative methods for energy production.

Ontario and the other provinces, as well as the government of Canada, are all concerned about reducing the use of fossil fuels and the release of greenhouse gases. Many projects, such as wind farms, involve an alternative energy source. Erie Shores Wind Farm is one of the most advanced **wind energy** development projects in Ontario. It includes more than 13 000 acres in Norfolk County and Elgin County along a 29-km stretch of Lake Erie (Figure 12.22). Other alternative energy sources are the Sun's rays, which provide **solar energy**, the heat deep in Earth, which provides **geothermal energy**, and the force of tides and waves in the ocean, which produce **tidal energy**.

A *renewable fuel* can be replaced in a short period of time. **Biofuels** are fuels that are produced from living things such as plants. Biofuels can be used as an alternative to non-renewable fuels such as oil and natural gas. Ethanol and biodiesel are the two main biofuels widely used today. In Canada, ethanol is made from wheat in the western provinces and from corn in Ontario and Quebec. An Ottawa-based company is a world leader in using straw to produce ethanol.

Figure 12.22 Erie Shores Wind Farm

D49 *Starting Point* Skills A C

Sorting Things Out

Your teacher will provide you with a set of energy tags. Each tag contains a tip for saving energy in your home. By yourself or with a classmate, follow your teacher's directions for classifying the energy tags. Classify by sorting the energy tags into categories so that the tags in a category are somehow related. Give each category a title. Then, record the information on the tags in your Energy Tag Recording Page. Have fun reading, learning about, and classifying your energy tags!

Energy Use in Canada

Figure 12.23 Energy is used to produce recreation equipment.

Figure 12.24 Gasoline and other fuels power a variety of vehicles.

In Canada, energy is used to produce:

- all the products you use, and all the containers you throw away (Figure 12.23)
- your share of the gasoline and other fuels that keep our vehicles moving (Figure 12.24)
- your share of fuels that produce the electricity that you use at home
- your share of the heat used to produce hot water for washing dishes and clothes and for showers and baths

The energy industry and transportation contribute the greatest share of emissions. For individual Canadians, transportation accounts for almost half of greenhouse gas emissions, mostly due to automobile use. Energy use in homes accounts for the other half. We might ask:

- How willing will Canadians be to reduce their use of automobiles and their use of energy at home?
- Are Canadians prepared to reduce energy by recycling and reducing waste as much as possible?
- Are Canadians willing to use and throw away fewer products at home, at school, and on the job?
- Should Canadians and Americans take these actions even if citizens in other countries choose not to?

D50 *During Writing*

Thinking Literacy

Point, Proof, Comment

Writers use different strategies to help them record, sort, and identify relationships among the information they gather for their writing. Use a "Point, Proof, Comment" organizer to record notes as you read the next page on the impact of climate change. Your point will be that global warming seems to be causing climate change.

As you read, write down information that supports your point – this is your proof. Record your own thoughts and ideas in the "Comment" part. Use the information in your organizer to write a cause and effect paragraph. Use signal words appropriate to this type of writing to connect your ideas.

The Impacts of Climate Change

Global warming seems to be causing **climate change**, which we can define as any major change in the climate of a region of Earth that lasts for a long period of time. Changes in Earth's wind patterns, average temperature, precipitation including rainfall, and the number and strength of extreme weather conditions such as floods and hurricanes, may be indicators of climate change. Figure 12.25 shows some of the effects of rising sea levels, increased temperature, and changes in rainfall. Every part of life will be affected.

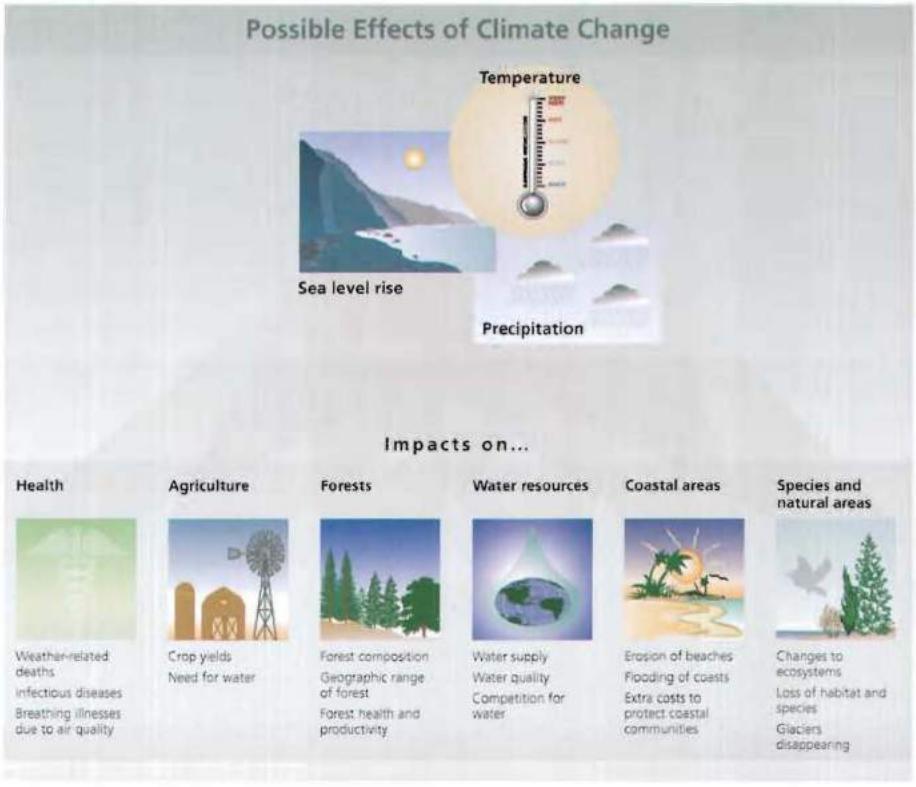


Figure 12.25 Possible effects of global climate change on Earth

Canada at Risk

Some results of climate change are already here. Canada's Arctic is warming faster than anywhere else on the planet. Certain regions have already experienced average temperature increases of as much as 3°C in the past 50 years. Nearly 1 million square kilometres of ocean ice have already disappeared, posing serious problems for seals, polar bears, and people who live in the Arctic.

Canada's forests are also at risk. For example, due to many years of warm winters, a tiny insect called the mountain pine beetle has been slowly moving through the forests of British Columbia and has now entered Alberta. The result? Since 1993, millions of lodgepole pine trees are dead or dying. Scientists have not found a way to combat this tiny killer (Figure 12.26). By 2013, it is expected that the beetle will have wiped out 80 percent of the pine forest.

Figure 12.26 The mountain pine beetle is only the size of a grain of rice but in huge numbers can have a very big effect. Mountain pine beetles and a fungus they carry kill trees. The needles turn a bright red, showing where the tiny insects have been. Colder winters are needed to stop the beetle's spread.

Solving the Problem of Too Much Heat

If adding carbon dioxide and other greenhouse gases contributes to global warming, then the solution would seem to be obvious — decrease the activities that produce and release greenhouse gases. But this is not a simple problem.

First, all countries do not contribute equally to the problem. Canada and the United States are two of the largest emitters of greenhouse gases. The United States produces 25 percent of the carbon dioxide pollution from fossil-fuel burning—by far the largest share of any country. Also, millions of tonnes of methane are released, due to drilling for oil and gas. And, according to a study by the United Nations, Canada's total carbon dioxide emissions for the year 2002 made Canada eighth on a list of almost 200 countries. Canada is one of the greatest consumers of energy per person, with each of us burning the equivalent of roughly 7700 L of oil per person each year.

One scientific report suggests that major reductions of carbon dioxide emissions will be required by all nations. For example, the United States would need to reduce by at least 80 percent below year 2000 levels by the year 2050. The question is: is such a large reduction possible in so short a period of time?

Global Warming – The Good News

Listening to the news and reading newspapers and Internet articles may make the current global warming situation seem hopeless. But, it is not. What can one person do?

- First, you can learn more about and support scientists who are studying climate change. Every year, measuring technology improves. This allows us to take different kinds of measurements and to make our measuring more accurate.
- Second, support politicians, organizations, and individual Canadians who are concerned about global warming and who are making efforts to inform Canadians. These efforts should help us begin to repair the environment.
- Third, become aware of the positive steps that countries, organizations, and citizens are taking to inform people and to help make the changes needed to reduce global warming.

- Fourth, continue to learn about Canadian issues related to global warming. Read newspaper, magazine, and Internet articles that discuss greenhouse gases.
- Fifth, discuss your concerns with your friends, family, school community, and local government representatives. Writing letters that contain accurate scientific information is often a useful means of communication.

The images in Figure 12.27 will help you to understand other aspects of the global warming issue and to see that some positive steps to combat global warming are being taken.

Figure 12.27 (a) Ontario has banned the sale of incandescent light bulbs (i) after 2012. New efficient lighting such as compact fluorescent bulbs (CFLs) (ii) use around 75 percent less electricity than standard old-fashioned incandescent bulbs.

Figure 12.27 (b) The farmers who grow crops in this field may benefit from global warming. Warmer atmospheric temperatures could produce longer growing seasons. As well, we might be able to grow new crops due to warmer temperatures and a longer growing season.

Figure 12.27 (c) A study conducted in 2007 indicates that warmer atmospheric temperatures result in fewer colds in the winter. However, this result was obtained from only a single study; more research is needed.

Figure 12.27 (d) Climate change and rising temperatures can lead to drought and the loss of farmland to the desert. Canadian technology is helping scientists in Israel to make clean water available. This technology can then be used in other places where a lack of water currently prevents crops from being grown.

Figure 12.27 (e) Technologies that exist today have already produced hybrid automobiles. These vehicles consume less gasoline than other vehicles by running partly on electricity from rechargeable batteries inside the vehicle.

Figure 12.27 (f) A study conducted in 2003 in Australia found that the amount of methane gas had remained steady for four years. Methane is released into the atmosphere from the production of rice, cattle, and sheep; from landfills; from natural wetlands; and from the mining and use of fossil fuels such as coal, oil, and gas.

What Is Happening in Ontario?

Today, much of Ontario's electricity is produced by burning coal to produce electricity and by using uranium in aging nuclear power plants. These methods release greenhouse gases and heat into the environment.

Ontario is moving toward producing energy that does not involve burning fuels. These sources of electrical energy are called **green renewable power** because they do not harm the environment by producing gases or heat pollution. The newer methods of green renewable power that Ontario is developing include solar energy, wind energy, bioenergy, and geothermal energy (Figures 12.28, 12.29, and 12.30). Since 2003, Ontario has begun more than 60 renewable energy projects (Figure 12.31).

Figure 12.28 Solar energy panels such as these can produce electricity for thousands of homes.

Figure 12.29 The power of the wind is everywhere.

Figure 12.30 In winter, geothermal heat pumps, like this one in Iceland, use liquid in underground pipes to draw heat from deep within Earth. In summer, the pumps work in reverse, extracting heat from inside a building and discharging it underground. In Ontario, about 8500 homes and 500 buildings have already installed geothermal systems, which eliminate the usual heating and air-conditioning systems.

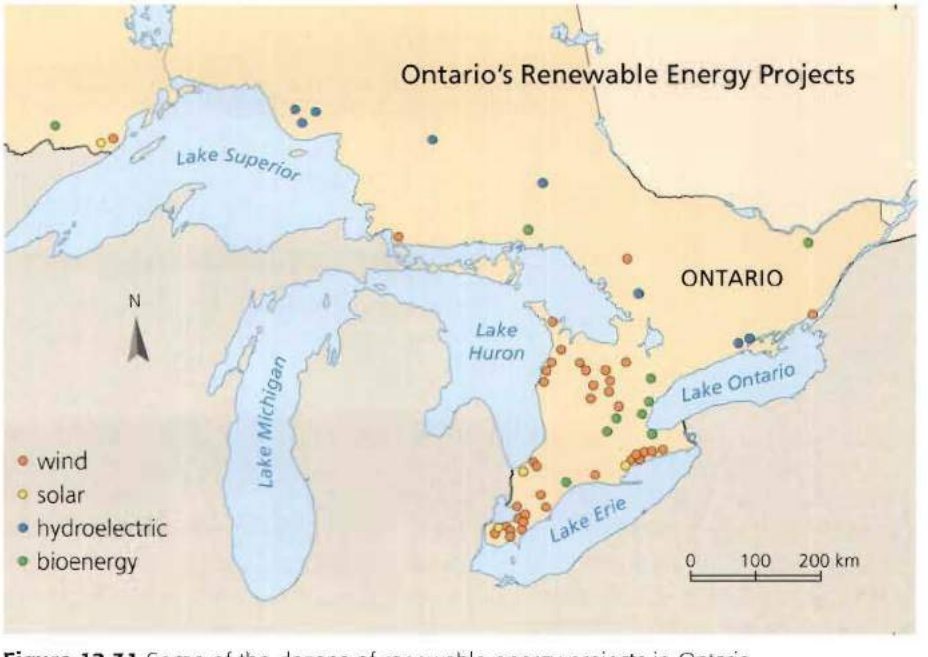


Figure 12.31 Some of the dozens of renewable energy projects in Ontario

SKILLS YOU WILL USE
- Recording information sources
- Stating a conclusion

Cutting Energy Costs

Issue

How can our community reduce the financial and environmental costs of home energy use?

Background Information

A home is more than just rooms, furniture, and a roof. It is an interactive, constantly changing set of spaces that includes a system for heating and cooling. In part, a home provides living and sleeping spaces and appliances for controlling the temperature of all spaces, water, and food.

Green buildings are structures that are built or refitted to use less energy and less water than the average structure. Many consumers and business owners realize that living and working in a green building is good for the environment, can provide a healthier living space or workplace, and can also save money.

We spend up to 90 percent of our time indoors. This requires year-round energy use for heating and cooling. In Canada, heating indoor spaces accounts for 60 percent of home energy use. Energy-reducing strategies mean that less fuel may be necessary to heat buildings, and using less fuel means producing fewer greenhouse gases. There are many ways to reduce the energy use of a building. A green roof is one way. Using new designs for windows is another. Around 20 percent of the heat lost from an average home is through the windows.

1. Select a method to reduce home energy use and/or reduce its effect on the environment from the list of homes provided. Or, choose your own method to research, after consulting your teacher.
   - a home that uses geothermal heating or a heat pump
   - a home that uses high levels of insulation in the attic and walls as well as energy-saving windows and a high-efficiency furnace
   - a home that uses solar energy to heat water
   - a home that includes a green roof
2. Research your topic. Begin your research at ScienceSource. Find out how the method you chose reduces energy use and/or reduces effects on the environment.
3. Prepare a report in your own words that provides background information and images. Include a glossary (words and their meanings) of the new vocabulary you have learned in your research. Also, include a bibliography of websites (URLs and website names) or reference materials you have used in your research.

Analyze and Evaluate

4. Form a group with classmates who have chosen other methods. Share your report. The group should try to reach consensus (agreement) on one or two of the methods that are the best choices for your community. Be prepared to report your decisions to your class.
5. How did the class groups rate the methods? Design and complete a chart to summarize the results.
6. While the groups are reporting to the class, record some of the reasons why they chose these methods.
7. Why is more energy used in Canada for indoor heating compared to most other countries? Suggest several reasons.

12.3 CHECK and REFLECT

Key Concept Review

1. Name several predicted effects of climate change.
2. For individual Canadians, which two human activities produce the greatest proportion of greenhouse gas emissions?
3. Describe two ways that Canada's environment is at risk from global warming.
4. List four ways that individual Canadians use energy produced from oil.
5. Briefly describe how geothermal heat pumps provide heating and cooling to buildings.

Connect Your Understanding

6. Design and draw a chart to name and summarize three kinds of green renewable power being developed in Ontario. Include a small drawing or piece of clip art for each.

Practise Your Skills

7. Figure 12.27 on page 363 illustrates six categories of possible impacts (changes) due to global warming. Select one of these categories. Then, write a sample "Letter to the Editor" for your community newspaper in which you discuss this category using your own words.

For more questions, go to ScienceSource.

D52 *Thinking about Science and the Environment*

It's Your Choice

Dr. Jane Goodall, the well-known scientist, has remarked: "Every individual matters. Every individual has a role to play. Every individual makes a difference." This is especially true in dealing with global climate change.

What to Do

Your teacher will provide you with a list of Terrific Tasks you can do. Use the rating form provided by your teacher or develop your own rating form in your notebook. Rate each item as one of the following:

- Use 1 if you feel you can accomplish this Terrific Task.
- Use 2 if you feel that you need more information before you can accomplish this Terrific Task.
- Use 3 if you think this Terrific Task is beyond your control or if you would be unwilling to try it.

Consider This

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

How many of the Terrific Tasks did you rate as number 1; as number 2; as number 3?

Figure 12.32 The Energy Star label indicates an energy-efficient consumer product.

DAILY PLANET

Making Connections

Jay Ingram

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

The Snake and the Squirrel

Heat is something we feel. We love it in winter and try to avoid too much of it in the summer. We are pretty sensitive to heat, right? Maybe, but our sensitivity is nothing compared to that of the rattlesnake.

Rattlesnakes are superb hunters. They hunt mostly in the dark, watching out for small mammals like ground squirrels. But they are not actually *watching* in the way you might think. For one thing, they are not using their eyes. They are using pit organs in their muzzles just behind their nostrils. And they are not looking, they are *scanning* for infrared radiation – what we call heat.

Infrared is the same as light, except that its wavelengths are too long for our eyes to see. When you turn on the stove element, it is glowing in the infrared long before you can actually see it turning red.

Body heat is infrared radiation. The body heat of a small mammal like a ground squirrel is a beacon to a rattlesnake. Pitch dark or not, it does not matter–the snake can target and strike without ever using its eyes.

This ability gives the snake a deadly piece of hunting weaponry, but, as often happens in nature, there is a defense. In this case, it is employed by the California ground squirrel. When confronted by a rattlesnake, the squirrel does something called "tail flagging," waving its tail rapidly back and forth in front of the snake. At the same time, the squirrel pumps blood into its tail to make it hot.

Imagine what this is like for the snake! Instead of a tempting, vulnerable target, it is suddenly confronted with overwhelming fireworks of infrared, lashing back and forth, suggesting a much larger prey than it had reckoned with. In the lab, the snake hesitates and even backs off.

This defense is tailored specifically for rattlers: squirrels do not bother to heat up their tails when faced with gopher snakes, which lack the infrared receptors. But the irony is that the squirrel itself cannot detect infrared, so it is only doing what has worked for thousands of its ancestors in the past – without knowing why.

12.0 Chapter Review

Assess Your Learning

Key Concept Review

1. What is heat pollution? K
2. Describe a heat island. K
3. Name two problems resulting from the operation of nuclear power plants. K
4. What is biofuel? Name two types of biofuels. K

Connect Your Understanding

5. Developing Atlantic salmon (salmonids), shown on the left, prefer a water temperature of 17°C. If the water temperature varies by even 1°C, there is a reduction in growth of 8 percent. Suggest how global warming might affect the growth of salmon and other fish species. C
6. How is global warming different from climate change? K
7. How can you and your family contribute to reducing your greenhouse gas emissions? A
8. Why is Canada especially sensitive to climate change? Use the map below to help you suggest several reasons. T

After Writing *Thinking Literacy*

Reflect and Evaluate

Exchange the cause and effect paragraph you wrote on the impact of climate change with a partner. Compare the signal words you and your partner used in your paragraphs. Were there any similarities or differences?

How did knowledge of the cause and effect pattern of writing help you as you read your partner's paragraph? What other science topics would best suit a cause and effect pattern?

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

9. Why do you think most of Ontario's renewable energy projects are located in southern Ontario? Suggest several reasons (see Figure 12.31 on page 364). C

10. Although we have many concerns about global warming, there are also positive signs. Look back through this chapter. Examine the information sections and the illustrations. Suggest several positive indicators that provide hope that humans can reduce our use of energy and Earth's resources. D

11. Today, many Canadians are concerned about greenhouse gases released into the atmosphere by transportation (cars, trucks, ships, airplanes). Suggest some of the changes that could be made to reduce these emissions. In your answer, consider attitudes, how we obtain data on emissions, publicity, and vehicle design. E

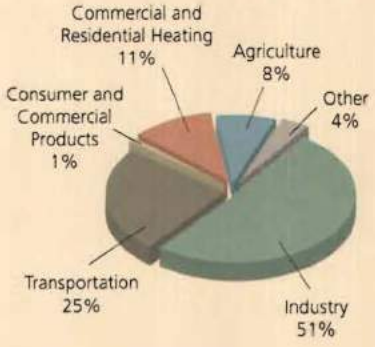
Practise Your Skills

12. Examine the pie chart on the right that shows greenhouse gas production in Canada. Identify the three major sources of greenhouse gases in Canada. A

13. Design and create a mini-poster or website home page to describe one type of alternative energy source that is in use or is being developed in Ontario. Begin your search at ScienceSource. For a Web page, include links to related websites. Include a relevant, creative title. B

Unit Task Link

Canadians endure some of the coldest outside temperatures in the world, so our country is one of the greatest consumers of energy. People's reliance upon energy is a major factor in the warming of the atmosphere. One way to reduce energy use is to improve the quality of insulation used in Canadian buildings.



D53 Thinking about Science and the Environment

Take Action Now

In this unit, you have learned that heat causes changes in the environment. Many of these changes may not be good for the environment or for humans.

What To Do

By yourself, then with a partner or group, develop an action plan to reduce the amount of energy used and released by you, your family, and your community. In your action plan, consider what you want to do and how you will communicate your information to others.

Consider This

1. Who will your audience be?
2. Suggest a time line for your action plan.
3. How will you "deliver your message" to your intended audience?

UNIT D Summary

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

KEY CONCEPTS

- Energy can be transformed and transferred.
- Heat is the transfer of thermal energy.
- Heat affects the volume of solids, liquids, and gases.
- Heat is transferred in three ways: conduction, convection, and radiation.

CHAPTER SUMMARY

- There are different forms of energy. Energy can be changed from one form to another.
- Thermal energy is the total energy of all the particles in a sample of matter. Temperature is the average energy of all the particles.
- Heating results in the expansion of solids, liquids, and gases. Cooling results in the contraction of solids, liquids, and gases.
- Heat is obtained by burning fossil fuels, from uranium, and from renewable heat sources. Heat is produced in all energy transformations.
- Cooking food and heating buildings are examples of human activities that transfer heat through conduction, convection, and radiation.

11.0 Heat plays an important role in nature.

KEY CONCEPTS

- Earth's atmosphere is divided into five layers.
- Earth's crust is constantly changing because of conduction and convection.

CHAPTER SUMMARY

- The layers of Earth's atmosphere are: the troposphere, the stratosphere, the mesosphere, the thermosphere, and the exosphere.
- Radiant energy from the Sun affects natural systems, including the water cycle and the weather.
- Ocean currents contribute to the movement of thermal energy and help to balance the extremes of temperature on Earth's surface.
- The rock cycle helps us to understand how heat causes changes in Earth.

12.0 Heat technologies offer benefits and require choices.

KEY CONCEPTS

- Human activities produce heat and greenhouse gases.
- Each person can play a role in protecting the global environment.
- Climate change may produce huge effects on ecosystems.

CHAPTER SUMMARY

- Heat pollution is heat that has negative effects on an ecosystem.
- Gases in Earth's atmosphere that trap heat and warm the planet are called greenhouse gases.
- Global warming describes the worldwide increase in average temperature that may lead to climate change.
- Ontario is developing a variety of alternative methods for energy production.

UNIT D Task

Keeping Our World Cool and Our Homes Warm

Getting Started

Insulation materials inside the outer walls of buildings help prevent heat loss to the outside air. By using insulation, Canadians can save energy and reduce the amount of greenhouse gases produced.

Your Goal

To determine how the properties of insulation materials relate to heat loss

What You Need

- 2-L clear soft drink bottle with screw cap
- selection of insulating materials
- crushed ice or snow in a large cooler
- thermometer
- hot water (50–60°C)
- elastic bands
- stopwatch
- putty or modelling clay
- ruler

CAUTION: Be careful when handling hot water.

Steps to Success

1. Create a table to record your time and temperature observations. Measure and record room temperature.
2. Punch a hole though the screw cap. Insert the thermometer so that the tip rests about halfway down in the bottle. The thermometer should extend above the cap so that you can observe the temperature readings. Use putty or modelling clay to seal the entry point.
3. Remove the screw cap with the thermometer and put it in a safe place.
4. Choose one of the materials to be tested as insulation. Wrap the bottle firmly and secure the insulation blanket with elastic bands. The insulation should be exactly **2 cm** thick on all surfaces of the bottle, including the bottom.
5. Add 1.7 L of hot water to the bottle. Immediately screw on the cap, which holds the thermometer. Start the stopwatch. Record the time and water temperature. Place the bottle into the snow (ice) cooler.
6. Record the temperature every 2 min for 20 min or until it approaches room temperature.
7. Pour the water out of the bottle. Repeat steps 3 to 5 with the other insulating materials.
8. Finally, repeat the procedure with a bottle that has not been wrapped in any material. This is your control.
9. Using the data in your table, graph your results for each insulating material you tested and the control.
10. List the samples in order from best insulator to worst insulator.
11. Examine the physical properties of the samples. Are there any common traits among the good insulators? The poor insulators? What makes a material a good insulator?
12. When you have finished the activity, follow your teacher's instructions for recycling the plastic bottles and other materials, if possible.

How Did It Go?

13. Would the insulating materials that you tested be equally effective in preventing heat from entering a building? How would you test this? Why would builders or home-owners be interested in knowing this?
14. Were all of the groups' results the same as yours? What might cause your findings to be different from those of others?

UNIT D Review

Key Terms Review

1. Design and draw a mind map that includes the terms below and any other new terms you have learned in this unit.

- atmosphere
- climate change
- conduction
- convection
- energy converter
- global warming
- greenhouse gas
- heat
- heat pollution
- ocean current
- particle theory of matter
- radiation
- rock cycle
- temperature
- thermal energy
- volcano
- water cycle
- wind

Give your central idea an original title, and use the titles of the three chapters as the main headings on your map. Use dashed lines to connect similar ideas that occur in more than one part of your map. Write a phrase or sentence along each connecting line to explain why you connected these ideas. K

Key Concept Review

10.0

2. Provide three or more examples of energy transformations in which thermal energy is produced. C

3. What are some examples of fossil fuels? K

4. Explain the differences between thermal energy, heat, and temperature. C

5. Explain how convection heats up your bedroom in the winter. C

6. Identify the form(s) of energy described in each of the following situations. You may need to list more than one form of energy for some of these situations. K

(a) studying for a science test at home

(b) eating an apple as a snack

(c) toasting bread

(d) using a microwave oven (**Hint:** Think carefully here.)

7. Use a Venn diagram with two circles to compare and contrast fossil fuels and renewable energy sources. K

8. Describe and illustrate three situations in which heat is transferred by conduction, convection, and radiation. C

11.0

9. What is the atmosphere? K

10. List the steps in the formation of raindrops in the atmosphere. C

11. Name the changes of state that are part of the water cycle. Indicate the change(s) that release heat and the change(s) that require heat. K

12. Why is it important for scientists to study ocean currents and their patterns? C

13. List the geographic features that make up Earth's crust. K

14. Name two events that may occur as a result of the movement of the plates below Earth's crust. C

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

15. How does heat play a role in the formation of igneous and metamorphic rocks? C

16. Less than one-billionth of the Sun's energy reaches Earth. What happens to this energy? (**Hint:** check Figure 11.7.) K

12.0

17. Name three or more energy converters that you use often. C

18. What do we mean when we say "greenhouse effect"? K

19. List three common ways that nitrogen oxides are released into Earth's atmosphere. K

20. Describe two possible ways of reducing the emission of carbon dioxide into Earth's atmosphere. K

21. List three Canadian animals or plants that may be at risk as a result of global warming. Describe why each one is at risk. C

Connect Your Understanding

22. Chapter 12 provides an example of heat pollution that describes how heat affects the amount of oxygen in a river or lake. Describe another example of heat pollution and its effects on the environment. C

23. As you hold a cup of ice cream, heat transfers from your hand to the cup and then to the surface of the ice cream touching the cup. What type of heat transfer does this describe? K

24. Identify a human activity that uses a large amount of electrical energy. Describe its effect on the environment. C

25. Infrared radiation can pass through transparent solids (like the windshield of a car) and colourless gases (like the air inside a car). On a sunny day in winter, the air in a closed car can become quite warm. Suggest a reason to explain why this happens. (**Hint:** Think about the other two types of heat transfer.) C

26. Figure 10.31 on page 303 compares the motion of particles to that of curling rocks. Select your own real-world example to make a comparison with particle motion. C

27. How does the engine of an automobile act as an energy converter? C

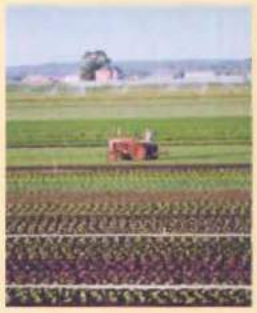
28. Compare the inner and outer cores of Earth. C

29. The word diamond comes from the Greek word *adamas*, which means indestructible. What role does heat from Earth play in producing diamonds and other valuable gems? C

30. Draw a Venn diagram with three circles. Label the circles *igneous rocks*, *sedimentary rocks*, and *metamorphic rocks*. Then, use the information you learned in this unit to fill in the circles. K

31. Installing double-pane and triple-pane windows on a building greatly reduces heat loss. Which of the three forms of energy transfer are reduced by these energy-efficient windows? C

32. Using satellite images, researchers have found that city climates influence the growing seasons of plants up to 10 km from a city's edges. Growing seasons in 70 cities in eastern North America were about 15 days longer in urban areas than in rural areas outside a city's influence. How would this affect the type of crops that farmers plant in and near cities? C



33. Would you expect higher air temperatures in summer above a city or above its surrounding suburbs? Provide reasons for your answers. C

34. Fill in a number chart similar to the one below, using information in this unit. You may include more than one set of information in each box. The first box has been completed for you. K

Number	Chapter	New Information and Descriptions
2	10	two types of melted rock: magma (underground) and lava (on the surface)
2	11	
2	12	
3	10	
3	11	
3	12	
4	10	
4	11	
4	12	

35. Could wind energy be an effective method of producing electricity in your region of Ontario? Provide reasons for your answer. A

36. Scientists estimate that approximately 23 billion tonnes of carbon dioxide (CO_2) are added to Earth's atmosphere every year. That is more than 700 tonnes every second.

(a) Name several human activities that produce CO_2. K

(b) How is CO_2 production related to the enhanced greenhouse effect? C

37. In April 2007, the Ontario government announced several renewable energy projects, including one of the world's largest solar energy farms. Why is solar energy considered to be a renewable form of energy? C

38. Think about the human activities that are important in your region of Ontario. For example, your region might include a high level of agriculture (farming), forestry, fishing, or mining. Develop a list of five or more human activities in your region of Ontario that depend on knowing about the weather. C

39. Think back to the new ideas and activities related to heat and the environment that you have seen in this unit. What changes have you already made in your daily activities? What changes do you plan on making? What further ideas do you think you need to research or explore? You could respond to these questions in writing or in an original, visual form. C

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

Practise Your Skills

40. Draw a circle and write "Greenhouse Gases" inside it. Draw four lines radiating out of the circle, and draw a small circle at the end of each line. Write "water vapour" in one of the circles. Write the names of three other greenhouse gases in the other small circles. To each of the greenhouse gas circles, attach a line that ends at a description of a common source of the gas. To each source, attach a comment that indicates whether it is necessary to reduce emissions of this gas or not. C

41. Construct a comparison matrix that compares four human activities that produce a very large amount of heat with the characteristics "heat the atmosphere" and "heats natural water systems." C

Revisit the Big Ideas

42. When the Sun shines on a metal doorknob on the outside of a home, what happens to the inside part of the doorknob? Write a paragraph to explain this. Use the words "heat," "particle theory," and "conduction" in your answer. C

43. You have learned how humans need and use heat and about the effects of adding heat to the environment. Write a letter to the editor of your school or regional newspaper to describe how your ideas changed since you began studying this unit. C

44. Create a home page for a website that informs viewers about our concerns for the environment as discussed in Chapter 12. Add additional Web pages and links that provide further information. Start your search at ScienceSource. C

D54 *Thinking about Science, Technology, Society, and the Environment*

STSE

Tie It All Together

At the beginning of this unit (pages 274 and 275), you learned about the concept Think Globally, Act Locally. You read about the efforts and creativity of some Ontario residents who care about energy and Earth's environment. Now, it is your turn! Brainstorm a list of climate awareness projects that you, your classmates, your family, and/or your community could develop in your local area. Choose one of these projects and create your own EAP – Environmental Action Plan. Design an original mini-poster to illustrate your EAP. Consult with your teacher to determine how your EAP can be put into effect.