UNIT D Water Systems

Unit Overview

Fundamental Concepts

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

- Sustainability and Stewardship
- Systems and Interactions
- Change and Continuity

Big Ideas

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

- Water is crucial to life on Earth.
- Water systems influence climate and weather patterns.
- Water is an important resource that needs to be managed sustainably.

Overall Expectations

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

1. assess the impact of human activities and technologies on the sustainability of water resources
2. investigate factors that affect local water quality
3. demonstrate an understanding of the characteristics of Earth's water systems and the influence of water systems on a specific region

Water is so valuable that some people have called it "blue gold." This image, taken at Rushing River Provincial Park, near Kenora, Ontario, seems to reflect that idea.

Exploring

Many children in the world must spend so much time getting water for their families that they often have little or no time left to go to school.

Without water, there would be no life. All living things need water to survive. Humans, for example, cannot live for more than a few days without water. We cannot breathe, digest food, or grow without water. Almost two-thirds of our body is composed of water, and we need to drink about 1–2 L of water daily to keep our organs working properly.

Water is also essential to the survival of other animals and plants. Even animals and plants that live in the desert require water to stay alive.

Imagine how your life would change if you had to walk several kilometres a day to fetch water for drinking, cooking, and washing.

Canada's Water Wealth

People cannot drink ocean water because it is too salty. We can drink only fresh water. In Canada, there is no shortage of fresh water. We never have to go far to see or stand beside a river, lake, pond, or wetland. Most of us have clean, potable water piped right into our homes. Potable water is fresh water that is safe and suitable for drinking. It is water that is free of harmful microorganisms and does not have an unpleasant taste, smell, or appearance. In many countries, the supply of potable water is limited.

Limited Supplies of Clean Water in the World

Access to clean drinking water is very limited in many places on Earth. This is especially a concern where the world's largest populations live. China and India, for example, have more than one billion people each. That equals about 35 percent of the world's total population. Those two countries, however, have only about 10 percent of the world's entire freshwater supply.

By comparison, the Great Lakes hold 20 percent of the world's freshwater supply. Yet, less than 1 percent of the world's population uses the lakes as a source of drinking water.

Not having easy access to water affects the way a person lives. Millions of people, most of them in Africa and Asia, must spend several hours each day collecting water for their daily needs. In many cultures, this task is the responsibility of the women and children in a household. They may have to travel as far as 6 km every day to collect one or two heavy containers of water.

As Earth's population continues to grow, so will demand for potable water.

The Great Lakes provide almost 10 million Canadians and more than 30 million Americans with fresh drinking water.

...MORE TO EXPLORE

D1 *Quick Lab*

Taking a Closer Look at Earth's Population

Our world population is expected to reach nine billion by the year 2050. All of these billions of people, along with every other living thing on our planet, are expected to share the same amount of water that we have on Earth right now.

Purpose

To investigate how Earth's population has grown and to compare that with the growth of bacteria

Materials & Equipment

- population data for Earth
- population data for one kind of bacterium
- graph paper
- pencil
- ruler

Procedure

1. Using the population data for Earth that your teacher gives you, draw a graph of Earth's population growth. Plot time on the *x*-axis and population size on the *y*-axis.
2. Using the bacteria population data that your teacher gives you, draw a graph of the bacteria population's growth. Plot time on the *x*-axis and population size on the *y*-axis.
3. Give both graphs a title.

Questions

4. (a) Describe the shape of the curve for Earth's population.
   (b) Describe the shape of the curve for the bacteria population.
   (c) How are the shapes similar?
5. During what years did most of Earth's population growth happen?
6. The bacteria population data that you were given was for bacteria that were allowed to grow in a test tube. Eventually, the population will die off because they will use up all of the nutrients in the test tube. Suppose that Earth is our "test tube." As a class, discuss how a limited supply of water would affect the growth of Earth's human population.

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

S T S E

Caring for Our Global Water Supply

Not everyone understands how essential potable water is to the survival of living things. You are part of a group that wants to start an awareness campaign about the importance of caring for and respecting our water supply.

Your group is designing a poster that would communicate three key messages to the general public about this issue. What three things do you think your group should say on the poster?

UNIT D

Contents

Unit Task

Clean drinking water may be a human right, but it is not easily available for an estimated 1.1 billion people worldwide. In the Unit Task, you will use a simulation to experience in a small way the effort of having to collect water daily from a community well for your family's needs. You will then analyze the idea that water is more valuable in places where it is less available.

Essential Question

Can the value of clean, safe water be determined in terms of the time and effort needed to gather and store the resource?

Getting Ready to Read

Thinking Literacy

Activating Prior Knowledge

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

10.0 Water on Earth exists in different states and is always moving and changing.

These icebergs, floating in the Atlantic Ocean just offshore from a Newfoundland community, will gradually melt away completely.

What You Will Learn

In this chapter, you will:

- identify the three states of water on Earth
- describe how Earth's water is distributed and how it circulates
- explain what a watershed is
- explain how large water bodies influence weather and climate

Skills You Will Use

In this chapter, you will:

- follow established safety procedures when using apparatus in labs
- use scientific inquiry and research to investigate water on Earth
- use appropriate science and technology vocabulary in oral and written communication

Why This Is Important

Understanding how and where water exists on Earth helps us to understand how water systems affect our lives and how our activities affect water systems.

Before Reading

Thinking Literacy

Determining Importance

Read each statement in the summary box at the start of section 10.1. Write down the key words in your notebook. Next, look for these words in section 10.1. What pattern do you notice about where these key words appear? How does this help you determine what the important concepts are as you read?

Key Terms

- salinity
- water table
- polar icecap
- groundwater zone
- aquifer
- watershed
- heat capacity

10.0 Getting Started

Figure 10.1 Vast amounts of goods are shipped up and down the St. Lawrence River by freighters.

Figure 10.2 Location of the St. Lawrence River

The St. Lawrence River has long been like a highway from the interior of North America to the world (Figure 10.1). It starts in the Great Lakes and flows more than 3000 km to the Atlantic Ocean, passing through Ontario and Quebec (Figure 10.2).

The St. Lawrence has supported human life for thousands of years. First Nations and, much later, European explorers and settlers travelled, hunted, fished, and farmed along the river. Today, millions of people live near the St. Lawrence. Large cities, factories, and industrial areas are located along its edges. Many people still depend on the river and its tributaries for drinking water.

In the 1950s, a series of canals and locks were built along parts of the river so that even large freighters could safely pass between the river and the Great Lakes. Before that, many rapids and shallow areas made the journey treacherous.

All of this human activity has caused high levels of pollution in the river over the past century. Oil spills and the dumping of chemical waste by industries are two major sources of this contamination.

One victim of the river's pollution is the beluga whale (Figure 10.3). Studies have found high levels of toxins in the bodies of these whales. Mercury, lead, and other chemicals are common. Scientists believe that the food the whales are eating, such as eels, is what is being contaminated first. Industrial waste along the Great Lakes and upper part of the river has polluted the eels' habitat, and they are absorbing that waste.

Efforts have been under way for nearly two decades to help the St. Lawrence River's beluga population recover. Solving the pollution problem is a necessary first step.

Figure 10.3 The beluga whales of the St. Lawrence River are suffering the effects of the river's pollution.

D3 *Quick Lab*

Would You Drink It?

It is not just the beluga whale that concerns scientists. A growing number of animal species are at risk from pollutants in our water systems. We know that diluting pollutants in large bodies of water does not solve the pollution problem. In this activity, you will test this for yourself.

Materials & Equipment

- 6 test tubes, each containing 10 mL water
- test tube rack
- 6 rubber stoppers or plastic wrap
- 1 mL cornstarch
- 1-mL dropper pipette
- iodine solution

Procedure

1. Add the cornstarch to the first test tube. Cover the tube with a rubber stopper or plastic wrap and shake well.
2. Before the mixture settles, use the pipette to remove one pipette volume from this test tube and put it into the second test tube. Cover and shake well. Rinse the pipette with clean water.
3. Repeat steps 2 and 3 until all test tubes contain about 1 mL from the tube before it.
4. Add one drop of the iodine solution to each test tube. Record what happens.

Questions

5. Iodine turns purple in the presence of a starch.
   (a) Describe the colour variations in the six tubes.
   (b) Did any test tube show an absence of cornstarch?
6. If you had used a toxic substance instead of cornstarch in your mix, would you drink the water from any of the diluted samples? Explain your answer.

10.1 Earth's Supply of Water

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

- Water exists on Earth in three states – liquid, solid, and gas – and is constantly changing from one state to another in a never-ending cycle.
- About 70 percent of the planet is covered with water, most of which is salt water contained in oceans.
- Fresh water exists on Earth's surface, under its surface, and in its atmosphere.
- A watershed is an area of land in which all water present (lakes, rivers, wetlands, and underground sources) eventually drains into one large main water body.

Earth is a very watery planet. About 70 percent of its surface is covered by water.

As you may recall from previous studies, there are two kinds of water: **salt water** and **fresh water**. If you have ever visited an ocean, you know that the water tastes salty. The reason for this is that the concentration of dissolved salts in ocean water averages 3.5 percent. **Salinity** refers to how much salt is dissolved in water. Fresh water also contains dissolved salts, but in amounts of less than 1 percent.

D4 Starting Point

Skills P C

Water Systems Alphabet

Working with a partner, write the letters of the alphabet in a list in your notebook. Think of a word starting with each letter, that describes a place that water is stored or found naturally. Use the pictures in Figure 10.4 (a) to (c) to get you started. As you work through this chapter, you will be able to add to the list.

(a)

(b)

(c)

Figure 10.4 Start your list by adding the names of these three water objects to it.

It is salt water that fills the world's oceans and makes up 97 percent of the water on the planet (Figure 10.5). Fresh water, the only water we can drink, represents only 3 percent of Earth's total water supply, but even that is not in a state we can easily use. Most of the planet's fresh water occurs as ice and snow or moves through the ground below the surface. Therefore, although water is abundant on Earth, the water that is readily available to use is in much smaller supply.

Figure 10.5 Most of Earth's water lies in its oceans.

Three States of Water

Water exists on Earth in three states: liquid, solid, and gas. You will remember the processes that change water from one state to another. Add enough heat to liquid water and it evaporates, changing into a gas (water vapour). Take enough heat away from liquid water and it freezes into its solid state.

Figure 10.6 shows the distribution of water on Earth.

Liquid Water

Liquid water is found both above and below the ground.

WORDS MATTER

A reservoir is a place for collecting and storing something. The word comes from the French *réserver*, meaning to reserve.

Surface Water

The oceans are massive bodies of surface salt water, with an average depth of 3.2 km. They are often called the planet's water reservoirs.

Surface fresh water is a common sight everywhere in Canada. It is the water in rivers, streams, lakes, ponds, and wetlands (such as marshes and swamps). In many communities, fresh water is also collected in human-made reservoirs such as artificial lakes and water towers. Precipitation (such as rain and snow) helps keep these water bodies filled.

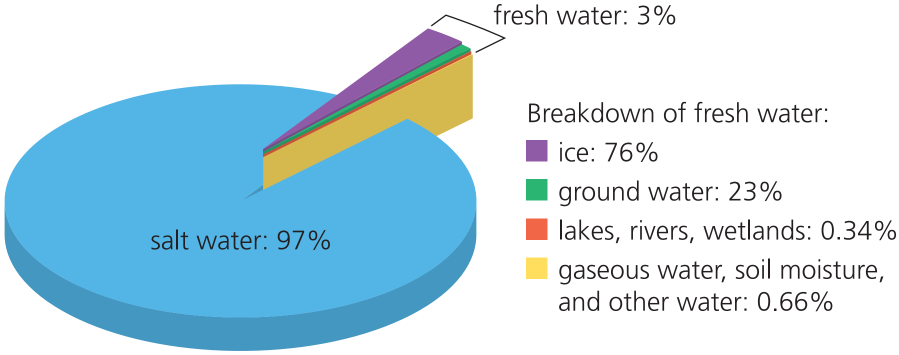


Figure 10.6 The distribution of water on Earth

Underground Water

It might be hard to believe, but more of Canada's fresh water exists underground than on the surface. This underground water is called ground water. In fact, scientists estimate that one-third of the world's fresh water lies underground.

As rainwater falls, it soaks into the soil and flows down between the soil particles. Slowly it continues draining downward through more soil and rocks until it reaches a layer that is difficult to permeate (meaning pass through). This may be a layer of rock or a very compact layer of clay. The area where water fills all the air spaces in the soil and in the tiny cracks in the rock is called the **groundwater zone**. This freshwater storage zone exists in all soils, but the depth differs from region to region. The upper surface of the groundwater zone is called the **water table** (Figure 10.7).

Some rock and soil layers in the ground exist in such a way that allows large amounts of water to collect within them naturally. This underground freshwater reservoir is called an **aquifer**. Most rural homes and small farms drill **wells** (long, hollow shafts) down into aquifers to obtain fresh water.

Ground water is always moving slowly out of our sight. Eventually, it reaches a wetland, river, lake, or ocean, or flows to the surface in what is called a natural spring. Where ground water reaches the surface in a desert, an oasis forms.

Suggested Activity
D8 Inquiry Activity on page 288

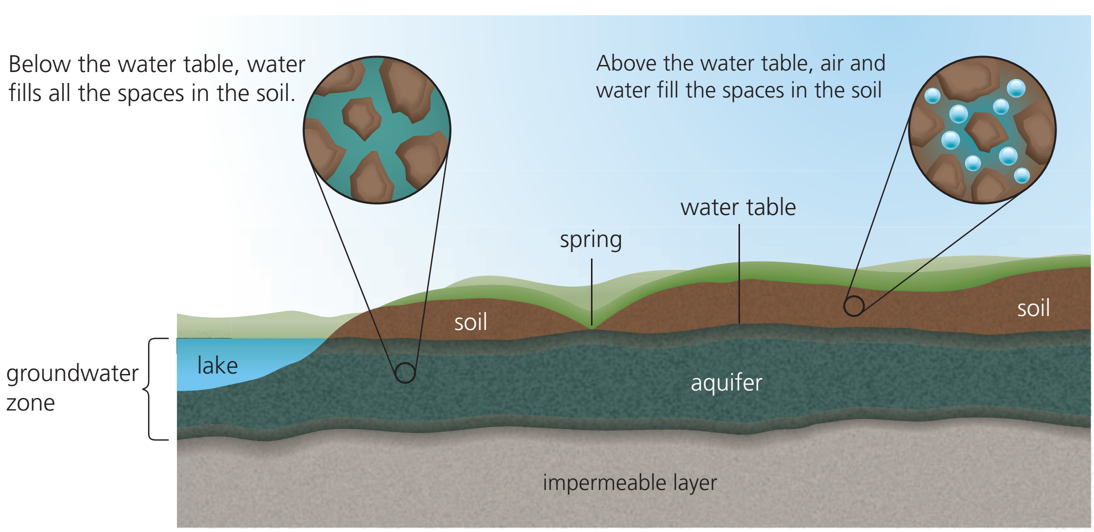


Figure 10.7 Fresh water below ground

D5 Learning Checkpoint

Liquid Water

1. What distinguishes salt water from fresh water?
2. How much more salt water is there on Earth than fresh water?
3. What is the upper surface of the groundwater zone called?

Solid Water

All of the solid (frozen) water on Earth is fresh water. Ocean water can freeze, but salt water requires a lower temperature than fresh water does to become ice (Figure 10.8). How much colder depends on the salinity of the water, but an average freezing temperature for ocean water is –1.8°C. As well, because the salt in salt water does not freeze with the water, all ocean ice becomes frozen fresh water.

In Earth's polar regions and on the tops of its high mountains, most fresh water exists in a solid state as ice and snow. It is estimated that glaciers and ice sheets contain more than 40 million km^3 of frozen fresh water.

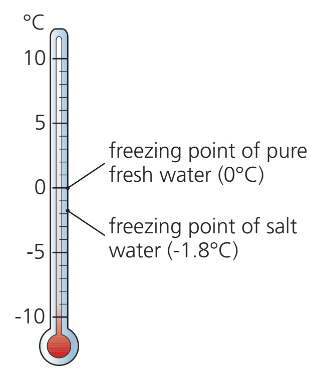


Figure 10.8 Salt water needs a colder temperature than fresh water to freeze.

Mountain Glaciers

In many mountain regions, temperatures are below freezing much of the year and the snow that falls never gets a chance to melt. The snow accumulates over centuries, producing a mass that becomes heavier and thicker. Over time, as the snow in the lower layers becomes more compacted, most of the air spaces are squeezed out. As this happens, the compacted snow begins to change into a solid mass of ice. A **glacier** is a mass of ice and overlying snow that moves slowly down a mountain slope under the influence of gravity (Figure 10.9).

Figure 10.9 The Salmon Glacier in northwestern British Columbia

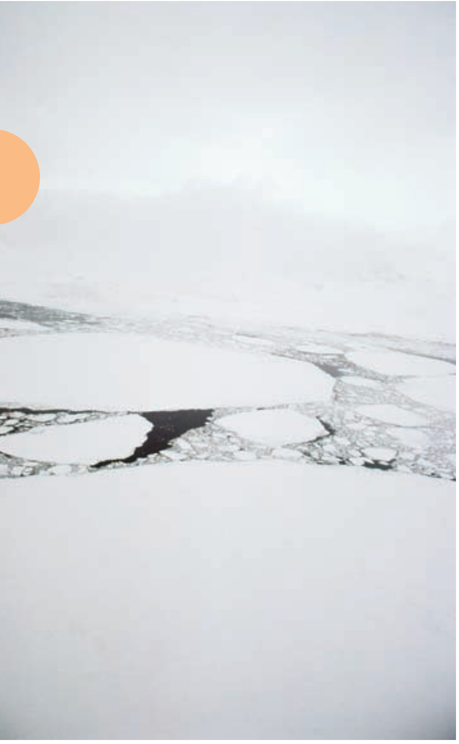


Figure 10.10 View of a portion of the Antarctic ice sheet

Ice Sheets

An **ice sheet** is a particularly large glacier that covers the land. Only two of these huge glaciers exist on Earth, one in Greenland and one in Antarctica (Figure 10.10). The term **polar icecap** is sometimes used to refer to these big ice masses at the poles. An ice sheet forms in the same way as a mountain glacier does, but on a much larger scale. The Antarctic ice sheet, for example, has an average thickness of more than 2 km.

Because ice floats, when an ice sheet reaches the ocean, the ice may float on the water. The floating ice is called an ice shelf. Large sections of an ice shelf that break off are called icebergs. As they float, icebergs melt, change shape, roll over, and eventually become part of the ocean water.

Gaseous Water

Water also exists in a gaseous state in the atmosphere. When liquid water evaporates from oceans, lakes, and rivers, it forms water vapour. You cannot see water vapour, but you can feel it as humidity in the air. Warm air can hold more water vapour than cold air, which is why summer can bring such muggy, humid days. As water vapour is carried upwards into the atmosphere, it becomes colder and condenses into droplets of water that form clouds (Figure 10.11).

Plants and animals also put water vapour into the atmosphere (Figure 10.12). Transpiration is the process of water evaporation from plant leaves, and animals exhale water vapour during respiration.

Figure 10.11 Clouds are made up of condensed droplets of water vapour.

Figure 10.12 When we exhale in cold air, like these horses, the water vapour in our breath condenses and we can see it.

The Cycling Nature of Water

The water on Earth is always changing state. In the time it will take you to read this paragraph, at least 5 L of every 100 000 L of Earth's total water will have cycled into another state. Somewhere in the world right now, water vapour is freezing into snowflakes, icebergs are melting, and puddles of rainwater are evaporating under the midday sun.

Figure 10.13 shows the processes by which water changes state as it moves from Earth's surface into the atmosphere and back to Earth again. This non-stop circulation is called the water cycle. The Sun provides the thermal energy that drives the whole cycle. Although the water in glaciers may stay frozen for thousands of years, even it will eventually change state and move through the cycle.

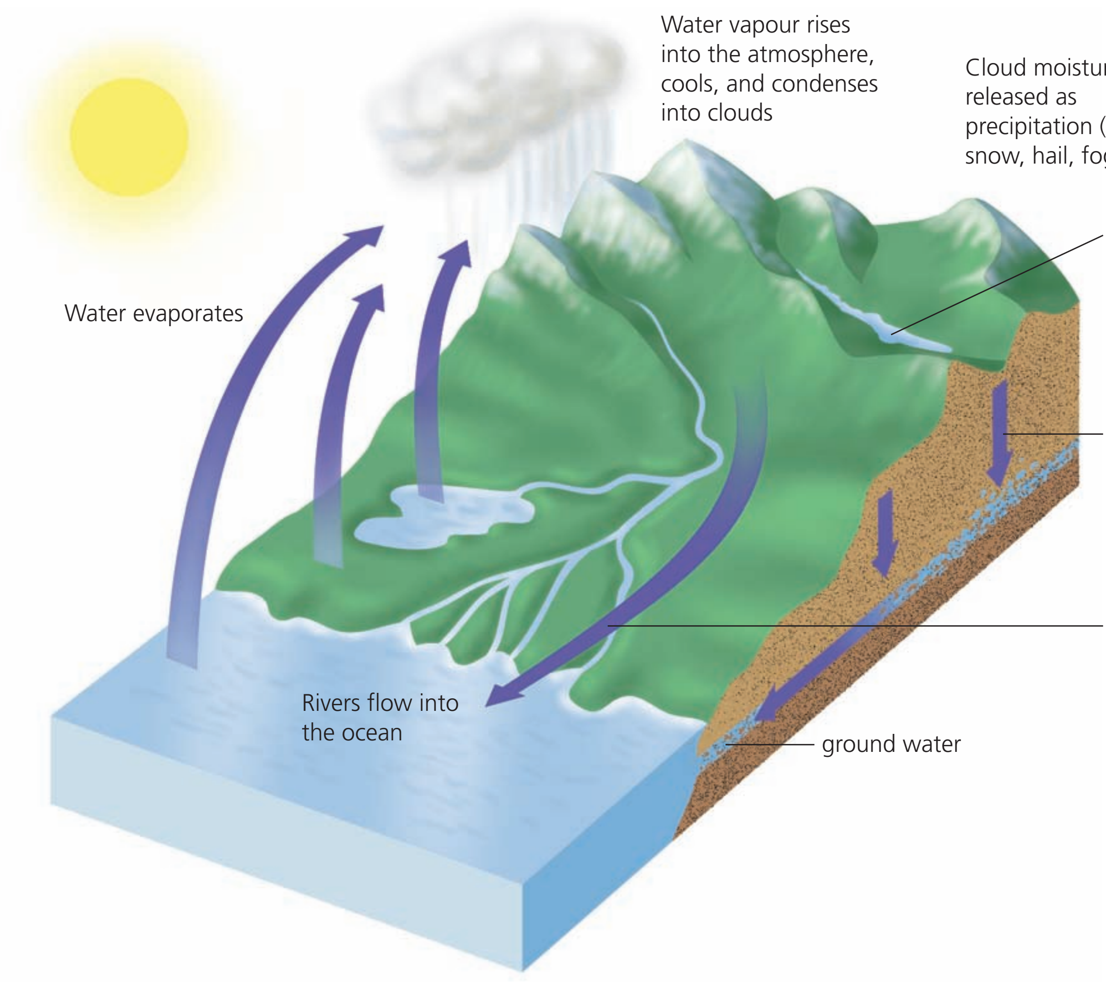


Figure 10.13 The water cycle. There is no beginning or ending to the cycle. Any place could be a starting point.

Watersheds

We all live in an area that is part of a water drainage basin known as a watershed. A good way to visualize a watershed is to think about making a small model boat that is unsinkable and could move downstream with a river's current all the way to an ocean. If you put your boat in a river in Jasper, Alberta, it would end up in the Arctic Ocean. If you lived near the Great Lakes, your small vessel would end up in the Atlantic Ocean. If you lived in the southwestern corner of Saskatchewan, your boat would flow south to the Gulf of Mexico.

A **watershed** is an area of land where all the water eventually drains into one main water body, such as a stream, river, wetland, lake, or ocean. Activities that affect water in one part of the watershed therefore have an effect downstream in the watershed.

Many smaller watersheds connect to other larger watersheds and finally empty into an ocean. North America has five ocean watersheds: Arctic, Atlantic, Gulf of Mexico, Hudson Bay, and Pacific (Figure 10.14).

As water cannot flow uphill, high points in the land such as mountain ridges create natural "divides." These are boundaries that direct where water flows. Mountain chains or especially long areas of high land mark the boundaries of major watersheds on the continents. For example, the Rocky Mountains act as a divide and are often referred to as the Great or Continental Divide. If you are west of the Rockies, much of the water flows to the Pacific Ocean. If you are on the east side, it flows to the other main watersheds.

Take It **Further**

Find out about your own watershed and how it connects to others. Begin your research at ScienceSource.

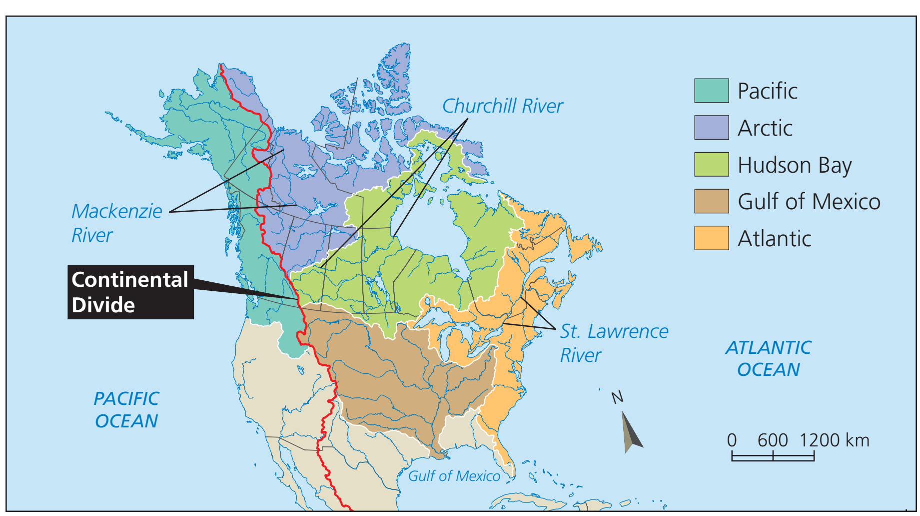


Figure 10.14 The five ocean watersheds of Canada. Approximately 60 percent of Canada's fresh water flows north in the Arctic and Hudson Bay watersheds.

D6 *Learning Checkpoint*

The Watershed Connection

Think about the following statement: "Only communities located downstream in a watershed need to be concerned about how the water resources are managed in the watershed." In a paragraph, explain whether you agree or disagree with this statement and give at least two reasons for your opinion.

DI Anchor Activity

D7 *Quick Lab*

How Much Fresh Water Is Available for Use?

You have learned that a great deal of Earth's fresh water is stored in its frozen state and is therefore unavailable to use.

Purpose

To find out how much fresh water is available for all living things to use

Materials & Equipment

- 100-square grid paper
- pencil crayons or markers
- ruler

Procedure

1. Draw a border around 100 squares.
2. Using different colours of crayons, colour the squares inside this border as follows.
   (a) Colour 97 squares (97 percent) to represent the salt water on Earth. The remaining three squares (3 percent) represent fresh water on Earth.
   (b) Divide the three freshwater squares into 10 equal sections.
   (c) Colour seven of these sections to represent frozen fresh water.
   (d) Colour two of the sections to represent ground water.
   (e) Colour the last section to represent fresh water available for human consumption.

Questions

3. Describe how the available freshwater portion of your grid compares to the remainder of the coloured areas.
4. Why might Earth's supply of frozen fresh water be considered as a source of drinking water in the future?
5. Why is it important to keep our usable supply of fresh water clean?

D8 *Inquiry Activity*

Toolkit 2

SKILLS YOU WILL USE
- Organizing information
- Evaluating procedures

Make a Model Aquifer

You have learned that water collects underground naturally in aquifers. In this activity, you will make a model of an aquifer.

Question

How can water become stored underground naturally?

Materials & Equipment

- 1 shallow, rectangular, transparent plastic container
- gravel
- coarse sand
- about 10–12 small rocks
- plastic drinking straw
- measuring cup or graduated cylinder
- tap water

Hypothesis

Examine the materials available to use. Write a hypothesis for your investigation.

Procedure

Part 1 — Making the Aquifer

1. Working in a small group, fill the container about one-quarter full of gravel.
2. Pour sand over the gravel layer until the container is three-quarters full. Smooth it down. Then, at one end of the container, add more sand to build up a hill.
3. At the shallow end of the sand, dig a small hole to the bottom of the container. Pile the rocks in this hole. Stand the straw in the middle of the rocks.
4. Wash your hands after handling the gravel and sand.

Part 2 — Filling the Aquifer

5. Over the next seven days, you will add small amounts of water to the container. Your teacher will give you a table on which to record your actions and observations.
6. On day 1, slowly begin pouring a measured amount of water onto the hilly end of your model. Continue adding water until all the sand on the top layer is uniformly moist. Record how much water you used to do that.
7. Continue adding water until the gravel layer becomes saturated. Record how much water you used and what you observe in the straw.
8. Observe your aquifer daily for the next six days. Add water each day to keep the sand wet, recording the amount on your table.

Analyzing and Interpreting

9. (a) What does the plastic container represent?
   (b) What does the layer of gravel represent?
   (c) What do the pile of rocks and the straw represent?
   (d) Draw a side view of your model. Label your diagram using the following words: water table, ground water, aquifer, well.

Skill Builder

10. Why is it important in this activity to observe your aquifer over several days?

Forming Conclusions

11. (a) Why did you need to add water to your aquifer each day?
    (b) In a paragraph, describe how what happened in your model is like what happens in the real world.

10.1 CHECK and REFLECT

Key Concept Review

1. Give two examples for each state of fresh water: (a) solid, (b) liquid, (c) vapour.

2. Copy the following table into your notebook. Then fill in the blanks for each column, Fresh Water and Salt Water.

Comparing and Contrasting Fresh Water and Salt Water

	Fresh Water	Salt Water
salt concentration		
freezing point		
distribution on Earth		
locations on Earth		

3. (a) What is a watershed?

   (b) What geographical features create natural boundaries for water to flow toward one ocean or another?

Connect Your Understanding

4. Think about the role that trees play in the water cycle. What are two of the ways in which they are part of the cycle?

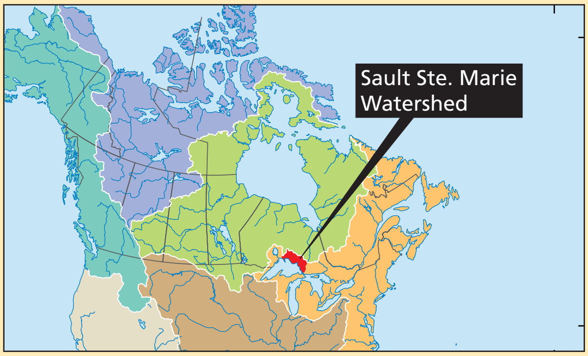
5. Explain how spraying pesticides on your lawn could affect communities downstream in your watershed.

Practise Your Skills

Below is a map of the main watershed for Sault Ste. Marie, Ontario. Use it and Figure 10.14 on page 286 to answer the following questions.

6. To what main ocean watershed does Sault Ste. Marie, Ontario, belong?

7. Explain what this means for the rivers in the Sault Ste. Marie area.



For more questions, go to ScienceSource.

D9 *Thinking about Science and the Environment*

Canada's Groundwater Mapping Program

The Canadian government is gathering and mapping detailed information about Canada's main aquifers. The maps show where the aquifers are located, how much water each one holds, how they are being used, and other groundwater information.

As a class, think about who would find these maps useful. Discuss ways you think the information on the maps could be put to use.

10.2 Water's Influence on Weather and Climate

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

- Water has a higher heat capacity than land or air. As a result, it heats up more slowly than land or air does, but stays warm longer.
- Oceans and large lakes have a moderating effect on the air temperature of coastal areas, keeping these areas warmer in the winter and cooler in the summer than inland areas.
- The interaction of large water surfaces and the atmosphere above can produce severe storms.

If you look at Canada on a globe or world map and move your finger along the 48th line of latitude, two places you touch are Victoria, British Columbia, and Timmins, Ontario. Both are located the same distance from the equator, yet their climates are very different from each other. The average temperature of Timmins ranges from 17°C in July to –18°C in January. That of Victoria ranges from 16°C in July to 5°C in January. Timmins receives an average of 313 cm of snow a year, while Victoria receives only 26 cm of snow.

The main reason for this difference in climate is that Victoria sits next to an enormous body of water, the Pacific Ocean. Timmins is far from any ocean or big lake.

D10 *Starting Point* Skills P C

The Water Cycle and Weather

Look at the photographs in Figure 10.15. Discuss with a partner the role the water cycle is playing in creating the weather shown in these scenes.

(a)

(b)

Figure 10.15 What part does the water cycle play in creating the weather shown in photographs (a) and (b)?

D11 During Reading

Thinking Literacy

Main Idea or Supporting Detail?

Good readers have several strategies to help them decide what is important in the text they are reading and what is an interesting or supporting detail. Read the statements in the summary box at the start of section 10.2. Which summary statement is talked about in the information on page 290? Use the key words in this summary statement to help you as you reread this information. Record "Important Information" and "Supporting Details" in a T-chart.

Also watch for "signal words" that tell you an important point is about to be made. Record these signal words and phrases in your notes on your T-chart. Then read further to add more of these words and phrases to your list.

Large bodies of water have a moderating effect on atmospheric temperatures and therefore on the climate of the nearby region. This means that the large surface area of the water keeps the region from experiencing very high temperatures in the summer or very low temperatures in the winter compared to areas farther inland.

How Water Moderates Air Temperature

As you may recall from previous studies, Earth is surrounded by an atmosphere made up of a mixture of gases, including water vapour. This atmospheric layer extends for many kilometres above the planet. Heat from the Sun passes through the atmosphere, reaching Earth's surface (Figure 10.16). The amount of energy absorbed at any location depends on what is at the surface.

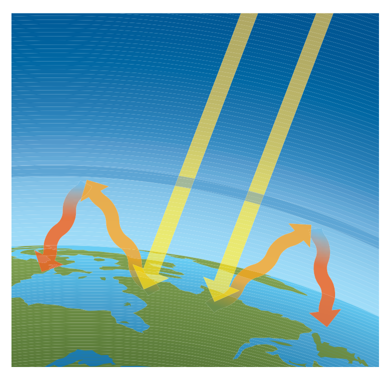


Figure 10.16 Sun's energy reaching Earth's surface

Heat Capacity

If you have ever swum or dipped your toe into a lake or unheated pool after dark on a summer night, you know how warm the water feels compared to the surrounding air. The reason for this difference is that water has a higher heat capacity than either the air or the land. **Heat capacity** refers to the ability of a material to absorb heat. When testing a material's heat capacity, scientists measure how long the material takes to heat up (absorb heat) and cool down (release heat).

Suggested Activity •
D14 Inquiry Activity on page 296

Moderation in Action

Water takes longer than air or land to absorb heat, but it can hold the heat it absorbs longer. In a large water body such as an ocean or lake, this results in an enormous amount of heat being constantly absorbed and released into the atmosphere above it. This moderates the nearby area in two ways.

During the day and in the summer, the land gets hotter than the nearby water does. When the warm air rises, the cooler air from the ocean or a large lake blows in to replace the rising air. The coast area thus maintains a lower temperature than areas farther inland do (Figure 10.17, top).

The opposite happens at night and in the winter. The air over the land cools faster than the air over the water. The warmth from the ocean or lake provides heat to the cooler land (Figure 10.17, bottom).

The land absorbs heat from the Sun more quickly than the water does. The air over the land becomes warmer as some of this absorbed heat is radiated back into the air. The warmer air begins to rise, and the cooler air over the water moves in to take its place.

As the Sun goes down, the land cools off quickly, but the water does not. The water radiates some of its stored heat into the air, and this warmed air begins to rise. The cooled air over the land moves in to take the place of the rising warm air over the water.

Figure 10.17 How a large body of water moderates air temperature on land

D12 Learning Checkpoint

Water's Heat Capacity

1. (a) How does a large body of water such as Lake Superior affect the climate of the surrounding land during the nighttime?
   (b) How does it affect the climate during the daytime?
2. Why does water heat up more slowly than soil does?

Water Bodies and Regional Climate

In every part of the world, the presence of large water bodies is a major contributor to climate differences experienced from region to region.

The Great Lakes are also notable for the strong moderating effect they have on the climate of the areas that border them. Their extensive water masses keep both summer and winter temperatures moderate. They also provide large amounts of moisture to the air. In the winter, this moisture eventually falls as snow. The heaviest snowfalls anywhere in Ontario occur in the stretch of land that extends east from Lake Huron and up to Georgian Bay.

Microclimates

Farmers living close to the Great Lakes typically enjoy a much longer frost-free period than farmers living elsewhere in Ontario. The warmer air from the lakes keeps nighttime temperatures on the shore above freezing longer into the fall than in areas further inland.

The Great Lakes are responsible for contributing to small pockets of microclimates in the surrounding regions. A **microclimate** is an area with a small, localized climate variation that differs from the larger climate area around it. These differences in climate can occur over a very small scale. Inside a greenhouse, for example, can be a microclimate that is much warmer and moister than the climate outside (Figure 10.18).

Figure 10.18 Even in the winter, a warm microclimate can be created inside a greenhouse.

Water Bodies and Global Climate

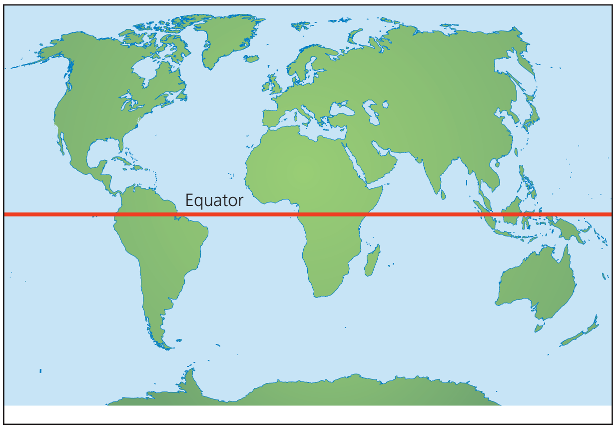


Figure 10.19 The southern hemisphere has more water area than the northern hemisphere does, and this affects climates on a global scale.

In the same way that water bodies affect climate at a regional scale, so their influence is felt at the much larger global scale.

You may have noticed when looking at a globe or map of the world that Earth's continents are not evenly distributed on both hemispheres (Figure 10.19). The northern hemisphere is 39 percent land and 61 percent ocean. The southern hemisphere is 19 percent land and 81 percent ocean.

Because of the greater proportion of water surface south of the equator, the moderating effect on that hemisphere's climate is notably greater than on the northern hemisphere's climate. In the southern hemisphere, annual average temperatures vary by only about 7.3°C from summer to winter. In the northern hemisphere, they differ by about 14.3°C.

Coastal Storms

In August 2005, Hurricane Katrina devastated much of the north-central coast of the Gulf of Mexico (Figure 10.20). Dramatic weather events such as this occur when air moves across large water bodies and picks up moisture and heat.

Hurricanes are a severe type of storm that starts out as a thunderstorm over warm ocean waters. Its air mass begins to swirl rapidly. For such a storm to be categorized as a hurricane, its winds must reach speeds of at least 119 km/h. If the path of a hurricane takes it over land, the result can be extensive destruction and flooding.

Hurricanes and somewhat less severe storms are fairly common in the Maritime provinces. Their after-effects can sometimes be felt inland as far as Ontario. Rarely are they still classified as hurricanes by the time they reach Ontario. Hurricane Hazel was an exception. It hit the Toronto area in October 1954, releasing 214 mm of rain over three days. Extensive flash flooding resulted. More than 20 bridges in the city were destroyed and 81 people were killed.

Figure 10.20 New Orleans, in the U.S. state of Louisiana, suffered the worst damage of any city affected by Hurricane Katrina in 2005.

The Great Lakes are well known for the winter storms they help create. Usually in the late fall each year, cold weather systems sweeping down from Alberta reach the Great Lakes region at about the same time as storm systems moving up from the U.S. Midwest. As both of these systems pass over the lakes, the water and air interactions create high winds and large amounts of precipitation.

Take It **Further**

Since the mid-1800s, at least 25 Great Lakes storms have been severe enough to capsize boats and freighters and cause much loss of life. Learn more about the long history of storms on the Great Lakes. Begin your research at ScienceSource.

D13 *Quick Lab*

Investigating Climate Data

As you read at the start of this section, the climate in Victoria, British Columbia, is moderated by the Pacific Ocean. Timmins, Ontario, is located inland, away from any large water body.

Purpose

To interpret what annual monthly temperatures indicate about climate

Procedure

1. Use the data in the following table for Timmins and Victoria to answer the questions below.

Table 10.1 Average Monthly Temperatures (°C) for Timmins and Victoria

Month	Timmins	Victoria
January	−18	5
February	−14	6
March	−8	8
April	1	10
May	10	12
June	15	14
July	17	16
August	16	16
September	10	15
October	4	11
November	−4	7
December	−13	5

Questions

2. For each city, calculate the temperature difference between the coldest month and the warmest month.
   (a) Which city has fewer average temperature extremes in a year?
   (b) Explain your answer for (a).
3. How do the average monthly temperatures in Victoria influence the kinds of plants that can live there?
4. In which season is there the greatest difference in temperatures between the two cities?
5. How would your daily life be different if you were living in Victoria in the season you identified in question 4?

D14 *Inquiry Activity*

Toolkit 2

SKILLS YOU WILL USE
- Recording and organizing data
- Drawing conclusions

Can It Take the Heat?

It is the high heat capacity of water that enables it to affect our climate. In this activity, you will take a closer look at this property of water.

Question

How do equal volumes of water and sand heat up over a 6-h period?

CAUTION: Light sources can get hot. Keep them away from combustible material and your skin.

Materials & Equipment

- 2 L of water at room temperature
- 2 L of coarse sand at room temperature
- 2 identical light sources
- 2 identical metal or glass pans
- thermometer

Hypothesis

Write a hypothesis for this inquiry. Begin it with "I think ..."

Procedure

Part 1 — Preparing the Samples

1. Make a table to record your temperature data and give your table a title.
2. Working with a partner or in a small group, prepare the samples *the day before* as described below.
   (a) Measure 2 L each of the water and the sand.
   (b) Spread the sand out in one pan, ensuring that the surface is even.
   (c) Pour the water into the second pan.
   (d) Set up the light sources so that they are placed at the same height above the samples. Do *not* turn them on yet.

Part 2 — Adding Heat

3. First thing in the morning the next day, use the thermometer to take an initial temperature reading of both samples. Record the readings in your table.
4. Turn on the lights over the pans.
5. Take temperature measurements every 30 min for 6 h.

Analyzing and Interpreting

6. Draw a line graph of your temperature measurements. Record both samples on the same graph. Give your graph a title. Label the *x*- and *y*-axes.
7. Compare the graphs for the two samples.
   (a) How are they the same or different?
   (b) How do your results compare with your hypothesis?
8. Why was it necessary to begin this activity with dry sand?

Skill Builder

9. It is important to hold a thermometer at eye level when taking temperature readings. Explain why.

Forming Conclusions

10. (a) Write a statement that summarizes what you have observed in this activity.
    (b) Connect this statement to the real world. How do your results explain microclimates near large bodies of water?

10.2 CHECK and REFLECT

Key Concept Review

1. What is a microclimate?
2. Describe how a large water body can affect the amount of snowfall a region receives in the winter.

Connect Your Understanding

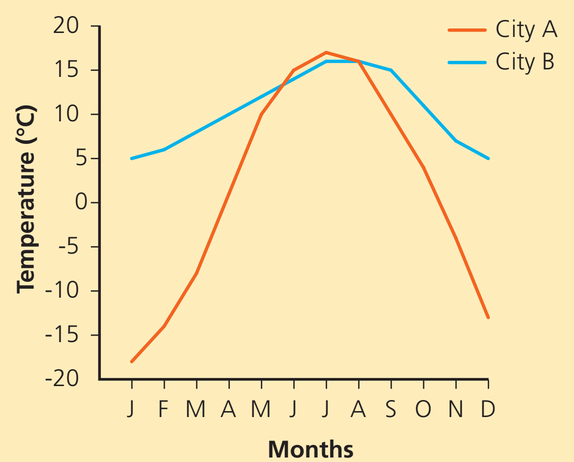
3. The average annual snowfall in Owen Sound, located on Georgian Bay, is about 345 cm. Belleville, located in eastern Ontario, averages 151 cm of snow annually. Explain why these two cities receive such different snowfall amounts.
4. Explain how a microclimate can affect crop production.

Practise Your Skills

5. The following temperature graph shows the annual average monthly temperatures for City A and City B.

Both cities are located at the same latitude. Look at the graph and answer the question below.

Average Monthly Temperatures for Cities A and B



Which city is more likely situated closer to a large water body than the other city? Give two pieces of evidence from the graph to support your answer.

For more questions, go to ScienceSource.

D15 *Thinking about Science and the Environment*

Weather in the Media

Weather is a popular topic of conversation. It is so popular that there are media channels dedicated to reporting the weather exclusively.

What to Do

1. List all the ways you receive information about the weather.
2. Working with a partner, discuss the method you rely on most for learning information about the weather.

Consider This

3. Why do you think weather is such an important topic of conversation?
4. What types of media do you think are the most accurate at predicting the weather?
5. Why do you think people are so fascinated by severe weather events?

10.3 The Effects of Ice on Water Systems

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

- The global climate has undergone natural periods of cooling and warming since Earth formed.
- When temperatures and precipitation amounts change significantly over time, glaciers and ice sheets are affected, increasing or decreasing in size.
- Changes in the size of glaciers and ice sheets influence local and global water systems.

Figure 10.21 Scraped rock such as this is evidence of glaciation.

Scientific evidence suggests that Earth is more than 4.5 billion years old. During that time, the planet's climate has gone through natural cycles of cooling and warming many times. Some of these periods of cooling or warming have lasted for hundreds of thousands of years.

When a period of global cooling occurs, Earth's temperatures decline, and ice begins to accumulate. This results in glaciers and ice sheets expanding in size. Scientists call these times glacial periods. The last great expansion of ice sheets ended about 10 000 years ago. It affected North America, Europe, and northern Asia. Ice sheets covered almost all of Canada. As the global climate gradually began to warm again, the ice retreated (Figure 10.21).

D16 *Starting Point* Skills A C

Predicting the Effects of Water System Changes

Look at the river scene in Figure 10.22. Predict how the scene would change if the river's normal water level became:

(a) 1 m higher 50 years from now

(b) 1 m lower 50 years from now

Figure 10.22 How might this scene change?

When a period of warming occurs, Earth's glaciers and ice sheets begin to disappear. These times are called interglacial periods. Earth is now in an interglacial period that started more than 11 000 years ago.

Factors Affecting Mountain Glaciers and Ice Sheets

You read in Section 10.1 about how glaciers form. Where temperatures on Earth are below freezing, precipitation falls as snow. When snow builds up over time, it creates glaciers. If the cold conditions continue, the glaciers continue to grow larger and spread.

Suggested Activity
D17 Inquiry Activity on page 301

On the other hand, if temperatures begin to rise and annual precipitation patterns change, glaciers start to shrink in size. Warmer temperatures mean that precipitation, even on mountaintops, is likely to fall as rain instead of snow. At the same time, the warmer temperatures cause the existing glaciers to melt. When they begin getting smaller in size, they are said to be receding or retreating (Figure 10.23).

Figure 10.23 A receding glacier

Weather's Effects on Ice

Glaciers frequently go through short periods of shrinking or growing. Such changes are caused by normal seasonal variations in weather. Think of a ski trip or outdoor hockey game that got cancelled in the middle of January because warm, rainy weather melted the snow and ice. Think of a cold snap in May that suddenly brought snow flurries just when you had put away your winter clothes. When unusual weather lasts over several months or years in high mountain areas, it will affect the size of the glaciers there.

Climate's Effects on Ice

In recent decades, glaciers in many parts of the world have been receding at a steady rate. The Arctic ice is also melting in a way that humans have not seen before. Most scientists agree that these changes reflect the warming trend occurring in some parts of the world. One overall trend, for example, is an increase in average nighttime temperatures.

Human activities that put more carbon dioxide and other gases into the atmosphere are thought to be part of the reason for this rise in temperatures. When the concentration of these gases builds up, heat that would normally be reflected back into space from Earth is blocked from doing so. That heat gets trapped right above Earth's surface. This is called the greenhouse effect.

What is not clear to scientists is whether the warming trend is simply a usual variation or the beginning of a longer period of changing climate conditions. The Antarctic ice sheet is not shrinking, but has been growing in recent years. Observations such as this make it difficult to come up with one explanation for any new climate trend.

Take It Further

Find out where the term "greenhouse effect" came from and how it applies to Earth's atmosphere. Begin your research at ScienceSource.

How Ice Changes Affect Water Systems

When mountain glaciers and ice sheets increase in size, it means that even less water is available to be part of the world's oceans, atmosphere, and other water systems. Extreme examples of this occur during ice sheet expansion. Scientists estimate that with nearly a third of the planet covered in thick ice during the last expansion, sea levels on Earth were more than 100 m lower than they are now. Figure 10.24 shows the extent of what was known as the Laurentide ice sheet that once covered Canada.

The opposite happens when glaciers and ice sheets shrink. Their frozen water is released in liquid and gaseous states. The melting glaciers slowly add more fresh water into the streams, rivers, and lakes they empty into. In turn, these bodies of water empty into oceans, adding to the volumes there. The increased amount of fresh water dilutes the seawater, reducing the salinity of the surrounding ocean water.

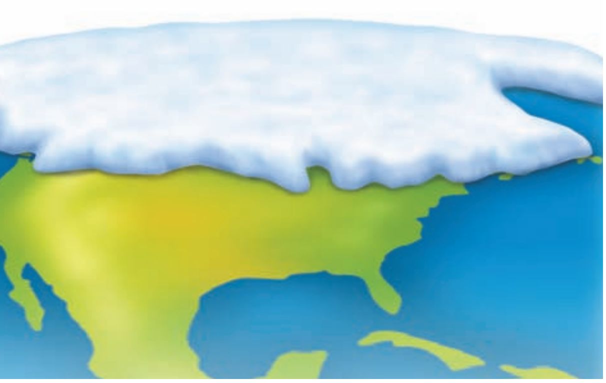


Figure 10.24 About 10 000 years ago, the Laurentide ice sheet covered all of Canada.

D17 *Inquiry Activity* Toolkit 2

SKILLS YOU WILL USE
- Asking questions
- Reporting results

Researching a Changing Glacier

Throughout Earth's history, glaciers have gone through a normal cycle of advancing and retreating. Scientists are concerned that the pattern of retreating that has been noticed over the past 100 years may not be part of this normal cyle. In this activity, you will investigate how some of Canada's glaciers have changed.

Question

How have some of Canada's glaciers changed in the past century?

Materials & Equipment

- science section of newspapers
- magazines (for example, *Canadian Geographic*)
- ScienceSource

Procedure

1. Choose a glacier to research from the following list:
   (a) Helm Glacier, Garibaldi Provincial Park, British Columbia
   (b) Illecillewaet Glacier, Glacier National Park, British Columbia
   (c) North Moraine Hill Glacier, Nahanni National Park Reserve, Northwest Territories
   (d) Peyto Glacier, Rocky Mountains, near Calgary, Alberta
2. Find information from two sources on the glacier that you have decided to research. Go to ScienceSource for Internet research.
3. Summarize the information that you have collected in a report.
4. Present your findings to the class.

Analyzing and Interpreting

5. By how much has the front edge of the glacier that you researched changed (advanced or retreated) in the past century?
6. (a) As a glacier retreats, what will happen to the volume of melting water that a mountainous region normally receives?
   (b) How will this affect the mountain streams and rivers downstream?
7. Think back to how a glacier is formed. What factor could contribute to a glacier advancing instead of retreating?
8. The graph below shows the change in the front edge (the "terminus") of two glaciers in 100 years. For each glacier, calculate how much its terminus has changed in that time.

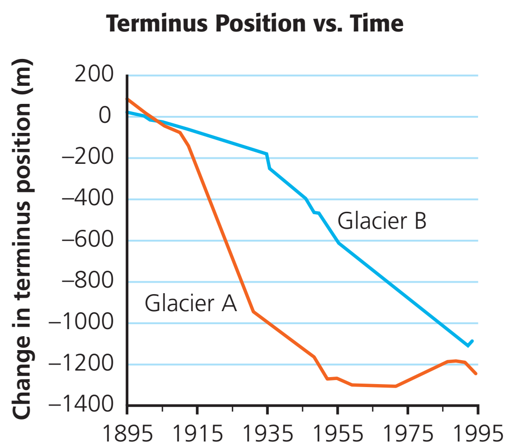


Figure 10.25 Change in the terminus of two glaciers between 1895 and 1995

Skill Builder

9. Why is it important to use more than one source when doing this kind of research?

Forming Conclusions

10. Make a concluding statement about the glacier you have researched.

10.3 CHECK and REFLECT

Key Concept Review

1. Explain what is meant by the term "glacial period."

2. What conditions cause glaciers:
(a) to grow larger and advance?
(b) to shrink and recede?

3. What have scientists noticed is happening to Arctic ice in recent decades?

Connect Your Understanding

4. Melting ice sheets increase the volume of water in the oceans and reduce the salinity of the water. How would this affect:
(a) sea animals in polar regions?
(b) coastal areas already at sea level?

Practise Your Skills

5. The glacier in the photograph below once covered much of the rock shown in the foreground.

(a) Describe what has happened to the glacier over time.
(b) List two events that could have caused this result.

For more questions, go to ScienceSource.

D18 *Thinking about Science and the Environment*

STSE

The Unfreezing of the Northwest Passage

The world's shipping traffic travelling west from Europe to Asia goes through the Panama Canal in Central America. For centuries, however, explorers and others have tried to find a much shorter route through the northern Arctic — a route named the Northwest Passage.

Because the area was frozen for much of the year, few countries have challenged Canada's claim to owning the northern waterways. Now, with the recent melting of ice in the Arctic, this is changing. As passageways become free of ice in the summer, some countries are suggesting that the Northwest Passage is an international route that anyone can use. Canada is moving to defend its right to control this territory. What do you think about the issue?

Consider This

1. In what ways would northern communities be affected if the world's shipping companies felt they could travel through the Northwest Passage as though it were an international waterway?

2. How might the environment be affected by increased shipping traffic?

3. If Canada can maintain its sovereignty (right to rule) over the waterways of the north, what are the pros and cons of this position?

Point Pelee: A Great Lakes Microclimate

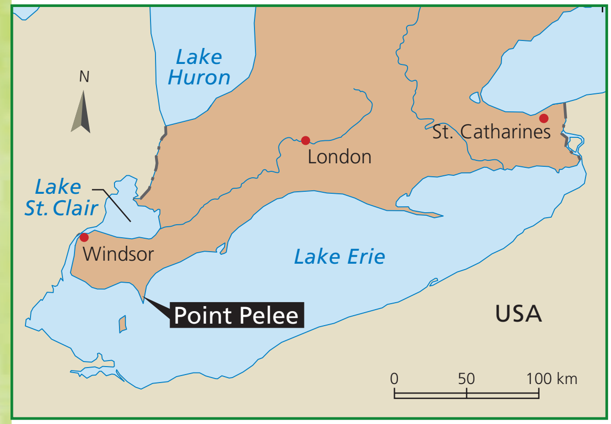


Figure 10.26 Point Pelee National Park is located on Lake Erie.

Where in Canada can you go if you want to see migrating monarch butterflies and dozens of species of birds? The answer is Point Pelee National Park, a 15-km^2 peninsula that sticks out into Lake Erie. A greater variety of animals and plants lives here than anywhere else in Canada. Some plants, such as the hop tree, native to Mexico, are not found elsewhere in the country.

Point Pelee, sitting almost exactly on the 42nd parallel, is the southern-most point of the Canadian mainland. It is at the same latitude as Rome, Italy. Just as Rome's climate is modified by the presence of the Mediterranean Sea, so Point Pelee's climate is influenced by the presence of the Great Lakes. With an average daily temperature of 8°C, Point Pelee has a warmer climate than other places in North America along the same latitude. The winds blowing from Lake Erie warm the surrounding land in the winter, creating this microclimate.

For many animals and plants, Point Pelee is the northern limit of where they can live.

Questions

1. Explain why Point Pelee is a suitable home to animal and plant species at the northern range of their habitat.
2. What role do the Great Lakes play in influencing the climate of Point Pelee?
3. In a short paragraph, describe what makes Point Pelee unique in Canada. Use the term "microclimate" in your answer.

Figure 10.27 Most of Point Pelee National Park is wetland. A boardwalk protects this fragile marsh and allows visitors to observe the wildlife.

Figure 10.28 Point Pelee is a migration stop for the monarch butterfly.

10.0 Chapter Review

Assess Your Learning

After Reading — Thinking Literacy

Reflect and Evaluate

Work with a partner to list all the strategies you know and have learned that help you determine importance when you are reading informational text. Create a short writing piece in a format of your choice that communicates these strategies to a student new to the intermediate division. Share your writing with the class.

Key Concept Review

1. Decide whether the following statements are true or false. Give one piece of evidence to support your decision. (k)

(a) Most of Canada's fresh water lies below the ground.

(b) Salinity is the term given to the humidity that you feel on a hot, summer day.

(c) Lakes and oceans have the same concentration of salt in them.

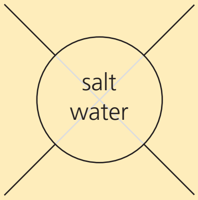
(d) The greenhouse effect refers to growing crops indoors.

(e) The Continental Divide separates Canada from the United States.

2. Draw the water cycle for the area that you live in. (a)

3. What three things do you do in a typical day that are part of the water cycle? (t)

4. Reproduce the following diagram in your notebook. Write a fact about salt water on each spoke that comes out of the centre circle. You may add more spokes to your diagram if necessary. (t)



Connect Your Understanding

5. What human activities can affect a watershed? (k)

6. List five ways that ground water could become polluted. (t)

7. The Columbia Icefield is located between Banff and Jasper in Alberta. It covers an area of more than 300 km^2 and has ice that is up to 365 m thick in some places. How can studying this icefield give scientists information on climate patterns? (t)

ACHIEVEMENT CHART CATEGORIES

(k) Knowledge and understanding (t) Thinking and investigation (c) Communication (a) Application

Practise Your Skills

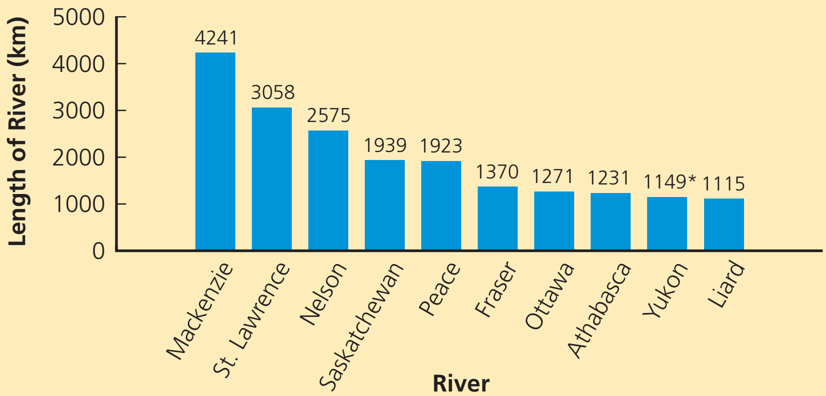
8. The graph below compares the lengths of Canada's longest rivers. Answer the following questions by using the information provided in the graph.

(a) What is the name and length of Canada's longest river?

(b) The Yukon River is actually 3185 km long. The graph shows its Canadian length. How much of the Yukon River flows in the United States?

(c) How much longer is the St. Lawrence River than the Ottawa River?

Lengths of Selected Rivers



*Amount that flows in Canada; total length is 3185.

Unit Task Link

You have learned that very little fresh water on Earth is in a usable state. How does this knowledge help you understand the struggles of countries that do not have an adequate supply of fresh water?

D19 *Thinking about Science and the Environment*

Predicting Major Storms

Many weather bureaus around the world use a technology called Doppler radar to predict when and where thunderstorms, hurricanes, and other major weather events will occur. An antenna from the radar system sends radio waves out into the atmosphere. The moisture in the air, such as raindrops, snowflakes, hail, and sleet, reflects the radio waves back to the antenna. The strength and frequency of those waves are then converted by a computer into maps. People trained in interpreting these maps are able to see where severe storms are building and in what direction they are moving. This information is passed on to the public in weather forecasts and warnings in the media.

What to Do

With a partner or in a group, discuss and record your ideas in response to the following questions.

1. How has technology such as Doppler weather radar improved the lives of residents located in areas where major storms are common?
2. Is predicting weather all that is needed to ensure people are prepared for coping with severe rain, snow, and wind storms? Explain your answer.