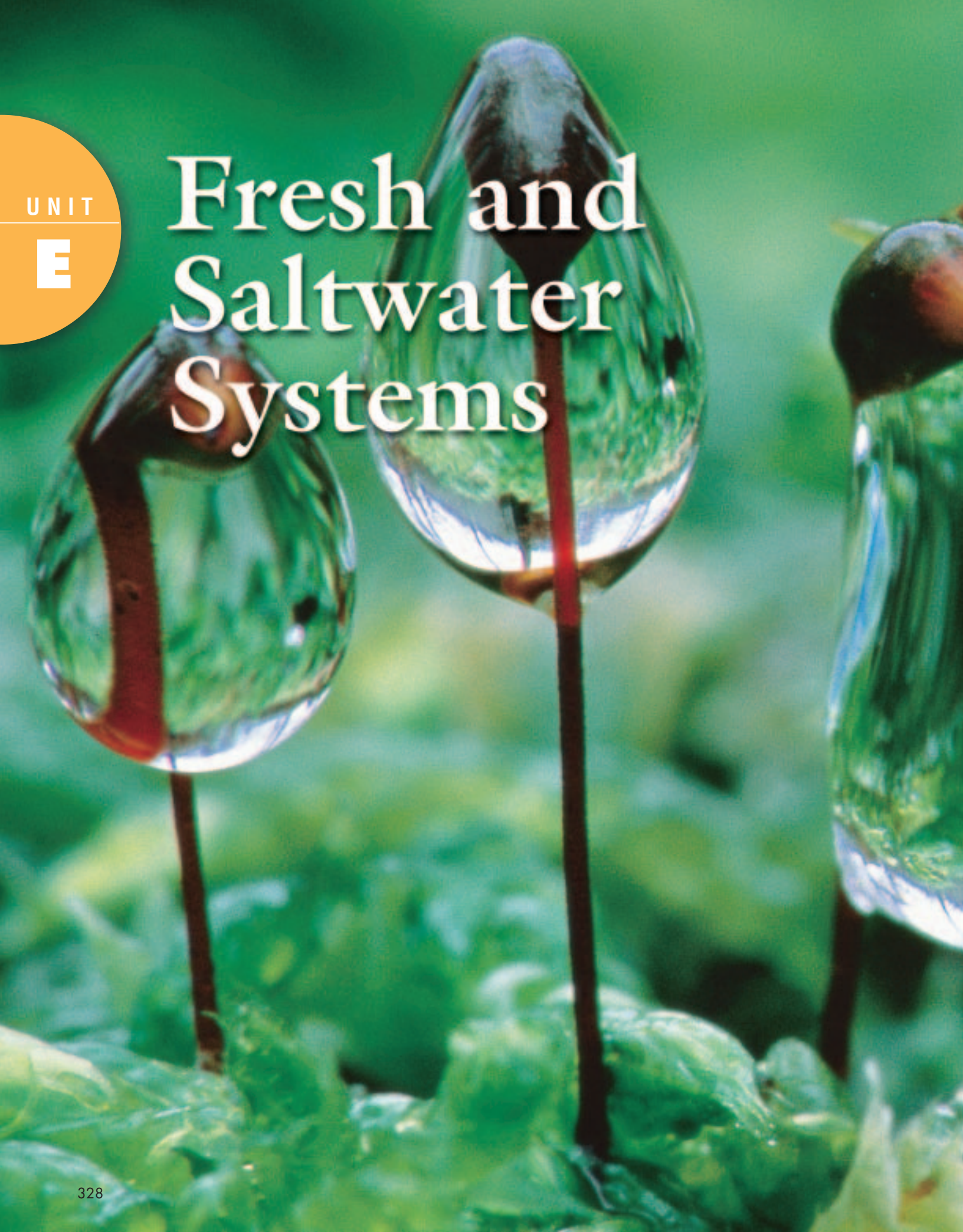
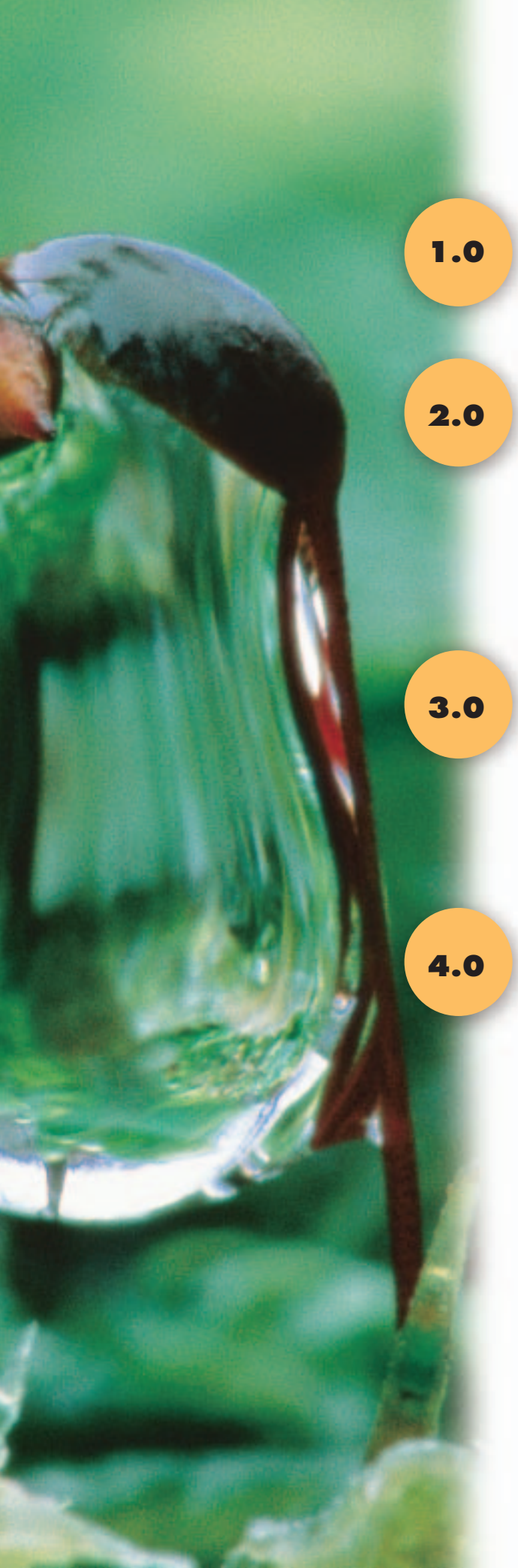


UNIT

E

Fresh and Saltwater Systems



In this unit, you will cover the following sections:

1.0 **Humans depend on water supply and quality.**

- **1.1** The Distribution of Water on Earth
- **1.2** Water Quality

2.0 **Water in its various states affects Earth's landforms and climate.**

- **2.1** Waves and Tides
- **2.2** Erosion and Deposition
- **2.3** Processes That Shape Ocean Basins and Continental Drainage
- **2.4** Water and Climate

3.0 **Living things in aquatic environments are affected by many factors.**

- **3.1** The Diversity of Organisms in Salt and Freshwater Systems
- **3.2** Populations in Fresh and Salt Water
- **3.3** Water Quality and Living Things

4.0 **Human activities affect aquatic environments.**

- **4.1** How Humans Use Water
- **4.2** Measuring Impacts

Exploring

Rain is just one of the ways that we experience Earth's water systems.

When you think of water, what comes to mind? Perhaps you think of drinking it, cooking with it, or washing in it. You might think of sailing on a lake, or skiing down a snow-covered hill. Water is all that and more. Living systems—including you—need it to survive. Ecosystems depend on it. The land is changed by it. Industry uses large amounts of it. Climate and weather are determined by it.

In this unit, you will explore fresh and saltwater systems. You will investigate how water quality influences living things, and how water affects landforms and climate. You will discover how human activities and needs have changed our planet's water supplies and the environments that depend on them.

Because you live in Canada, you see water in the environment all the time—in lakes, rivers, and streams, and falling from the sky. Canada is a water-rich country. Most countries in the world have much less fresh water than we do. In fact, in some areas of the world, it hasn't rained in years! But even in Canada, water isn't always where we need it when we need it.

In the 1930s, farmers in Alberta struggled to keep their farms going during the severe drought.

Coping with a Dry Climate

In the 1930s, much of Alberta and Saskatchewan was in the grip of a long drought. Lake and river levels dropped significantly. Small streams, sloughs, and ponds simply dried up. The water in the soil evaporated into the dry air. Topsoil turned to dust and blew away. Farming became almost impossible.

Today, southern Alberta is a very different place from the "dust bowl" of the 1930s. Large irrigation projects have brought water from the foothills of the Rockies to these dry areas. Crops can now be grown in areas where only grasses and cacti once lived. Such irrigation projects have also changed parts of southern Saskatchewan and British Columbia.

The rich crops of southern Alberta today rely on irrigation to ensure a steady supply of water.

Human Water Use

Irrigation is only one of the many ways that humans use Earth's water supply. In agriculture, in industry, and in our personal uses, we use water every day. And in our many uses, we affect the other organisms on Earth that depend on water as well. Can you think of any living thing on this planet that does not require water in some way to survive?

Give it a **TRY** **Activity**

Your Water Use

Water is essential to life—your life as well as that of all other organisms on the planet. Fresh water is especially important to humans. We think we have lots of water, but even in our water-rich country, the amount of clean, fresh water we want isn't always available. As you saw from the effect of a severe drought on Alberta, lack of water can be a serious problem. Can individuals like you help to conserve water?

- In what ways do you use precious water? With a partner, brainstorm all of the ways you can think of that you use water. Look over the items on your list, and identify the ones where you might be wasting water. For example, do you leave the tap running while you brush your teeth?
- For each item on your list, suggest a way that you could reduce your water use. Add your ideas to a class suggestion board on how to reduce water consumption at home.

Using Water Indirectly

When you use water for brushing your teeth or drinking or washing dishes, you are using water directly. But all day long, you're also using water indirectly. Every food you eat, every item of clothing you wear, every vehicle that you travel in—everything you use involves water in some part of its production. Water for irrigation is important in growing fruit and other crops. In manufacturing jeans, water is used for washing fabrics and dyeing. In making soft drinks, water is an ingredient, as well as part of the cleaning process for bottles.

All of these uses can have negative impacts on Earth's water. It's up to all of us to understand Earth's water system—what it is, how it works, and how we affect it—so we can keep our planet healthy.

Focus On

Social and Environmental Context

As you work through this unit, you will learn about the science of water systems and the social and environmental importance of water. Think about the focussing questions below as you perform activities and answer questions throughout the unit.

1. **What are the characteristics of fresh and saltwater systems?**
2. **How do these water systems function?**
3. **How do fresh and saltwater systems interact with Earth and its atmosphere?**
4. **How do the actions of humans affect these water systems?**

Thinking about these questions will help you understand the importance of water to all life on Earth—including our own. They will also help you understand how science and technology help us meet our needs for water.

In the project at the end of this unit, you will consider the effect of human activity on the water we drink. This project will give you an opportunity to use the research, thinking, and decision-making skills you practise in this unit. You will also be able to use the scientific knowledge about water systems that you learn here.

1.0

Humans depend on water supply and quality.

Key Concepts

In this section, you will learn about the following key concepts:

- water quality
- human impact

Learning Outcomes

When you have completed this section, you will be able to:

- describe the distribution of water on Earth
- recognize that fresh and salt water contain other materials
- define water quality
- describe tests for water quality
- describe methods for making fresh water from salt water

When astronauts first viewed Earth from space, they were impressed by its beautiful blue and white colour. Earth is unique among the planets because 74% of its surface is covered with water. It is often called the "water planet" or the "blue planet." Yet, parts of Earth are so dry that they are deserts. In other areas, there is enough water, but people may not be able to drink it because of minerals that give it an unpleasant taste and odour. These are all natural variations in Earth's water supply.

The water supply can also be affected by human activities. Industries might pollute the water in lakes and rivers. Overuse by people in cities might reduce the amount of water available in an area.

An important first step in managing our water supplies is to understand how and where water occurs on Earth and what water quality means to humans and other living things. Let's begin by exploring fresh water, salt water, and water quality.

1.1 The Distribution of Water on Earth

Our planet has more water than any other planet in the solar system. Our water also exists in different forms. It isn't all frozen the way water on Mars is. But is it evenly distributed all over Earth? Where is the water on Earth, and what kind of water is it?

Think about a map of the world and what you know about water already. Draw a circle. The whole circle represents the total amount of water on Earth. If the circle was a pie, how big a piece of this pie do you think would represent all the drinking water available in the whole world? Draw that slice of pie on your circle. Keep your prediction handy so you can refer to it later in this subsection.

Figure 1.1 How many different states of water can you see at this lake?

Drinking Water for Humans

Humans, and many other animals, would die if they had only salt water to drink. Drinking water must be fresh water, not salt water. However, not all fresh water is drinkable. Think about the water that collects in puddles on the street after a summer rainstorm. Would you drink that? Why not? Or the water that runs in ditches along country roads in the spring—would you drink that? Both of these are examples of fresh water, but you shouldn't drink them. Water that humans can drink safely is called **potable water**. Only a tiny amount of water on Earth is potable.

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Water in Alberta

Alberta is fortunate to be a water-rich province with large rivers, huge lakes, and gleaming glaciers. However, most of our major rivers are far from the large urban centres of Edmonton and Calgary, which need a lot of water. Some of Alberta's largest rivers, such as the Hay, Peace, and Athabasca, drain to the north. The Bow and Elbow rivers, and the North Saskatchewan River all have reservoirs for water storage and management. A *reservoir* is an artificial lake. A reservoir may be used for drinking water, irrigation, or generation of hydro-electricity.

Alberta's major rivers and lakes

Inquiry Activity

Water, Water Everywhere

The Question

How much water on Earth is available for humans to drink?

Materials & Equipment

Part A

- 1000-mL graduated cylinder or beaker
- 100-mL graduated cylinder
- salt
- balance
- 10-mL graduated cylinder
- freezer
- eyedropper

Part B

- graph paper or graphing software

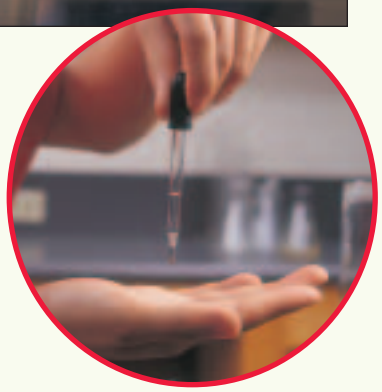
Procedure

Part A Using a Model of Earth's Water

1. Fill a 1000-mL graduated cylinder with water. This represents all the water on Earth.
2. Predict the amount of this 1000 mL that you will use to represent the amount of drinkable water on Earth.
3. Pour 30 mL of this into a 100-mL graduated cylinder. This 30 mL represents the total amount of fresh water on Earth.
4. Use the balance to measure out 29 g of salt. Dissolve the salt in the 970 mL of water remaining in the 1000-mL graduated cylinder. This represents the amount of water in all the oceans. It is too salty to be drinkable. Put it aside.

Figure 1.2 In this activity, you are creating a model of the distribution and characteristics of water on Earth.

5. Now pick up the 100-mL graduated cylinder containing the 30 mL of fresh water. Pour 6 mL into the 10-mL graduated cylinder. Take the 100-mL graduated cylinder that now contains only 24 mL of water, and put it in the freezer. This represents the amount of fresh water that is frozen in glaciers and icecaps.



6. You now have 6 mL of water left in the 10-mL graduated cylinder. Use an eyedropper to remove a small amount of water. Let one single drop fall into your palm. This one drop represents all the fresh water on Earth that is available for people to drink! It is about 0.003% of the total amount of water on Earth.

Here's what you've learned about the distribution of water on Earth:

- Of all the water on Earth, 97% is salt water in the oceans, and 3% is fresh water.
- Of the fresh water (3% of the total water), 77% is ice, 22% is groundwater, and 1% is in lakes, rivers, and wetlands.

Part B Graphing the Distribution of Water on Earth

7. Another way to represent Earth's water supply is to graph it. Either by hand or using graphing software, draw two separate circle graphs, one for each of the statements about water shown in the box.
   - Remember to be accurate when graphing. If you are doing it by hand, make sure to convert the percentages to degrees, and use a protractor to measure the angles accurately.
   - Colour your graphs, and give each one a title and a legend.

Analyzing and Interpreting

8. In this activity, you used two different methods of presenting information about the distribution of water on Earth. What were the two methods? What were the benefits of using each method? What were the drawbacks to each method?

Forming Conclusions

9. Using words, pictures, or both, describe how much water is available to humans as drinking water, compared with the rest of the water on Earth.

Applying and Connecting

While you were doing this activity, water was evaporating from your samples into the air. About 0.0009% of all the water on Earth is a gas in the atmosphere at any one time. In some places in the world, water in the atmosphere is the only fresh water that's available for people to drink. How can they drink water from the air? A village in the desert on the north coast of Chile uses special web collectors to gather water from the fog that forms early every morning. In Peru, Ecuador, Namibia, and Oman, people are also using this technology.

RESEARCH

Canada's Water Riches

Canada is awash with water. We are bounded on three sides by oceans. We have 9% of all the world's fresh water. We have over 2 million lakes. And we have large reserves underground as well. Should we share our fresh-water riches with the United States and other countries? Use the Internet to learn more about this issue. Decide for yourself what Canada's policy on water exports should be.

Water on Earth

Earlier in this subsection, you learned that humans can drink only fresh water. From the information above, it looks as if there's plenty of water for us to drink. But most of the fresh water is locked in icecaps and sea ice in the Arctic and the Antarctic far from population centres. And not all of the water underground, and in lakes, rivers, and wetlands is accessible. In fact, only about 0.003% of all the water on Earth is available for humans to drink. The remaining fresh water may be too far below Earth's surface or in places where humans don't live.

Imagine that you had 1000 glasses of water in front of you, representing all the water on Earth. You would be able to drink less than one-third of one glass! Figure 1.3 is another way of illustrating the amounts of salt water and fresh water on Earth.

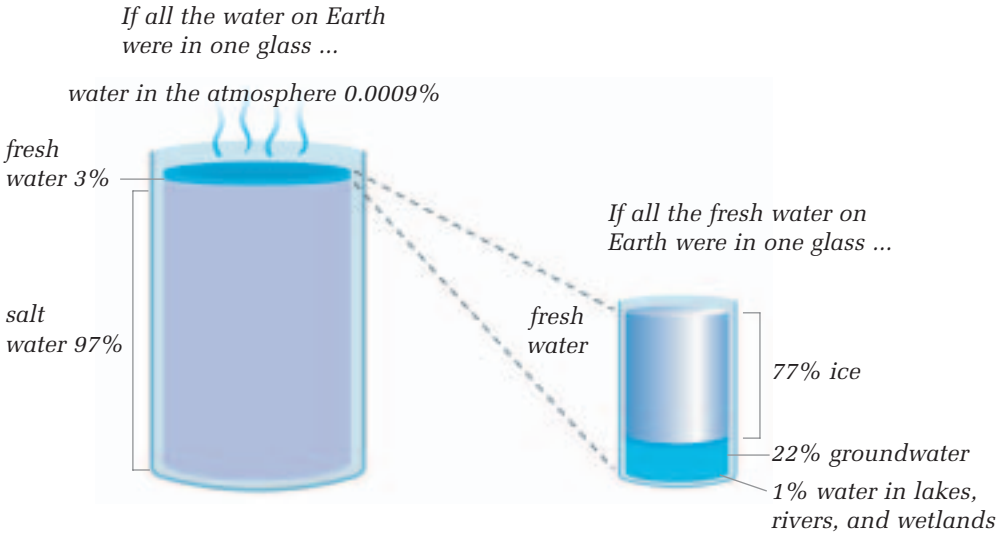


Figure 1.3 Most of the water on Earth is in the salty oceans. Most fresh water is frozen solid.

Check and Reflect

1. a) Where is most of the fresh water on Earth?
   b) Is it readily available for humans to use? Why or why not?
2. a) How much of all the water on Earth is available for humans to drink?
   b) Find the circle graph that you drew at the beginning of this subsection predicting the amount of drinking water compared with the total amount of water on Earth. Was your prediction close? Why or why not?
3. We know that Earth's population is increasing. Do you think enough drinking water will be available for future generations? Why or why not?

1.2 Water Quality

When you turn on your tap, you expect your glass to fill up with clear water that has no unpleasant odour or taste. In Canada, we expect the quality of our water to be good all the time. **Water quality** describes how pure the water is. You can determine water quality by measuring the amount of substances besides water that are in a water sample.

Water in nature is never pure—it always contains organisms, organic material, minerals, and other chemicals. You are about to explore water quality in more detail. To prepare for your exploration, start a concept map with the phrase *water quality* in the centre. Build your concept map as you read about and investigate water quality. See Toolbox 9 for information on creating concept maps.

Substances Dissolved in Water

Many different substances are dissolved in both fresh and salt water. Most of these substances are called *salts*. The most common salt dissolved in water is sodium chloride—the same mineral we use for table salt. The total amount of all salts dissolved in water is called its **salinity**. Seawater (water in the oceans) has a much higher salinity than fresh water. Seawater's average salinity is 3.5%. Seawater also contains many other substances in much smaller amounts. It even contains gold and silver! But you would have to process an enormous amount of seawater to obtain even a small amount of gold.

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Unsafe Water

Over 1 billion people drink dirty water every day because they can't get clean water. Worldwide, 3 to 5 million people die each year from unsafe water. Most of them die from diseases carried by the local water supply. The diseases may be caused by bacteria, viruses, or small parasites in water. Most of these diseases are spread by drinking water contaminated by feces of infected animals or people.

Why is this water unsafe for human use?

Hard Water

Fresh water can be found both on Earth's surface and underground. As it flows, it dissolves minerals from the soil and rocks it passes through. One of these minerals is salt. Fresh water contains much less salt than seawater does. But in some places, the salinity of fresh water is high enough that you can taste it. In Canada, salty fresh water can be a problem in places on the Prairies. Other substances can also be a problem. In some places in Ontario, water contains so much iron that it affects the taste.

Many areas across the country have **hard water**. Hard water contains a high concentration of the minerals calcium and magnesium. You can tell that you have hard water if soap doesn't lather properly. Hard water also leaves mineral deposits in appliances such as kettles and hot water heaters.

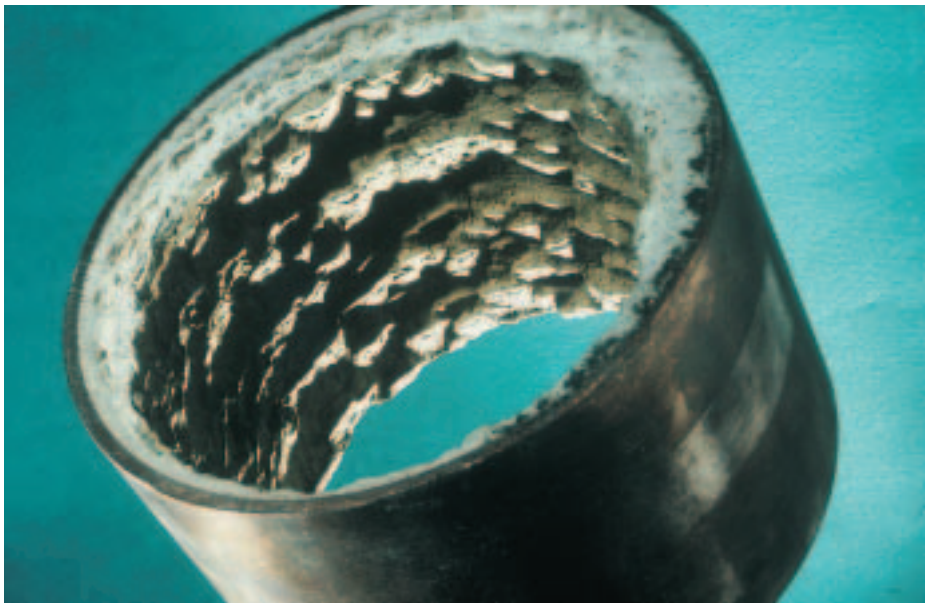

Figure 1.4 Hard water causes mineral deposits called *scale* to form on the inside of pipes. The scale clogs up the pipes.

mathLink

Seawater is a solution containing 96.5% water and 3.5% dissolved salts. The following substances make up these salts:

sodium	30.6%
chloride	55.0%
sulphate	7.7%
magnesium	3.7%
calcium	1.2%
potassium	1.1%
other	0.7%

Which substance makes up the largest percentage of dissolved salts? What percentage of seawater is this substance?

Organisms in Drinking Water

Fresh water also contains organisms and other organic matter. Some of the substances and organisms that may be found in water are harmful and some are not. Most minerals are not a serious health problem, but some organisms that may be found in fresh water can be. For example, *Escherichia coli*, known as *E. coli*, is a type of bacteria that can cause sickness and even death. Usually, our water treatment processes prevent these organisms from becoming a problem.

Water Quality Testing

If you get your water from a well, your family probably doesn't have the water tested very often. Because the water comes from deep underground, it is protected from most pollutants—both natural and human-made. But most cities and towns get their drinking water from surface sources, either lakes or rivers. They then filter this water and treat it with chemicals. This processing brings it to a level of quality that is safe for human use. Such water must be tested regularly to make sure that it is potable.

Figure 1.5 A scientist tests water quality. Water quality is important to all living things. Different organisms can withstand different levels of water quality. The close-up shows the parasite *Giardia*. It causes intestinal problems in humans.

reSEARCH

Community Water Processing

Getting good quality water to people, businesses, and other users is a big effort. Water from a source such as a lake, river, or groundwater is pumped into a treatment plant. There it passes through a series of stages that gradually make it cleaner and cleaner until it is safe to drink. Find out how water treatment is done in your community.

Inquiry Activity

Testing the Waters

The Question

Are there physical and chemical differences between treated water and untreated water?

Materials & Equipment

- 1 500-mL sample of tap water in a beaker
- 2 500-mL samples of untreated water from 2 different sources (provided by your teacher)
- filter paper (or white paper coffee filters)
- funnel
- 250-mL beaker
- graduated cylinder
- 3 test tubes
- silver nitrate (1% solution)
- 3 Erlenmeyer flasks
- soap flakes (not detergent)
- 1-mL measuring spoon
- 3 stoppers for flasks
- bromothymol blue

Caution!
Do **not** taste any of the water samples at any time during this activity.

Caution!
Always follow your teacher's instructions in handling and disposing of chemicals.

The Hypothesis

Write a hypothesis about the differences you would expect to find between treated and untreated water.

Hint: Think about their appearance and what substances they might contain.

Procedure

Checking for Clarity

1. Observe the samples in their beakers. Record their appearance, including colour.
2. Read the next step and predict what you will see after filtering each water sample.
3. Place a filter paper cone in a funnel and place the funnel in the empty beaker. Using the graduated cylinder, pour 100 mL of one water sample through the filter paper. Wait until the water has drained through the filter entirely. Observe the filter paper and the water in the beaker. Record your observations.
4. Repeat step 3 for each of the other two water samples.

Testing for Chlorine

5. Predict which water sample will contain the most chlorine.
6. Pour a small amount from each water sample into separate test tubes. Add 5 drops of silver nitrate solution to each test tube. Record any changes you see in the water in the flasks. Wash your hands.

Testing for Hardness

7. Use the graduated cylinder to measure 100 mL of each sample into 3 separate Erlenmeyer flasks. Label each flask.
8. Add 1 mL of soap flakes to each flask and put the stoppers in the flasks. Shake each flask vigorously for 30 s. Observe the soap froth in each flask. Record your observations.

Testing for Living Organisms

9. Thoroughly wash out, rinse, and dry the 3 Erlenmeyer flasks and rubber stoppers. Pour 125 mL of the tap water into a clean Erlenmeyer flask. Put the same amount of each of the other samples in separate flasks. After you measure each sample, make sure to clean the measuring container thoroughly with soap and water. Then rinse and dry it carefully before using it for the next sample.

10. Add 5 drops of bromothymol blue to each flask. Tightly stopper the flasks and label them. Record the colour of the solution in each flask. Place all the flasks in a warm, dark place where they won't be disturbed for 24 h. Wash your hands. After 24 h, remove the flasks from the dark and record the colour of the solution in each one.
11. Wash your hands after you have completed all the tests and cleaned up your equipment.

Figure 1.6 Step 3. Pour 100 mL of one water sample through the filter.

Collecting Data

12 Record your observations in a table similar to the one below.

Purpose of Test	Appearance of Sample before Test	Appearance of Sample after Test	What the Test Indicated

Analyzing and Interpreting

13 Explain any differences you observed in the appearance of the filter papers used for the water samples.

14 Which sample contained the largest amount of chlorine? Why?

15 Which sample contained the hardest water? How do you know?

16 When you were preparing the test for living organisms, you had to clean the graduated cylinder between water measurements. You also had to make sure the Erlenmeyer flasks were clean. Why did you have to be so careful?

17 Which sample contained the most living organisms? Do you think it would be safe to drink? Remember: Do **not** taste any of the water samples.

18 Which sample had the least number of living organisms? Why?

Figure 1.7 Step 6. Add 5 drops of silver nitrate solution to each test tube.

Forming Conclusions

19 Are there differences between treated water and untreated water? Summarize the results of your tests to support your conclusion.

Applying and Connecting

For years, the Cree community of Split Lake, Manitoba, had suffered health problems because of poor water quality. They went to Environment Canada for help and then linked up with the International Development Research Centre (IDRC) in Ottawa. IDRC had been working on low-cost water-testing kits for developing countries. The Split Lake community used the IDRC technology to prove that people in isolated areas could do their own water testing and take action to improve their water quality.

Water Testing Criteria

Figure 1.8 Which glass of water is safe to drink? Maybe neither of them is!

One of the first things that a technician does when testing water is to look at it. Look at the two glasses of water in Figure 1.8. Which one of these glasses of water would you be more likely to drink? Another step in water quality testing is smelling the water. Does it have any unpleasant odours? For example, in some areas, dissolved hydrogen sulphide gas can give water a rotten egg smell. And it's not only the smell that is bad. Hydrogen sulphide is unsafe for human consumption.

Always remember, however, that clear water is not a sign of clean water. Ocean water can be very clear, but we can't drink it because of the high salt content. Similarly, a stream in the woods may look clear, but it may contain organisms or chemicals that are dangerous to humans. In order for us to be sure that our water is safe to drink, it must be tested regularly. After testing, the water is filtered and treated with chemicals, such as chlorine, to kill any dangerous organisms.

These are some of the items that drinking water is tested for:

- taste and odour
- turbidity (cloudiness) and colour
- toxic substances and other pollutants
- bacteria
- hardness or mineral content
- pH (how acidic or basic the water is)
- dissolved oxygen
- solids, including floating materials
- dissolved solids

Changing Salt Water to Fresh Water

As you learned in subsection 1.1, most of the water on Earth is in the salty oceans. Much of the fresh water is locked up in icecaps and glaciers. Only a small percentage of liquid fresh water is available for drinking. In some areas of the world, very little fresh water is available, but there is lots of salty water. Is there a way to use salty water for drinking? Salt water must be processed to remove the salt to make the water potable. The two most common processes used for producing fresh water from salt water are distillation and reverse osmosis.

Distillation

Distillation equipment produces pure water (distilled water) from water that may contain minerals, such as salt, and other substances. In **distillation**, the solution is boiled so that the water evaporates and leaves the salt behind. Liquid fresh water is then formed from the water vapour.

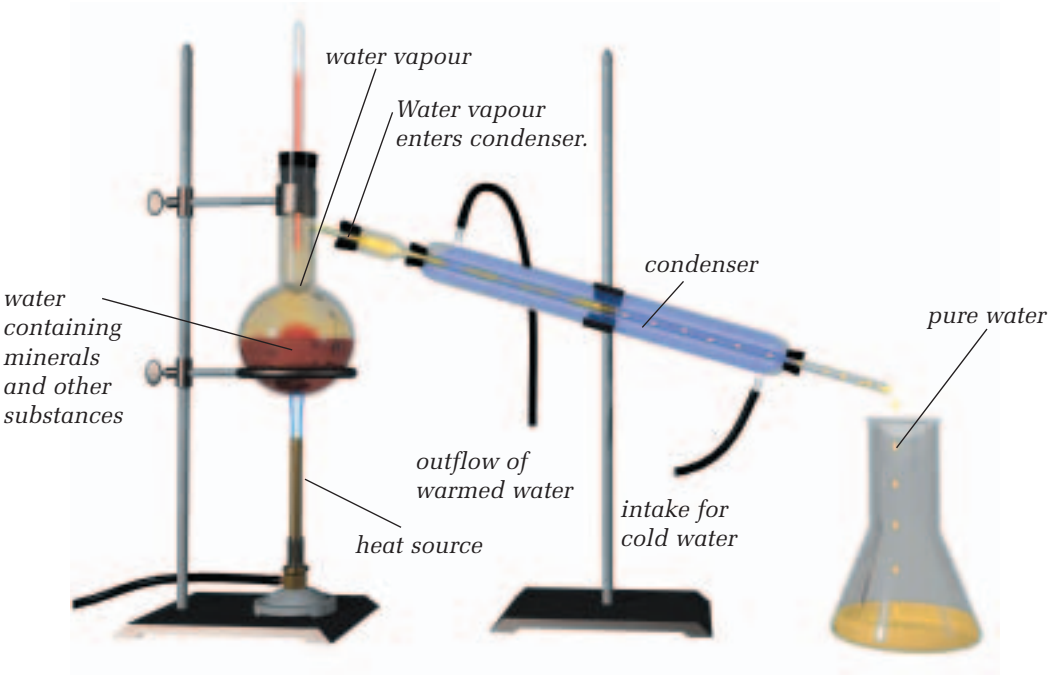

Figure 1.9 This simple lab apparatus can create pure water.

Reverse Osmosis

Reverse osmosis operates by forcing salt water through a filter or membrane with holes too small for the salts to pass through. *Osmosis* is the movement of water particles through a membrane. The particles move from an area of higher water concentration to one with a lower water concentration. In reverse osmosis, the water moves from an area of lower water concentration to one of higher water concentration. In this way, the water leaves behind the unwanted dissolved substances.

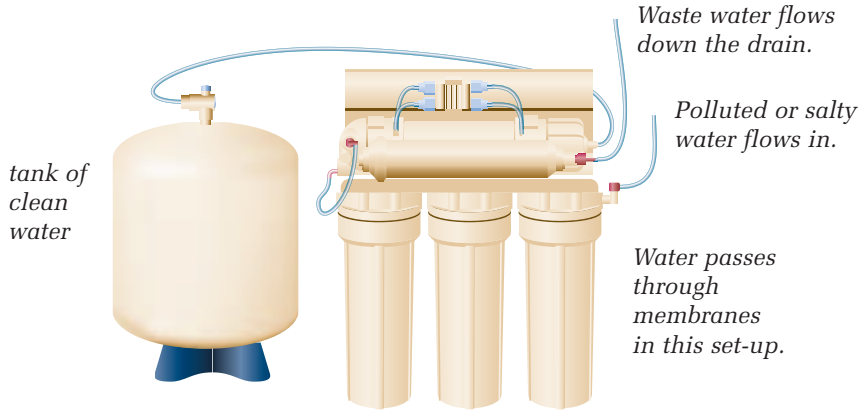

Figure 1.10 This reverse osmosis set-up can also create pure water from salty or polluted water.

Check and Reflect

1. You are walking along a dry, dusty road in summer. Feeling really thirsty, you stop by a clear, running stream. Would you drink the water? Why or why not?
2. Some cities and towns take their drinking water from rivers and lakes. Sometimes their water quality changes during the year. What do you think might cause these changes? Suggest an example of the difference in water from a lake between summer and winter.
3. Saudi Arabia is a desert country with very little fresh water. However, it has a long coastline along the Red Sea and the Persian Gulf. Large commercial desalination operations in Saudi Arabia produce fresh water from salt water. The availability of inexpensive fuel in the form of oil makes these huge operations possible. One of the reasons Canada does not have huge desalination operations is the high cost of fuel to heat the water. Can you think of any other reasons why we don't use distilled water?

TRY This at Home

Activity

Salt Water into Fresh Water

You can turn salty or dirty water into drinkable fresh water simply by using the sun. After all, it's the sun's energy that converts the salty water of the oceans into the fresh water of the rain. All you need is a clean, clear plastic bag, a twist-tie to close the bag, some table salt, and a cereal bowl of water.

- Dissolve a tablespoon of salt in the bowl of water. Taste the water by touching it and tasting it off your fingertip. It should taste very salty.
- Place the bowl inside the plastic bag and close the top of the bag tightly with the twist-tie.
- Set the bag and bowl next to a sunny window, and leave it there for 24 h.
- After 24 h, open the bag, and touch the liquid collected on the inside of the bag. Taste it. Is it still salty?
- Explain what happened to the salty water.

Figure 1.11 Set-up for activity

Assess Your Learning

1. Explain what potable water is. If all the water on Earth is represented by a 1000-L tank, how many millilitres of that would represent potable water?
2. Do you think there are reserves of fresh water that have yet to be used by humans? Explain your answer.
3. What chemical is usually added to water that will be piped to households? Why?
4. What is hard water? What do you think soft water is?
5. If you haven't already done so, add information on water quality and testing to your concept map. Keep your concept map so you can add to it later in this unit when you learn how water quality can affect organisms.

Focus On Social and Environmental Context

Science and technology have contributed to human well-being. Think about what you learned in this section.

1. How have water quality testing techniques improved people's lives?
2. Why do you think more and better water desalination technology is being developed?
3. What did you learn about water quality in this section that helped you understand the importance of protecting our sources of drinking water?

Desalination plant

2.0

Water in its various states affects Earth's landforms and climate.

Key Concepts

In this section, you will learn about the following key concepts:

- water-borne materials
- erosion and deposition
- stream characteristics
- continental drainage systems
- ocean basins
- climate
- glaciers and icecaps

Learning Outcomes

When you have completed this section, you will be able to:

- describe the causes of waves and tides
- describe erosion and deposition and their causes
- identify stream characteristics
- describe processes that shape ocean basins and continental drainage
- identify factors that affect glaciers
- recognize evidence of glacial action
- describe the link between water and climate

Water exists in many different forms on Earth. You can find it in all three states—solid, liquid, and gas. You can find it underground, on the surface, and in the air. Because there is so much of it, water affects both the living and non-living parts of Earth's environment. Waves and tides erode shorelines and influence the kinds of animals and plants that live there. On land, moving water in streams and rivers, and moving ice in glaciers change the geography of continents. And water—or the lack of it—determines climate and weather around the world. In this section, you will learn more about how fresh and saltwater systems interact with the atmosphere and Earth's surface.

For Web links relating to 2.0, visit **www.pearsoned.ca/scienceinaction**

2.1 Waves and Tides

In Figure 2.1, waves splash onto the ocean's shore at low tide. Above the line of waves, you can see another line on the shore where the waves hit at high tide. Waves and tides are two examples of ways in which water moves.

Waves are movements on the surface of the water. Tides are the regular rising and falling of very large bodies of water. You can also see in Figure 2.1 evidence of erosion caused by the waves. Make a sketch of what you see in Figure 2.1. Label it to show where the waves are coming from, the effect they have had on the shore, high tide level, and low tide level. As you read through this subsection, add information on waves and tides to your diagram.

What Is a Wave?

If you have ever been to the ocean or a lake, you know that the water's surface is constantly moving. On calm days, waves lap along the shore. On stormy days, they crash against it. But even small bodies of water—right down to puddles—have waves sometimes. How do these waves form?

Figure 2.1 Waves and tides both affect the shape of the shoreline.

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Boats and Shore Erosion

A large cruiser travelling at 8 knots (14.8 km/h) will cause a wash big enough to sink small boats, damage moored ones, and contribute to shore erosion. In waterways where major bank erosion is occurring, you may see "NO WASH" signs displayed. This means that boat drivers must slow down so that no waves are created that could damage the shore.

Boats create waves called "wash" that can affect other boats and the shore.

Inquiry Activity

Making Waves

The Question

How does the movement of waves affect objects floating on the water?

The Hypothesis

Write a hypothesis to explain how the movement of waves affects objects floating on the water.

Materials & Equipment

- deep, flat baking pan
- water
- 1 cork

Procedure

1. Fill the baking pan three-quarters full of water, and place it on a desk or table. Wait for the surface to be calm.

Figure 2.2 Set-up for making waves

2. Create waves by blowing across the water's surface.
3. Take turns trying to produce different kinds of waves. See if you can change the height of the waves.
4. Place a cork on the water, and wait for the water to calm. Predict what will happen if you blow on the water and not on the cork. Blow on the water to make waves, but do **not** blow directly on the cork.

Collecting Data

5. Draw labelled diagrams of the different waves you make and the cork's movement.

Analyzing and Interpreting

6. Were you able to change the heights of the waves you created? If so, how did you do it?
7. Were you able to move the cork across the pan? Explain why or why not.

Forming Conclusions

8. Using words and pictures, create a summary of what you know about waves.

The Movement of Water Waves

Waves are changes in patterns that move along the water's surface. The water itself does not move very far, but waves can move thousands of kilometres across the surface of the ocean. You can use a rope as a model of wave motion. In Figure 2.3, a student is shaking a rope to create waves. The waves move through the rope, but the rope itself doesn't go anywhere.

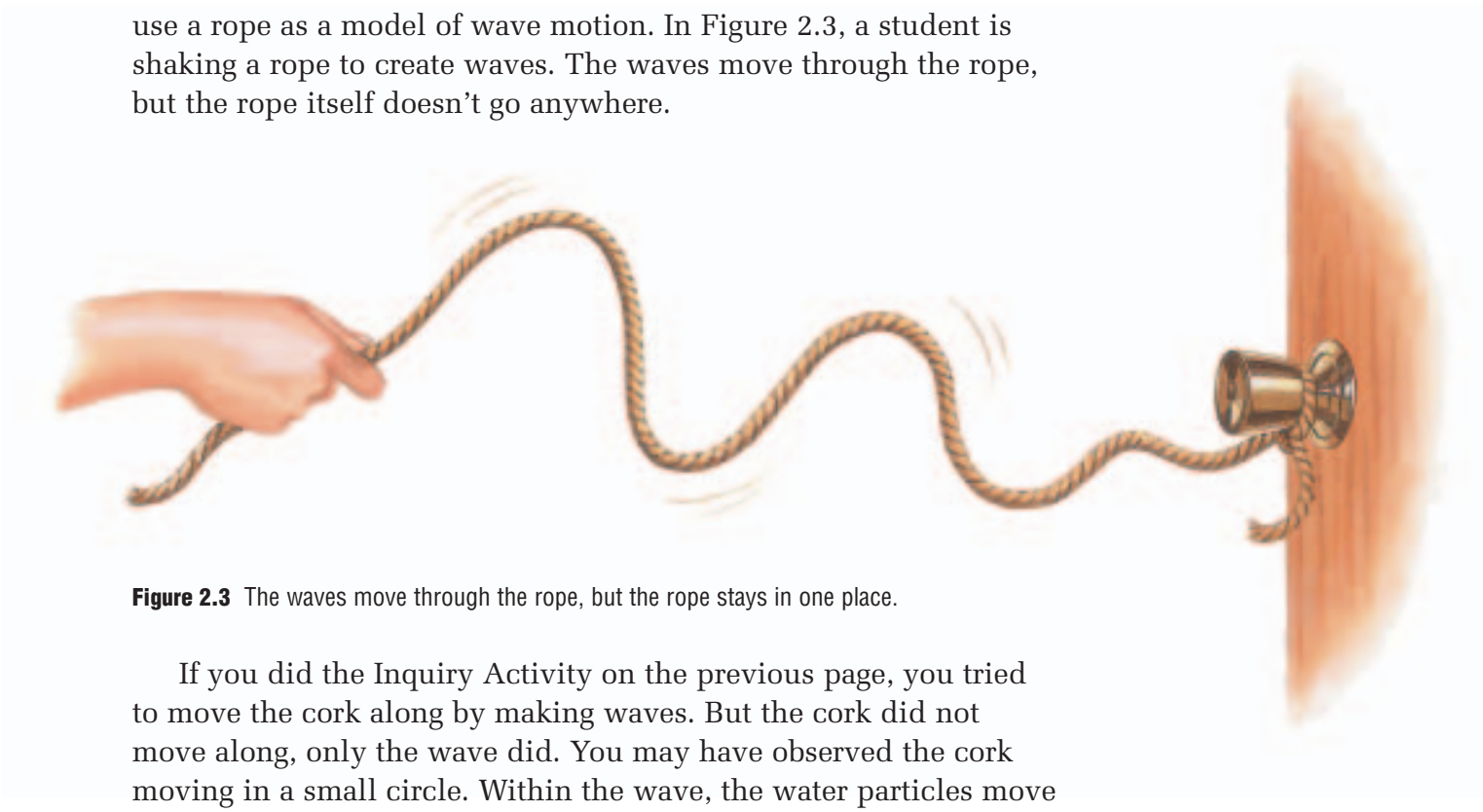

Figure 2.3 The waves move through the rope, but the rope stays in one place.

If you did the Inquiry Activity on the previous page, you tried to move the cork along by making waves. But the cork did not move along, only the wave did. You may have observed the cork moving in a small circle. Within the wave, the water particles move in a circular motion as shown in Figure 2.4. But the water particles themselves do not move long distances.

Causes of Water Waves

Most waves are caused by the wind. The stronger the wind, the bigger the waves. Out in open water, waves appear as up-and-down water movements. If you were in a boat, you would feel this up-and-down movement as the waves passed under your boat. Near the shore, the water becomes shallower, and the lower part of the waves drags on the bottom of the ocean or lake. This slows the waves down, and the tops of the waves rise up and eventually break, crashing onto the shore. This is where waves do the most damage.

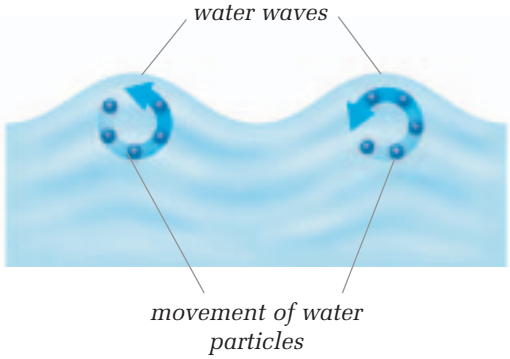

Figure 2.4 A wave moves along the surface of the water, but the water itself moves only in a tiny circle in one place.

Effects of Waves on Shorelines

The force of waves crashing against a shoreline can change the shape of the shore, whether it's hard rock or soft sand. Large waves erode away the shore. But small waves move gently onto the shore. They can deposit sand or other materials near the shore. Figures 2.5 and 2.6 show some examples of the effects of waves on coastlines.

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Tsunamis

Earthquakes can create huge ocean waves, called *tsunamis*. Although these waves are large, they are spread out over a long distance. Because of this, they are not very noticeable in the open ocean. Once they begin to slow down in shallow water, however, they can grow as high as a 15-storey building. Find out how an earthquake causes a tsunami.

- Why do we hear of tsunamis in the Pacific Ocean more than anywhere else?
- How does the tsunami warning system in the Pacific Ocean work?

Figure 2.5 Percé Rock is the most famous landmark on the Gaspé Peninsula in Quebec. Wave erosion has pierced a hole through the rock and is gradually eroding away the whole rock.

Figure 2.6 Waves are eroding and depositing gravel along these beaches in Nova Scotia. Gravel ridges are being deposited out in the water, as gravel is being eroded from the land.

What Are Tides?

Figure 2.7 Why does the water level change in this bay?

The two photos in Figure 2.7 were taken at the same spot about 6 hours apart on the New Brunswick coast. What happened to the water in the bay? Where did it go? If you waited another 6 hours, how much water would be in the bay?

Because New Brunswick is on the shore of the ocean, the water level along its coast changes regularly every day. This change in water level is called the **tide**. People who live beside the ocean are used to seeing and working around high and low tide. High tide is the highest water level along the coast, and low tide is the lowest water level. In most places, there are two high tides and two low tides a day.

The Causes of Tides

The main cause of tides is the gravitational force of the moon. Figure 2.8 shows how tides occur. The side of Earth that is closest to the moon feels the strongest pull from the moon's gravity. This is where the bulge of water is the largest. But other forces are also at work, resulting from Earth's and moon's rotations. These forces cause another, smaller bulge on the other side of Earth at the same time. The two large bulges, on either side of Earth, are the high tides.

As the moon orbits Earth, it pulls the large bulge of water along. At the same time, Earth is spinning in its rotation, *and* orbiting around the sun. All of these movements combine to create two low tides and two high tides every 24 hours and 50 minutes. Because every day is 24 hours, this means that low tide or high tide is 50 minutes later every day. People who live along the ocean use guides called tide tables to tell them when the tides occur, and how high or low they will be that day.

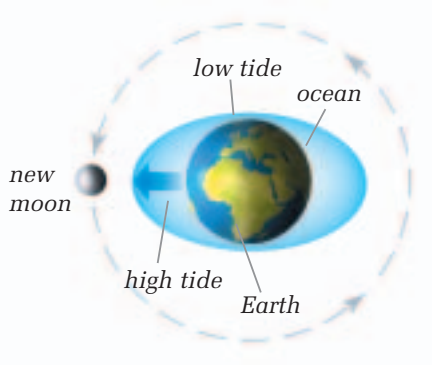

Figure 2.8 The gravitational force of the moon is the main reason for ocean tides on Earth.

Check and Reflect

1. Describe the movement of water in a wave.
2. What happens to waves in a lake as they get closer to shore?
3. We usually think of waves on lakes and oceans. Can rivers have waves? If so, what causes them?
4. What causes tides?
5. Look at your drawing of the shoreline that you started at the beginning of this subsection. If you haven't already done so, add information from this subsection to it. Did you learn anything in this subsection that surprised you? What was surprising about it? How would you explain this new idea to another student?

Careers and Profiles

Glaciologist

Glaciologists are scientists who would rather spend a summer cooling their heels on ice than soaking up the sun on a southern beach. They study glaciers, investigating how glaciers move and their connection to world climate.

Glaciologists use radar to find out what the ground is like under a glacier. When they have gathered enough data, they design computer programs that describe the movement of glaciers and predict how and why glaciers change.

Glaciologists exploring an ice cave

1. Why is it important to understand the natural environment?
2. What do you think would be the most interesting part of a glaciologist's job? Why?
3. List three important skills a person would need to be a successful glaciologist.

2.2 Erosion and Deposition

Think about a river or stream in or near your community. How fast does it flow? Is the water clear or muddy? Does it flow straight or does it wind its way through the area? The answers to these questions would describe some of the characteristics of your stream or river. Scientists use these characteristics to help them understand where different types of organisms might live in a river and how they might be affected by human activities. Engineers use these characteristics in building dams and bridges.

Stream Characteristics

To learn more about a stream or river, you would develop a *profile* of it. A stream's profile is a description of its characteristics. How fast does it flow? How steep is the stream's channel? How is it eroding its banks? Each stream has a pattern of flow that is shaped by its characteristics. **Stream characteristics** include the rate of water flow and the slope of the stream's bed. Rivers can be described with these same characteristics. Figure 2.10, after the next Inquiry Activity, is an example of a river's profile.

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Hot Springs

Rivers and streams carry and deposit sediments on Earth's surface. Hot springs bring dissolved sediments up from within Earth and deposit them on the surface. The water of the hot springs comes from deep underground, where the temperature of the rocks is higher than at the surface. From earlier studies, you know that warm or hot water can dissolve more solute than cold water. As the hot water passes through rocks and soil, it dissolves more and more minerals. But once it reaches the surface, it cools down. As it cools, it can no longer keep so much solute in solution, so it deposits the sediment near where it emerges from the ground.

These terraces of calcium carbonate are deposited by the hot water from hot springs in Nahanni National Park.

Inquiry Activity

Stream Flow

The Question

What is the relationship between the slope of a stream bed and the erosion of the material in the stream bed?

Materials & Equipment

- gravel and sand mixture
- buckets or pails
- stream table or roof gutter
- mixing spoon
- 2 lengths of plastic tubing
- books
- paper towels, sponges

The Hypothesis

Form your own hypothesis to test the relationships between stream-bed slope and the erosion of stream-bed material.

Procedure

1. Use a bucket to get enough sand and gravel mixture to fill the stream table to a depth of 3 to 5 cm. Use the mixing spoon to spread the mixture evenly. Connect one piece of plastic tubing to the drain port at one end of the stream table. Place the other end of the tubing in an empty bucket.
2. Connect a second length of plastic tubing to your water source, if it is a faucet. If it's not a faucet, place one end of the tubing in a clean bucket full of water.
3. With the help of another student, raise the stream table or roof gutter 1 cm at the end opposite the drain port. A third person then places a 1-cm pile of books under the raised end. Lower the stream table onto the books and make sure it is steady before you let go.
4. Read the next three steps. Predict what will happen to the stream-bed material and the water's flow each time.
5. Check the drain port and remove any sand and gravel mixture that is blocking it. Allow the water to flow at a slow trickle onto the raised part of the stream bed or roof gutter. Squeeze the end of the tubing until you get the flow you want. Observe the direction and speed of the water's flow. Observe its effect on the stream-bed material. Make sure to keep the flow rate of the water the same for each trial.
6. With the help of another student, increase the slope of the stream table by lifting the end opposite the drain port to 5 cm. A third person places a 5-cm stack of books under the raised end. Make sure the gravel and sand mixture is evenly spread on the bottom of the stream table. Empty the water in the outlet bucket, and check all tubing connections. Use the same flow of water as in step 5. Observe the direction and speed of the flow of water. Observe its effect on the stream-bed material.
7. Use the same procedure as in steps 5 and 6 to raise one end of the stream table to 20 cm. Make sure the gravel and sand mixture is evenly spread on the bottom of the stream table. Empty the water in the outlet bucket, and check all tubing connections. Use the same flow of water as in steps 5 and 6. Observe the direction and speed of the flow of water. Observe its effect on the stream-bed material.

Caution!
At least two people must be used to lift the stream table.

8 With the help of another student, lift the stream table off the pile of books. A third person removes the books. Place the stream table flat on the desk, and let any remaining water drain from it. Use the paper towels and sponges to clean up any spills.

Figure 2.9 Setting up the stream table

Collecting Data

9 Design a data table to record your observations in your notebook. Draw diagrams to illustrate changes to the gravel and sand mixture.

Analyzing and Interpreting

10 What happened to the stream-bed material as the water flowed over it?

11 How did the stream flow behave on the shallow slope? Did this change as the slope was increased?

12 Why was it important to keep the water flow rate constant for all the trials?

13 Was your hypothesis correct or would you have to restate it? Would you have to change any of the variables in the set-up before you could verify your hypothesis?

Forming Conclusions

14 Using a written summary and labelled diagrams, describe the relationship you discovered between the slope of the stream bed and the erosion of material on the stream bed. Include observations of the speed of the water in the stream in your summary.

Applying and Connecting

Operators of river rafting companies have to know every twist and turn of the rivers they use. Before they determine a suitable course on a river, they must understand the river's characteristics. This helps them choose the route that is both the safest and the most exciting. It also helps them identify places where they can come ashore easily, if necessary.

Extending

During this activity, you observed the flow of water when the stream bed was at different heights. You probably described the water as moving faster or slower, depending on how high the stream bed was placed. This type of information is called *qualitative data*. It describes events without using exact measurements. Suppose you had measured the speed of the water in metres per second for each height of the stream bed. This type of information is called *quantitative data*. It describes events in measurements or quantities. In this activity, the quantitative data would be the measurement of speed. In another activity, it might be temperature or amount of solute. Design a procedure to collect quantitative data on the rate of water flow in your stream bed. Test your procedure. Compare the speeds at different heights of the stream bed.

Profile of a River

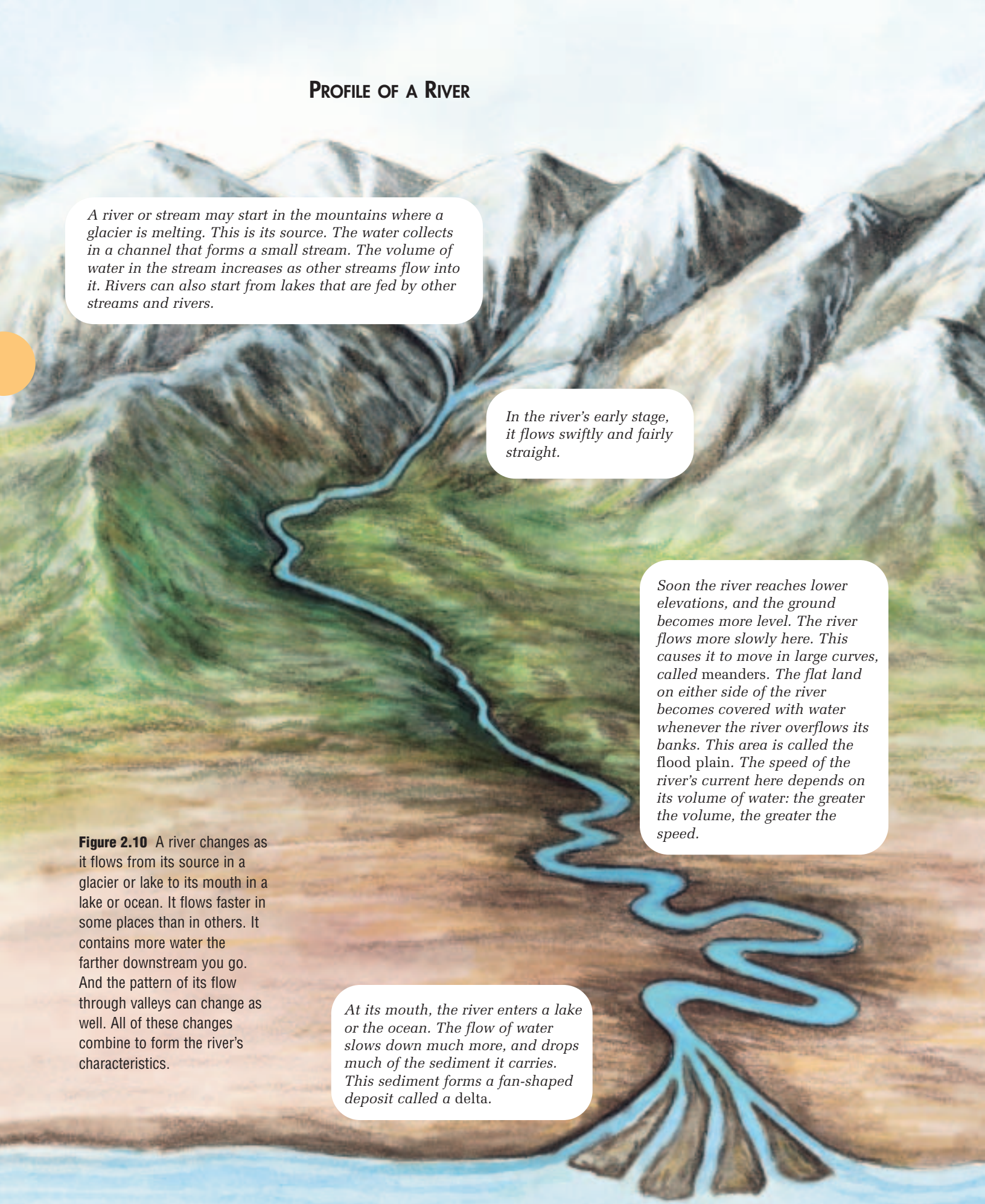

Figure 2.10 A river changes as it flows from its source in a glacier or lake to its mouth in a lake or ocean. It flows faster in some places than in others. It contains more water the farther downstream you go. And the pattern of its flow through valleys can change as well. All of these changes combine to form the river's characteristics.

Erosion and Deposition

Moving water is one of the most powerful forces on Earth. It can tear away pieces of rock and lift and carry sand and soil long distances. Earlier in this section, you saw how waves can affect shorelines by eroding in some places and depositing sediment in others. Streams and rivers also shape the land as they flow through it.

Recall from your earlier studies that erosion is the wearing away and transporting of rock fragments and soil. These are called **sediments**. Deposition is the laying down or depositing of sediments. A river's *sediment load* is the amount of water-borne materials, such as soil, rocks, and organic matter that it carries. *Water-borne* means "carried by water." Remember that as long as water is flowing, it can carry sediment. But the slower it flows, the less load it can carry. As it slows down, it deposits some of its sediment load. Once it stops flowing, it can't carry any load. It deposits all the sediment it still carries.

Chemical Weathering

Erosion can also occur because of chemical weathering. Caves form when rainwater and streams dissolve limestone and other rocks. The water collects in cracks and holes in the rock. As it sits there, it gradually dissolves more and more of the rock until large caverns form. Streams and rivers flowing through these caverns cause even more erosion.

Figure 2.11 Streams and rivers flowing through caves carry dissolved sediments.

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Karst Landscapes

The formations shown below form part of what is called a *karst landscape*. Such a landscape typically has caves, sinkholes, natural stone bridges, sinking streams, and other features. Find out how karst landscape forms. What are sinkholes and sinking streams?

These karst formations are in the Mackenzie Mountains in the Northwest Territories.

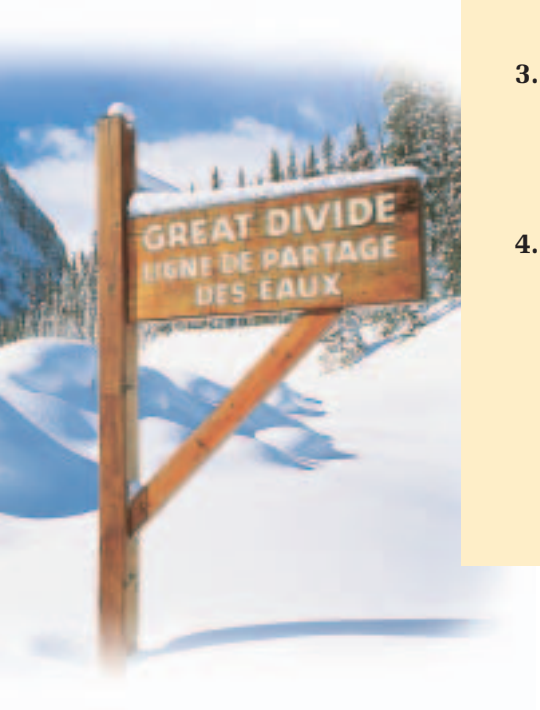
What Makes a Watershed?

A **watershed** is all the area of land that drains into one main lake or river. It can contain many smaller rivers and lakes, which all eventually drain into a larger one. Even your neighbourhood is part of a watershed.

Most watersheds drain into lakes and rivers that drain into other lakes and rivers, which finally drain into an ocean. The location of the highest land on the continent determines the direction that a watershed drains. This high land is called the **Continental Divide**. In North America, the major divide is in the Rocky Mountains. To the west of the Continental Divide, rivers flow into the Pacific Ocean. To the east of the Continental Divide, rivers flow into either the Arctic Ocean or the Atlantic Ocean. The borders between British Columbia and Alberta, and Yukon and the Northwest Territories follow the Continental Divide.

Check and Reflect

1. List two characteristics you would want to know about a stream if you were planning to wade across it. Why would you want to know these?
2. Do you think that all hot springs deposit the same kinds of minerals? Explain your answer.
3. a) Describe some natural factors that might cause erosion along riverbanks.
   b) Describe some human activities that might cause erosion along riverbanks.
4. Using maps and references, create a map to show the streams, rivers, and lakes that are part of the watershed you live in.
   a) Find out how your watershed is connected to the Continental Divide.
   b) Mark on your map the direction to the Continental Divide from your community and the direction to the ocean that your watershed eventually drains into.



This sign marks the Continental Divide in the Rocky Mountains.

2.3 Processes That Shape Ocean Basins and Continental Drainage

In your short lifetime, Earth has been a stable place. Familiar places—rivers, mountains, continents, and oceans—have not changed very much. We may forget that Earth is very old and much of what we see now is not the way it appeared in the past. Earth is in a constant state of change.

Processes That Form Ocean Basins

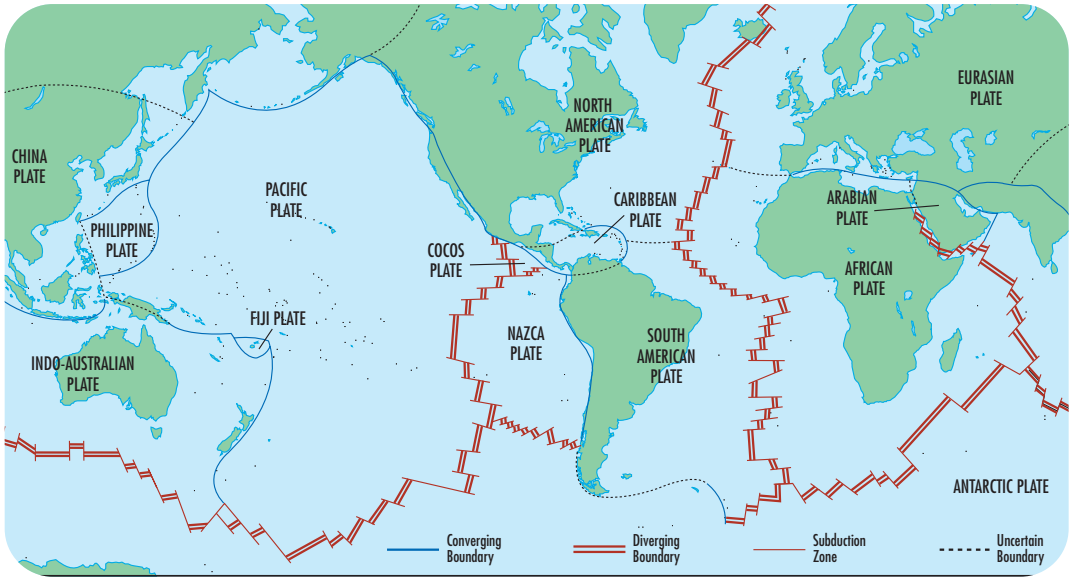


Figure 2.12 The Theory of Plate Tectonics states that the surface of Earth is divided into huge moving plates.

In earlier grades, you learned that the solid outer part of Earth is called the *lithosphere*. The lithosphere is made of rock that is broken into huge plates. The map in Figure 2.12 shows the shape and position of these plates today, but these plates are not fixed in these positions. They are moving very slowly over Earth's surface because of convection currents within Earth. Some plates are moving toward each other. Others are moving apart. And some are moving alongside each other in opposite directions. These movements have shaped the geological features on the ocean floors and many of those on the continents. Figure 2.13 shows the major features on the ocean floors and how they formed.

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What Is the World's Tallest Mountain?

If you said Mount Everest, you're right—sort of! Mount Everest is the tallest mountain on dry land (8850 m). But Mauna Kea in Hawaii starts on the ocean floor. If it's measured from its base underwater, it's taller than Mount Everest. Mauna Kea is about 10 023 m tall.

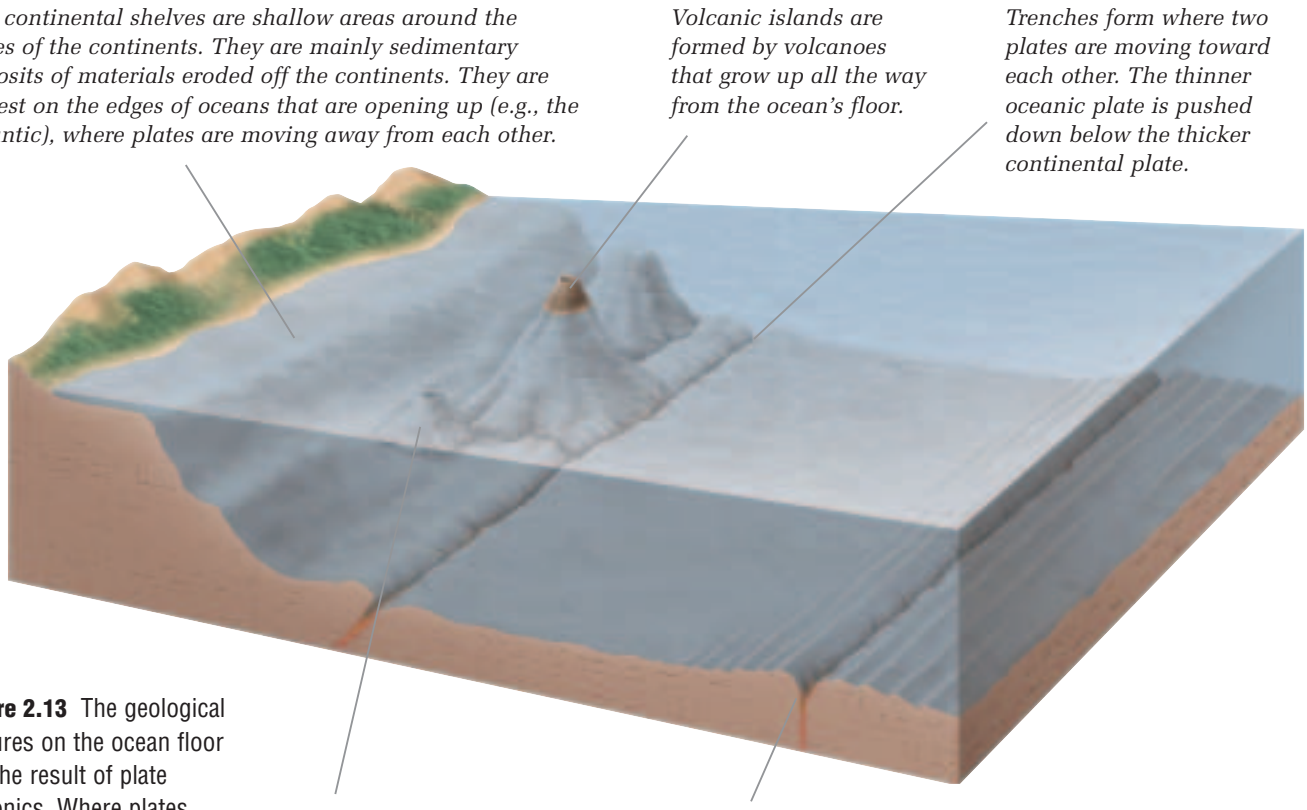

Figure 2.13 The geological features on the ocean floor are the result of plate tectonics. Where plates move toward each other, trenches form. Where they move apart, ridges and faults form. Ridges are a sign that new crust is forming.

Continental Drainage Systems

The changing lithosphere also affects the major drainage patterns of our continents. Changes have occurred over millions of years. Earlier, you learned that the Continental Divide sets the pattern for the directions in which rivers flow. That divide in Canada follows the ridge of the Rocky Mountains. But how did the Rocky Mountains form?

The same forces that shaped the ocean basins built the Rockies. Look again at the map of the plates that form Earth's surface in Figure 2.12. At the edge of the continent, two plates meet. As they push against each other, the continent's surface wrinkles and pushes up. The Rockies and other folded mountains were created this way.

Plate tectonics have formed many mountain ranges. These mountains have helped to shape continental drainage systems. But another major force has carved much of North America's surface to create the lakes and river valleys we see today. This force is ice.

Figure 2.14 Notice where the Rocky Mountains are located. They were formed by plate movements. How are the major river systems related to the mountain ranges?

GLACIERS

Glaciers are large moving bodies of ice. Glaciers that cover vast areas of land are called *continental glaciers* or *icecaps*. They form in Earth's coldest regions. Antarctica and Greenland are covered by continental glaciers. Glaciers also form high up in mountain ranges. Here the temperature is so cold that snow and ice melt very little. More and more snow and ice build up and begin to move. These glaciers, called *valley glaciers*, flow down through the high valleys between mountain peaks.

As glaciers move, pieces of rock become imbedded in the ice. These pieces range in size from tiny fragments to huge boulders. It is these pieces combined with the massive glacier that grind down and shape the land they pass over.

The movement of glaciers depends on the climate. In a cooler climate, little melting occurs. The snow and ice continue to build up, and the glacier continues to move forward or advance. If the climate becomes warmer, more melting occurs. Snow continues to fall in the highest parts of the glacier. But now more melting than build-up occurs. The ice that already forms the glacier melts more and more. The glacier melts back or retreats. It leaves behind the soil, rock, and boulders it once contained.

RESEARCH

Frozen History

Since 1900, glaciers all over the world have been retreating faster than ever before. In 1991, a man who died 5000 years ago was found preserved in a glacier in the Alps. The glacier had retreated as far back as it was 5000 years ago. It is still retreating. Who was this man? What have scientists learned about him and the world in which he lived?

This man died as he was travelling through the Alps 5000 years ago.

Recognizing Glacial Features

Today we have continental and valley glaciers only in certain areas. But many times over Earth's history, large areas were covered with glaciers. This was the time of the Ice Ages. Much of Canada's geography was shaped by these huge sheets of ice. See if you recognize any of the glacial landforms in the photos below. Are there any of these features in the area where you live? Have you seen any of these features in other areas you have visited?

Glacier Landforms

Figure 2.15a) *Moraines* form from rocks and gravel that build up along the sides and at the end of the glacier. As the edges of the glacier melt, large deposits form.

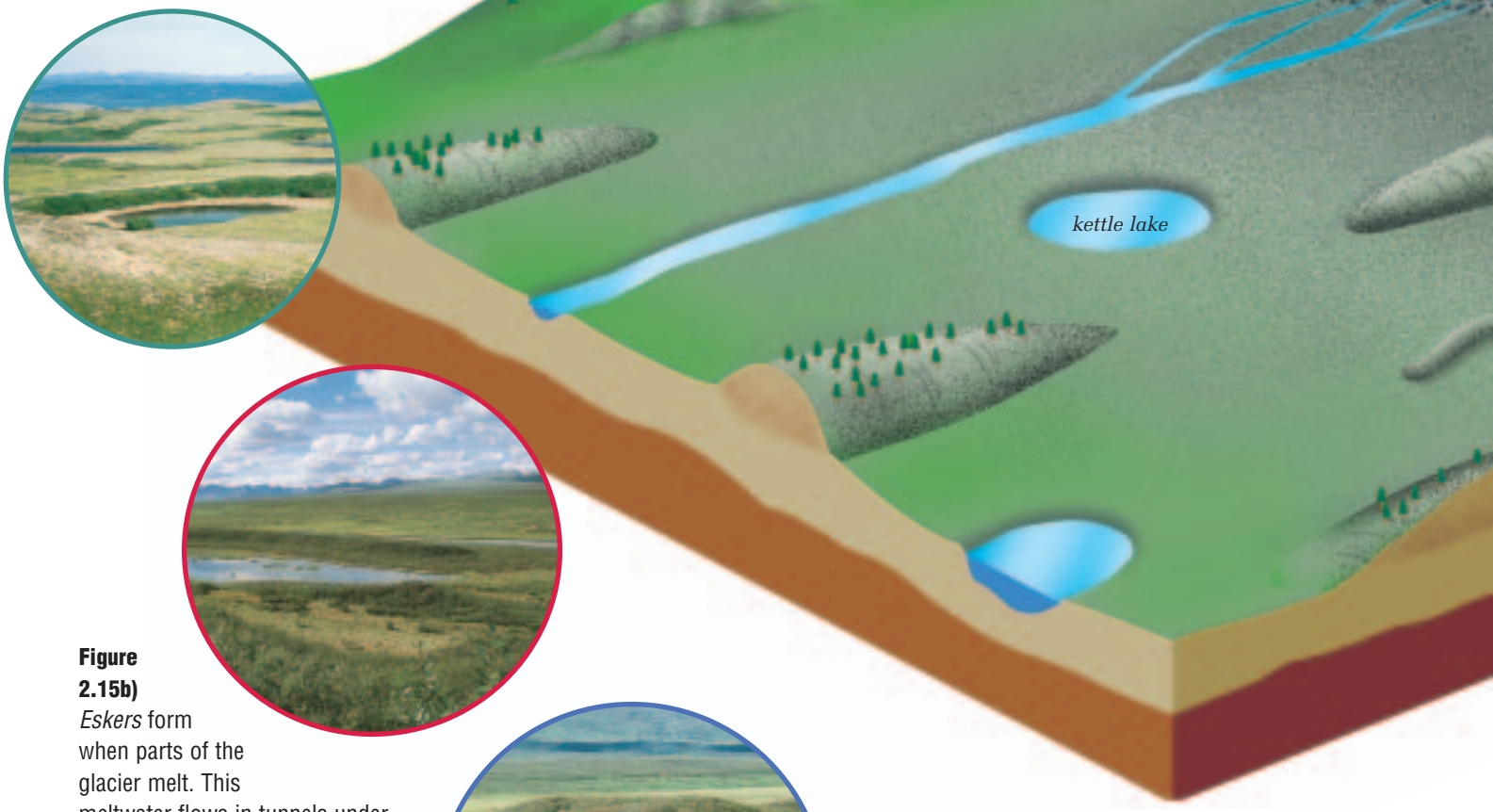

Figure 2.15b) *Eskers* form when parts of the glacier melt. This meltwater flows in tunnels under the ice. The melting releases sand and gravel from the glacier. These sediments are deposited by the meltwater in the pattern of a winding river.

Figure 2.15c) *Drumlins* are small hills with a distinctive teardrop shape. They form when a glacier moves over moraines that had formed earlier. The tip of the drumlin points in the direction that the glacier was moving.

Figure 2.15d) When these mountains formed hundreds of millions of years ago, they had tall sharp peaks like the Rocky Mountains. Repeated glaciation has worn them down to the rounded hills we see today.

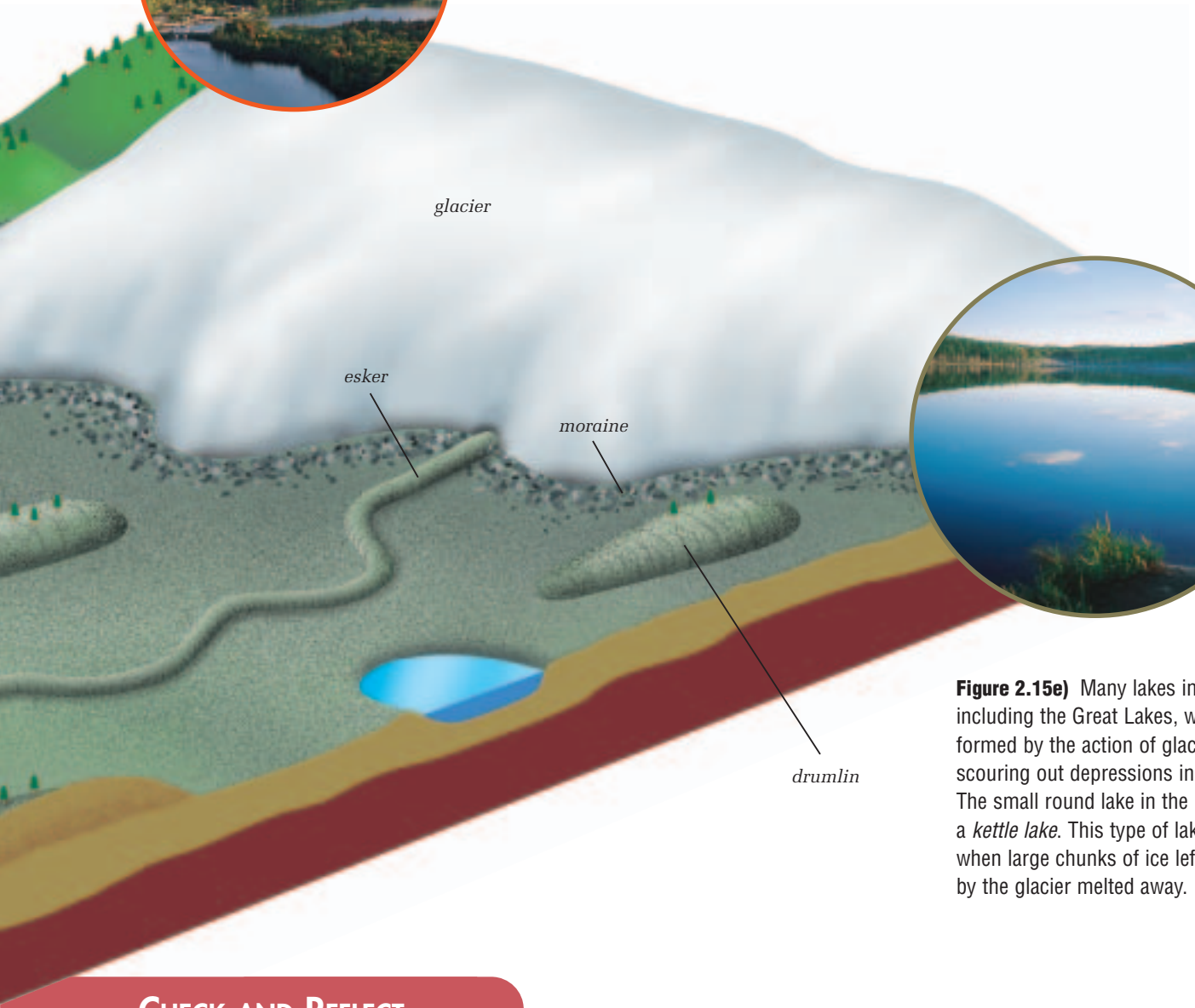

Figure 2.15e) Many lakes in Canada, including the Great Lakes, were formed by the action of glaciers scouring out depressions in the land. The small round lake in the photo is a *kettle lake*. This type of lake formed when large chunks of ice left behind by the glacier melted away.

Check and Reflect

1. Describe one of the processes that shaped the continental drainage system we have today in Canada.
2. The Athabasca Glacier is part of the Columbia Ice Fields between Banff and Jasper. It once extended much farther across the valley than it does now. Is the glacier advancing or retreating? Why do you think this is happening?
3. Find out how glaciers have formed the landscape where you live. Using reference books, maps, the Internet, and your own observations, identify glacial features in your area.

2.4 Water and Climate

Lethbridge, Alberta, and Nanaimo, British Columbia, are both located at almost the same latitude. This means that they are both about the same distance north of the equator. But the climates in the two cities are very different. The two pictures below were taken in the spring. What differences do you notice in the way the trees, grasses, and flowers look in the two places? Find the two cities on a map of Canada. Suggest reasons why there might be such major differences in their climates.

Climate

Climate is the average weather measured over a long period of time. On some days in summer, Lethbridge and Nanaimo may have the same amount of sun and the same temperatures. But over a whole year, their weather varies in different patterns. The two cities have different climates.

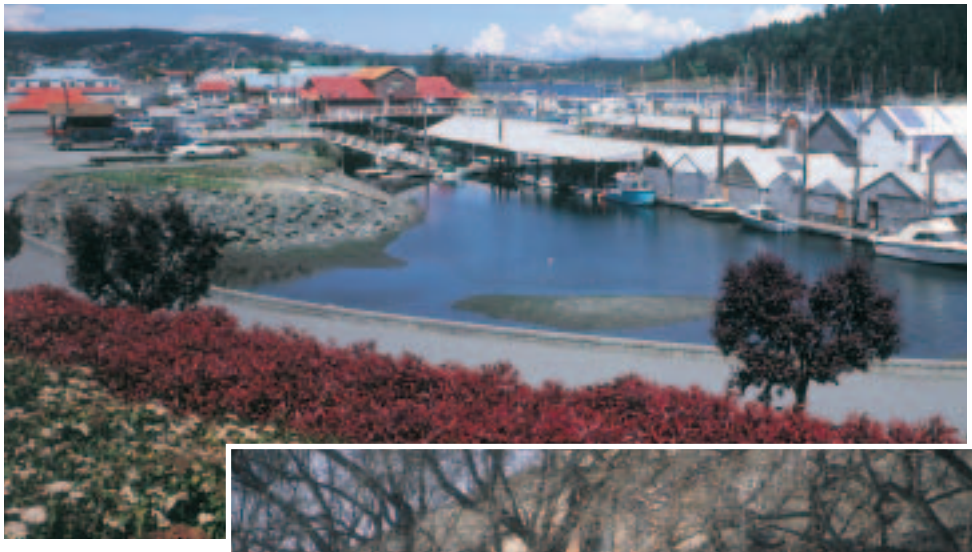

Figure 2.16 In March, the leaves are already coming out on the trees in Nanaimo.

Figure 2.17 Spring arrives later in Lethbridge than in Nanaimo. This picture was taken in April.

The Effect of Large Bodies of Water on Climate

Large bodies of water, like the oceans and the Great Lakes, influence the weather and climate in their regions. In earlier studies, you learned that water has a higher heat capacity than most other substances. This means that it can hold onto the heat longer than other substances do. It takes a very long time to raise the temperature of a large body of water, and a long time to lower it. Even with small lakes, it takes many hot days and warm nights in a row to raise the temperature of just the few centimetres of water near the surface.

The main effect that this has on the climate in an area is to prevent extremes in temperature. For example, Nanaimo is beside the ocean, so temperature differences between day and night, or between winter and summer are not as great as they are in Lethbridge. Lethbridge has few lakes in the area, and it is surrounded mainly by land. Land heats up and cools down quickly compared with water. It is affected much more rapidly by changes in the amount of sunlight and the air temperature.

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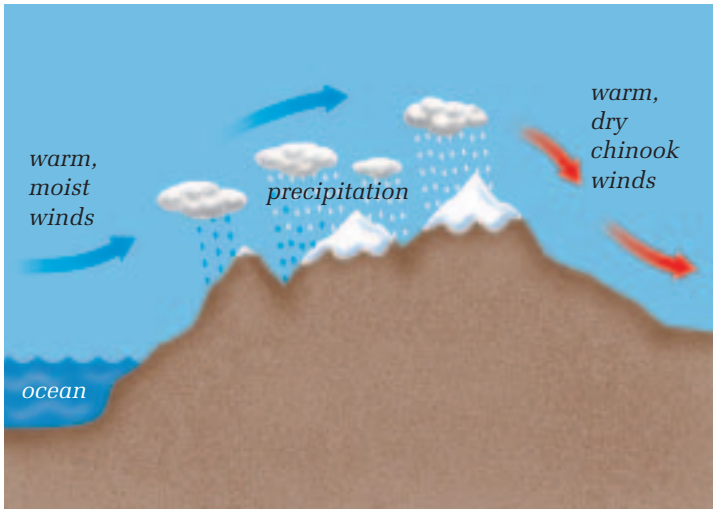
Mountain Weather Effects

The Rocky Mountains have a major influence on Lethbridge's climate. Southern Alberta, where Lethbridge is located, has a very dry climate because it's in a rain shadow. The winds coming in from the Pacific Ocean are loaded with moisture. When they hit the west side of the mountains, they have to rise higher where the air temperature is colder. The cold air causes the water to condense and fall as rain or snow. By the time these winds cross the Rockies, they have lost much of their moisture, so the air on the east side of the mountains remains dry. These same Pacific winds are responsible for chinooks. The Pacific air warms as it moves down the east side of the Rockies. The warm air becomes the chinook wind. A chinook can raise air temperatures more than 25°C in one hour.



The Rocky Mountains create a rain shadow that affects southern Alberta.

Decision Making Activity

Choosing a Winter Vacation

The Issue

Throughout Canada and the rest of North America, there are major differences in climate from place to place. When deciding on a winter vacation, you could easily find places that would have snow for skiing. Or you could go somewhere for a snow-free holiday. In this activity, you will investigate factors that influence climate, and gather data to design travel promotional material for a winter holiday.

Background Information

Mean Temperature and Precipitation TOOLBOX

When you're packing for a holiday, it's important to know what kinds of temperatures and how much precipitation to expect. Your teacher will give you an information sheet about the climate in some Canadian cities. Using a map of Canada, plot the locations of the cities listed on the information sheet. With a partner, and based on your own experiences, predict what a typical January day might look like in each place. Now choose a latitude where you will find at least two cities from your list on or near that latitude. Make a bar graph to compare their mean temperatures. Make another bar graph to compare their total precipitation.

Influences on Climate

Large bodies of water and landforms, such as mountains, can influence the climate of an area. Using your bar graphs and your maps, try to explain how these two factors may have led to the differences that you see in your bar graphs.

Support Your Opinion

Now choose one Canadian city of interest to you and your partner. Design a travel brochure or a radio commercial for a winter vacation there. The following topics should be included:

- mean annual temperature and precipitation for the area
- factors that contribute to local weather patterns
- water-related recreational activities for winter

Remember, you are supposed to be "selling" your area for a winter vacation. Your brochure or commercial must grab the interest of a potential vacationer. If you choose a brochure, it should be illustrated and should highlight the major points that you want to get across. If you choose a radio commercial, you can use sound effects to help you sell your ideas.

Figure 2.18 Winter vacation

Current Events

You have learned that you can make some predictions about climate for a location if it is next to a large body of water or far from one. But what if two places at the same latitude on the same ocean have very different climates? Look at the map below. Labrador, on Canada's east coast, and Scotland are at about the same latitude. Labrador has very cold winters and short, cool summers. Scotland has a mild climate with little snow. Yet they are both beside the Atlantic Ocean.

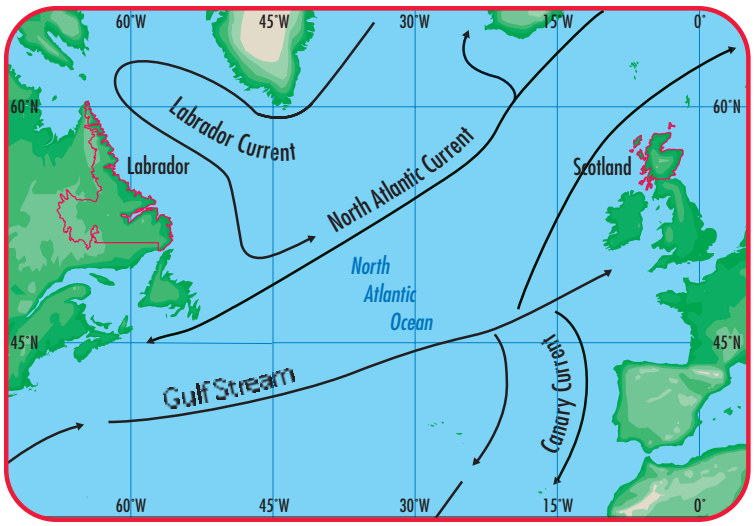


Figure 2.19 Why are the climates of Labrador and Scotland so different?

The difference between the two areas is the effect of ocean currents. **Currents** are streams of water that move within a larger body of water. They can be caused by any of the following:

- wind
- temperature differences in the water
- salinity differences in the water
- Earth's rotation

Currents and Climate

Currents are different from waves because the water in currents actually moves from place to place. Surface currents are caused mainly by steady winds. The currents that affect the climates of Labrador and Scotland are both surface currents. These currents move water thousands of kilometres through the ocean. If they start near the equator, they may carry warm water far into the northern hemisphere, like the North Atlantic Current does. If they start closer to the North Pole, they may carry very cold water down into more southerly areas, like the Labrador Current does. When these currents flow close to shore, they can influence the climate of the land there.

reSEARCH

El Niño and La Niña

A change in ocean currents is one of the key indicators of the climate event known as El Niño. Using the Internet and other research sources, find out:

- What causes El Niño?
- How does it affect climates around the world?
- What is La Niña?
- How can scientists predict when these events will occur and how strong they will be?

Ocean Currents and Precipitation

The temperature of an ocean current affects more than just the air temperature. It also affects the amount of precipitation that a location receives. Warm air can hold more moisture than cold air can. As a result, wind blowing over a warm ocean current will carry moisture. Wind blowing over cold ocean currents will be relatively dry. Figures 2.20 and 2.21 show the effects of this difference.

Figure 2.20 The winds that blow in from the north Pacific Ocean pass over the warm North Pacific current. They carry so much moisture that the coast of British Columbia is a rain forest.

Figure 2.21 The cold Peruvian current flows northward along the coast of Chile and Peru. The winds off the current are cold and carry so little moisture that desert covers the entire coast.

Check and Reflect

City	Mean January Temperature (°C)	Mean July Temperature (°C)
A	−4	+22
B	−7	+18
C	−11	+17
D	−15	+18

Figure 2.22 Question 1. Which cities does this information represent?

1. Look at the temperature data for the four cities given in Figure 2.22. Match each pair of temperatures to one of the following cities: Calgary, Toronto, Edmonton, Charlottetown. Give reasons for your matching.
2. Do you think that large bodies of water are able to influence the kinds of plants that people can grow in an area? Why or why not?
3. What is the difference between weather and climate?

Assess Your Learning

1. Describe how a wave forms in a lake. Explain what would happen to the speed and direction of a small boat when a wave passes underneath it.
2. Why do many inland waterways have speed limits for boats?
3. When camping in the mountains near the border between Alberta and British Columbia, you noticed one stream flowing west and the other flowing east. What is the area or geological feature called where you are camping? Where will the water in these rivers eventually end up?
4. How do caves form?
5. Why do hot springs have more minerals deposited around them than cold springs do?
6. What geological evidence do we have here in Alberta that glaciers once covered this province?

Focus On — Social and Environmental Context

Science and technology are developed to meet human needs and expand human capability. Think about what you learned in this section.

1. A frontier is an area that hasn't yet been fully explored or developed. You may have heard outer space called "the final frontier." But we have a huge frontier right here on Earth. Working with a partner, discuss why the oceans can be called a "frontier."
   - Why do we still have so much to learn about the oceans?
   - What role do you think technology plays in helping us explore the oceans?
   - In what ways is oceanic exploration similar to space exploration?
2. How do you think understanding a stream's characteristics could help us protect our water supply?

3.0

Living things in aquatic environments are affected by many factors.

Key Concepts

In this section, you will learn about the following key concepts:

- water quality
- adaptations to aquatic ecosystems
- human impact

Learning Outcomes

When you have completed this section, you will be able to:

- describe the diversity of organisms in salt and freshwater systems
- recognize that some common characteristics allow species to live in water
- identify factors that contribute to development of adaptations in aquatic species
- describe populations in fresh and salt water
- identify seasonal, short-term, and long-term changes in populations
- explain the relationship between water quality and living things

Think about the view of Earth from space at the beginning of section 1.0. What was Earth's major surface feature? Most of Earth is covered in a salty water solution that we call the *oceans*. This water is home to a wide range of living things from microscopic organisms to the largest animals on Earth, whales.

Some of the same organisms that live in salt water can also live in fresh water, but most cannot. Each is adapted to its own environment. In what ways do you think animals that live in salt water might be different from those in fresh water? In what ways would they be the same? In this section, you will learn some of the ways that aquatic organisms are adapted to their environments. You'll also discover how they interact with their environment and each other.

3.1 The Diversity of Organisms in Salt and Freshwater Systems

When we think of a variety of organisms living in water, we might think of the organisms in a large lake or in a tidal pool of the ocean. But even in a small pond or slough, you would find a variety of species, each adapted to its own small part of the pond ecosystem. Such variety is often used as an indicator of a healthy environment. The more species in a pond, lake, or river, the more nutrients, light, and oxygen you are likely to find there. Figure 3.1 shows some of the organisms you might find in a pond.

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Greatest Diversity
The most diverse ecosystems in the world are the tropical rain forests of South America, Asia, and Africa. Coral reefs are the second most diverse ecosystems.

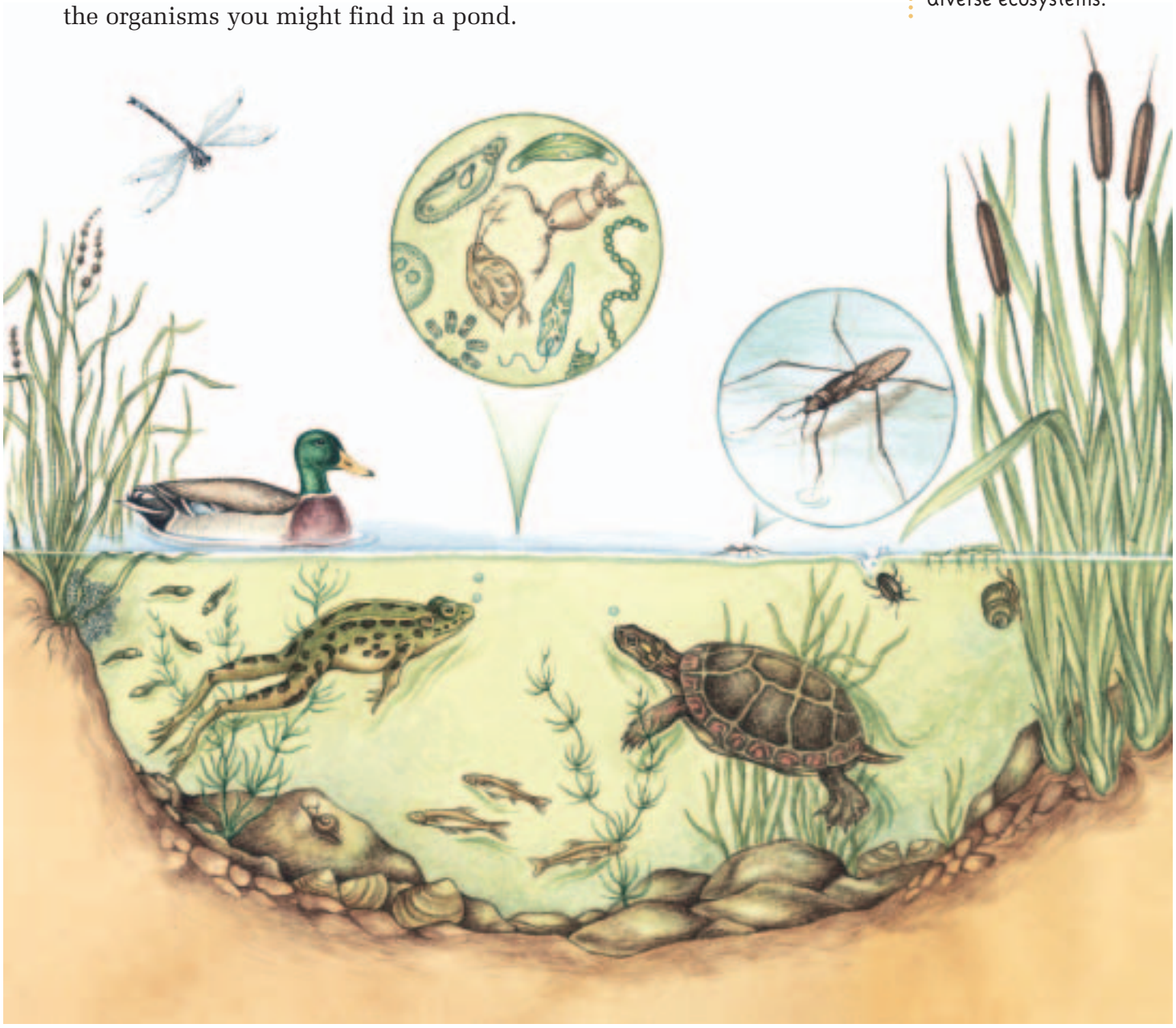


Figure 3.1 Even a small pond can support many different kinds of living things.

Give it a **TRY** ACTIVITY

POND DIVERSITY

A pond near you is in an area that will soon be developed for housing. A local environmental group wants to make the pond part of a small park in the development. But some people in the area say the pond isn't worth saving because it's probably already so polluted that nothing lives in it. As a member of the environmental group, you want to prove that the pond has a diverse group of organisms living in it.

- Look at the pond and its inhabitants shown in Figure 3.1 on the previous page. List as many different kinds of living things as you can see.
- Beside each one in your list, briefly describe where it lives in the pond. Describe any features it has that allow it to live there. (For example, fish have fins that help them swim through the water.)
- Do you think the pond is worth saving? Give reasons for your answer.

DIVERSITY IN FRESH AND SALT WATER

In earlier grades, you learned that an *ecosystem* is any place on Earth where living things interact with other living things and non-living things. **Diversity** in an ecosystem refers to the variety of different kinds of species living there. Many different kinds of organisms live in freshwater lakes and rivers. But the salt water of the oceans supports a greater diversity of living things. Many more, different kinds of organisms live in salt water because the oceans have more, different kinds of environments. Two-thirds of all the major types of organisms in the world live all or part of their lives in salt water. Figures 3.3 and 3.4 will help you compare the diversity of freshwater and saltwater ecosystems.

Figure 3.2 A coral reef is one of the most diverse ecosystems in the world.

Lake Diversity

Figure 3.3 Lakes are freshwater bodies in low areas of land. Like the ocean, lakes have layers or *zones*. Some organisms live only in one or two zones. Others live in all three. Lakes are much more affected by local climate than the ocean is. In northern countries such as Canada, some lakes freeze over in winter. The organisms that live in them must be able to cope with extremely cold temperatures in winter and warm temperatures in summer.

b) The middle zone is the open water area that still has light penetration. Phytoplankton are food for the fish that live there. Some of these fish move between the middle zone and the darker, deepest water of the lake.

limit of light penetration

a) From the shore down to where aquatic plants stop growing is the upper zone of a lake. Plants here might include bulrushes and water lilies. Here, you might see small fish, clams, insects, snails, worms, leeches, and frogs.

c) The lowest zone is the deepest water of the lake. No light penetrates this zone, so no plants grow here. Food for the fish and other animals that live here comes floating down as waste from the plants and animals that live near or on the surface.

Ocean Diversity

Figure 3.4 The ocean is similar to a huge lake because it has a shoreline, shallow areas, and deep areas. But in the oceans, there are greater differences in water motion, salinity, and depth than in a lake. The deepest part of the ocean is about 11 000 m. The deepest lake in the world is Lake Baikal in Russia at about 1700 m.

Intertidal Zone

Animals and plants that live along the shoreline of the ocean have to be able to withstand the pounding of the waves. They also have to be able to live out of the water for some time every day at low tide. This shoreline area they live in is called the *intertidal zone*.

- Different ecosystems form in intertidal zones, depending on whether the shore is rocky, sandy, or muddy.
- Animal species have developed special adaptations to live in this zone.

Estuary

One of the most diverse and richest ecosystems is an *estuary*. Here fresh water from rivers and streams mixes with the salt water of the ocean to form *brackish* water.

- Marshes often grow in or around estuaries.
- Many different kinds of plants, animals, and insects that can tolerate the brackish water live here.
- Estuaries are rich in bird life, because of all the food and shelter available.

Continental Shelf

The *continental shelf* is a shelf of land that extends out from the edge of a continent below the ocean's surface.

- Canada's largest continental shelf is on the east coast.
- The water here is warmer than in the open ocean, and light penetrates almost all the way to the bottom.
- The combination of warm water, light, and nutrients make this a very rich area for both plants and animals.

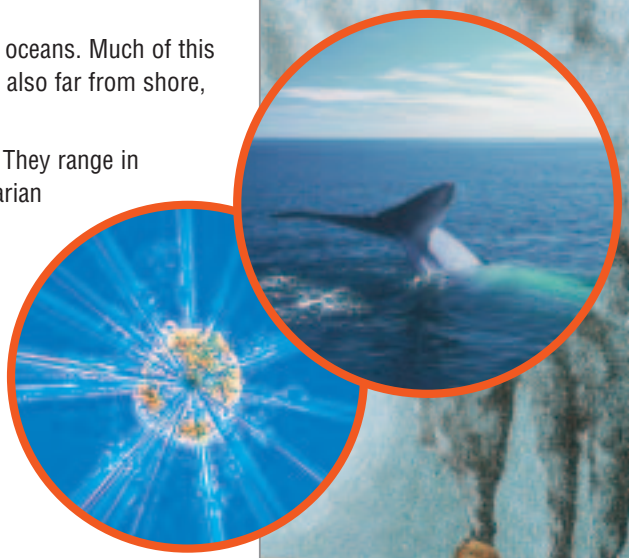
zone of light penetration

zone of little to no light

The Oceanic Zone

Beyond the continental shelves are the deepest parts of the oceans. Much of this water receives no light at all and contains little oxygen. It is also far from shore, so not as many nutrients are available for plants.

- Many different kinds of animals live in this *oceanic zone*. They range in size from microscopic plants and animals, like the radiolarian in this photo, to the largest animal on Earth, the blue whale.
- Animals that live in the upper part of the ocean feed on microscopic plants called *phytoplankton*, or on each other. In the deeper, dark parts of the ocean, animals live on each other or waste that drops down from above.
- In between the surface and the deeper ocean are different kinds of fish, jellyfish, shellfish, squid, octopus, shrimp, and many other animals.



Adaptations of Organisms in Aquatic Environments

An **adaptation** is a physical characteristic or behaviour of a species. An adaptation increases the species' chances of survival in a particular environment. All living things have adaptations that are specific for the environment they live in. And living things continue to adapt if their environment changes. Aquatic species have adaptations that help them to breathe, feed, move, and reproduce in water. For example, fish have gills to enable them to remove oxygen from the water.

When you go into a pet store, you can see tanks full of brightly coloured tropical fish. Do you think these fish would survive in your local lake or river? These fish are adapted to warmer waters than those we have in Canada. The only way we can keep these fish here is indoors. Water temperature is just one of many factors that organisms have adapted to in aquatic environments. Here's a summary of the main environmental factors that lead to the development of adaptations by species.

Figure 3.5 What special conditions do these fish need to survive?

Temperature

The fish in Figure 3.5 can't survive in cold water. And fish that live in very cold water can't survive in warm temperatures because their bodies overheat. There are fish in the Arctic that have a natural antifreeze that keeps their blood and body tissues from freezing in the frigid water temperatures.

Light

Most organisms thrive in light. Plants need light to photosynthesize. In the deepest parts of the deepest lakes and oceans, animals survive without light. Look at the animal in Figure 3.6. How do you think it has adapted to the lack of light?

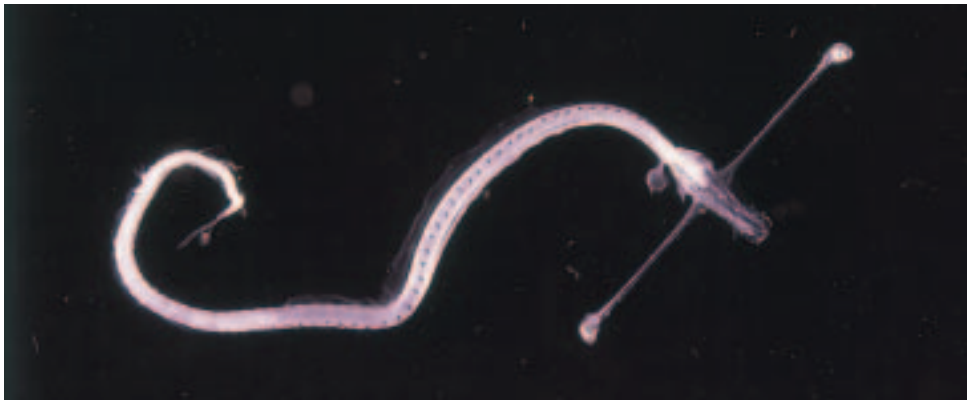


Figure 3.6 This dragonfish manages to survive in an environment without light. It produces its own light from spots on its body called *photophores*.

Pressure

The animal in Figure 3.6 must also survive under very high pressure. The weight of the water above it is many times greater than at sea level. These animals cannot survive when brought into shallower water because their bodies can't function at lower pressures.

Salinity

The salt content of water can be very high in some inland seas like the Dead Sea. The organisms that live there cannot survive in fresh water. Most freshwater organisms cannot live in salt water. The salt in the water actually draws fluid out of their organs. For that reason, humans and many other animals can't drink salt water.

Figure 3.7 Salmon are unusual because they can survive in both fresh and salt water. They are born in fresh water, then migrate out to sea. They live in the ocean until it's time to come back up the rivers to lay eggs.

*re*SEARCH

Game Fish

A variety of game fish inhabit lakes, streams, and rivers. The temperature of the water, the amount of oxygen dissolved in the water, and the availability of food all determine the types of fish that can be found in each habitat. Talk to fishers and do research to answer the following questions.

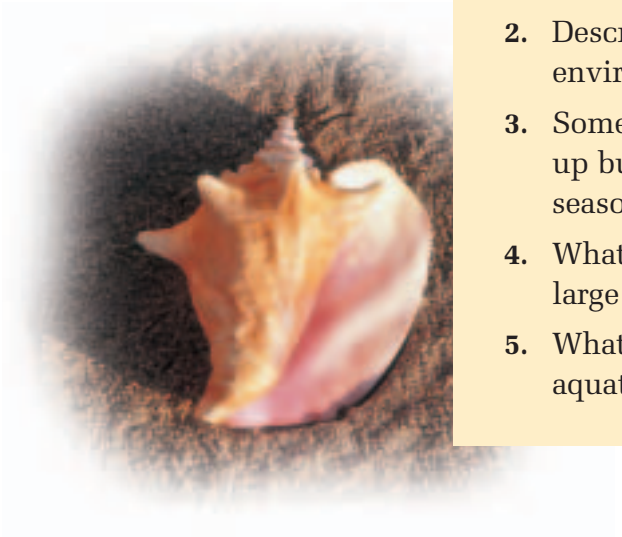
- What water conditions would you look for if you wanted to catch trout?
- Sturgeon are a very primitive, ancient type of fish. Some sturgeon weigh more than 50 kg. Where would you go to fish for sturgeon? In what type of water conditions would you find them?
- Which fish species can tolerate poor oxygen and high temperature conditions?

Figure 3.8 Barnacles grow on rocks at the tide line, so they are constantly battered by waves. They attach themselves firmly to rocks so the waves can't take them away. Their hard shells also protect their bodies from the waves.

Water Movement

Some animals and plants live in areas where the water moves strongly. Like the barnacles shown in Figure 3.8, they have to be able to withstand the water's movement and the debris that the water carries. They may have adaptations for attaching themselves to rocks and other fixed objects. Or they may be adapted to digging into sand for protection.

Check and Reflect



1. Why is the diversity of living things in salt water greater than in fresh water? Give as many reasons as you can think of.
2. Describe three characteristics that enable fish to live in aquatic environments.
3. Some water plants thrive in our lakes. Every summer they grow up but every winter they die back. How have they adapted to seasonal changes in their environment?
4. What might happen to the fish in a lake if a factory discharged a large amount of hot water into the lake?
5. What did you find the most interesting about the factors that aquatic organisms have to adapt to? Why?

3.2 Populations in Fresh and Salt Water

Something has happened between the time of John Cabot 500 years ago and now. Why are there so few fish now compared with even 100 years ago? Natural changes in animal populations are not unusual, but the rapid decrease of one species of fish from plenty to so few is unusual. Is the decrease a result of overfishing only, or are other factors involved? Hypothesize what factor or factors you think could have caused the decrease in the number of cod. Write down your hypothesis so you can look at it again later.

Figure 3.9 When John Cabot arrived in the waters of Newfoundland, he wrote that there were so many fish in the water that the boat could only move slowly.

Understanding Populations

In this section, you have learned about the diversity of organisms in fresh and saltwater environments. You have also seen the adaptations that some of these species have to enable them to live in these environments. Another important aspect of understanding ecosystems is the study of populations.

When we looked at diversity, we were looking at how many different species there are in fresh and saltwater environments. When we looked at adaptations, we were looking at how species have adapted to their environments. The study of populations looks at groups within species. A **population** is a group of organisms of the same species that live in a particular area. For example, perch are common in the lakes in Alberta. But the perch that live in Sullivan Lake form a separate population from the ones in Lesser Slave Lake.

mathLink

A researcher is estimating the population of mussels in an intertidal zone. She marks out an area 50 m long by 5 m wide. She counts the number of mussels in five 1-m^2 squares along one end of the area. Here are the amounts she found: 22, 26, 20, 18, and 16. What is the average number of mussels she found in a 1-m^2 square? Use this number to estimate the total number of mussels in the whole marked area. (Hint: Draw a diagram to help with your calculation.)

Decision Making Activity

Can the Cod Fishery Be Saved?

The Issue

The cod population off Canada's east coast was once so huge that ships came from all over the world to fish there. Today, there are so few cod that fishing for them in Canadian waters is carefully controlled. Is overfishing entirely to blame for the large reduction in the cod population? Can anything be done to restore the cod stocks?

Background Information

1 You know that aquatic organisms have adapted to specific environmental conditions. You may also know that different changes can occur in populations of aquatic organisms. You will now develop your opinion about the main reason for the large decrease in the cod population off Newfoundland. Was it caused by humans' fishing? Have each member of your group research information on one of the following:

   a) where cod are found and what temperatures and depths they prefer

   b) what cod feed on and where and when they breed

   c) the opinion of the Department of Fisheries and Oceans scientists on the reasons for the cod's disappearance and on the possibility of the stock growing back

   d) other opinions, including those of fishers, on the reasons for the cod's disappearance and on alternatives to the ban on fishing

2 When you have gathered your information, share it with your group. Design a presentation to summarize your group's findings. Be prepared to share your group's findings with the rest of the class.

Figure 3.10 The Grand Banks off Newfoundland is a rich fishing area.

Support Your Opinion

3 Was the hypothesis you made at the beginning of this subsection correct? Do you think that overfishing is the only reason for the decline in the cod population?

4 Can anything be done to allow more fishing? What recommendations would you make to the government on how to deal with the cod problem in a fair way for fishing families?

5 Share and compare your group's opinion with those of other groups.

Figure 3.11 Factory trawlers can catch and process huge amounts of fish. This Spanish trawler has been caught fishing illegally in the Grand Banks by a Canadian fisheries patrol boat.

Changes in Populations

A change in a population may mean an increase or decrease in the number of individuals. Or it may mean a change in the number of females compared with males. Or it may mean a change in the number of young compared with the number of old individuals. A population changes because something in its ecosystem has changed. There are three major types of changes to populations: seasonal, short-term, and long-term changes.

Seasonal Changes

In Canada, we can observe dramatic seasonal changes in populations of freshwater organisms. Because of the extremes of temperatures between summer and winter, populations swell during the warm summer months, and then disappear during the winter. This does not mean they are all dead. Some are dormant and hibernating. Another seasonal change is connected with breeding stages of some organisms, as shown in Figure 3.12. Can you think of other seasonal changes in aquatic populations that you've observed?

Figure 3.12 Mosquitoes lay their eggs in water. When the eggs hatch, the larvae live in the water for a couple of weeks before becoming adults and flying away. So in a very short time, the population of mosquito larvae in a pond can change dramatically.

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Plunging Populations

On Canada's west coast, another important fish population is decreasing dramatically. The population of wild salmon off British Columbia may be as little as half of what it was 100 years ago. The decrease in salmon population is mainly due to overfishing. But loss of streams for egg-laying and warming of the ocean may also be affecting these fish.

Figure 3.13 An oil spill can cause short-term changes in populations of aquatic organisms. Toxic chemicals can kill fish and other organisms. In this aerial photo, you can see large, floating barriers called *booms*. They are used to keep the oil from spreading.

Short-Term Changes

Short-term changes in populations are those that take place over a relatively short period and don't last very long. Unlike seasonal changes, they don't happen every year. A short-term change might be part of a natural event, or it might be caused by human activities. A population of salamanders might disappear because a drought dries up its pond. But a few months later, the rain begins, the pond fills up, and a new population of salamanders develops. Where do you think the new salamanders came from?

Long-Term Changes

Long-term changes in populations may also result from natural causes or human activities. A natural landslide might change the course of a stream. All the mosses and plants that lived in the old stream bed below the slide die off because water no longer flows there. An example of long-term human effects on populations is the introduction of zebra mussels to the Great Lakes. Zebra mussels are a European species that was first noticed in the Great Lakes in 1988. They probably came over in the ballast tanks of ships. The ships emptied the water from their tanks, and the mussels were in this water. By 1994, there were about 93 000 mussels per square metre in some areas of the Great Lakes. Many native shellfish populations were reduced because of competition with this species.

rESEARCH

The Effect of El Niño on Fish

An example of a short-term natural event is the effect of El Niño on fish populations off the coast of South America. Find out what fish are affected and why. How does this change affect fishers?

Check and Reflect

1. When populations or species die off, or when they're unhealthy, it's a sign that something in the ecosystem has changed. Do you agree or disagree with this statement? Explain your reasons.
2. Look at Figure 3.14. Does it show a single population or several populations? Explain your answer.

Figure 3.14 Question 2. Is there more than one population shown here?

3. The zebra mussel population in the Great Lakes has exploded. Do you think that this population growth will continue in the same way? Why or why not?
4. The following table shows the cod catch off Canada's east coast over 21 years. Make a bar graph of this data to help you answer the questions below.

Cod Catch in Tonnes			
1972	1979	1988	1993
219 000	378 000	400 000	50 000

TOOLBOX

   a) What trend do you see in the cod fishery over the years shown here?
   b) Why do you think this happened?
   c) From the information you have here, what do you predict will happen to the cod stocks over the next five years?
5. Look again at the hypothesis you made about cod at the beginning of this subsection.
   a) Did any of the information in this subsection support your hypothesis? Explain your answer.
   b) What other information would you need to confirm or change your hypothesis?

3.3 Water Quality and Living Things

Figure 3.15 What is happening to Twin Lake?

The fishing at Twin Lake was always good when you first started going there with your family. During the last few years, however, you have noticed that people are catching fewer and fewer fish. When you go swimming, you have noticed that fewer young fish seem to be darting in the shallows. Someone commented that the fish seemed to be all small and of one species, whereas they used to be a variety of sizes and species.

The lake itself did not seem different—the water was still clear, and its temperature seemed to be the same. The loons still raised their young on the lake, and the heron family still fished in the shallows. But there seemed to be fewer of them as well. Was something happening to the lake?

After discussing this possibility, you and your friends decide to investigate the apparent changes in the lake. What type of information would you want to include in your investigation? Where would you find this information? Are there professionals you might contact? Make a list of the information you would need before you could decide if there is a problem with the lake.

*info*BIT

Alkali Lakes

Some Prairie lakes have a white material coating the rocks around the shore. These are deposits of natural chemicals called carbonates and bicarbonates. The water has dissolved them out of the soil and rocks in the area. When water has a high concentration of these chemicals, it is said to be *alkaline*. The chemicals are essential for plant life. But in very alkaline lakes, not many different types of organisms can survive.

Changes in Water Quality

At the beginning of this unit, in section 1.0, you learned that humans depend on a high level of water quality for safe drinking water. Other living things also have water quality requirements, but they can be very different from human ones. Living things, such as fish and water plants, do not need water as pure as humans do. Water that we could not drink can support a large number of different species that are adapted to those water conditions.

A lake like the one described at the beginning of this subsection contains many different species. Your local lake or pond probably has different types of insects, algae, microscopic plants and animals, and fish. As you learned earlier in this unit, they are all adapted to survive in that environment. But some species are more specialized than others. That means they are adapted to a narrow range of conditions. Even slight changes in the water quality or its temperature can affect them.

Inquiry Activity

Changing Water Quality

The Question

What effect could changing water quality have on an organism?

The Hypothesis

Write a hypothesis to explain how changing the salt concentration in water could affect the hatching of brine shrimp eggs.

Materials & Equipment

- 4 600-mL beakers
- masking tape
- pen
- 2 L room-temperature bottled water (non-chlorinated)
- 25 g sea salt
- stirrers
- 1 mL measuring spoon
- brine shrimp eggs
- 4 squares of paper, each large enough to cover the top of a beaker
- hand lens (optional)

Procedure

1. Fill each beaker with 500 mL of room-temperature bottled water. Label the beakers A, B, C, and D.
2. Set beaker A aside. It contains fresh water only. To beaker B, add 2.5 g of sea salt. To beaker C, add 7.5 g of sea salt. To beaker D, add 15 g of sea salt. Stir beakers B, C, and D to dissolve the salt.
3. Predict what will happen to the brine shrimp eggs in each beaker within 3 days after adding them. Add about 0.5 mL of brine shrimp eggs to each beaker.
4. Put the beakers in a place where they won't be disturbed, away from direct light and heat. Cover each beaker with a square of paper. Wash your hands.
5. Observe the beakers daily for 3 days.

Collecting Data

6. Record the appearance of the beakers on the day that you set them up. Record their appearance after 3 days.

Analyzing and Interpreting

7. In which beakers did the brine shrimp eggs hatch?
8. What can you conclude about the amount of salt in the brine shrimp's natural habitat?

Forming Conclusions

9. Describe how the differences in water quality affected the brine shrimp eggs.

Applying and Connecting

Adult brine shrimp have been used for many years as fish food for fish kept in aquariums. Brine shrimp eggs are also used now in large quantities in commercial aquaculture. Aquaculture is the growing of fish and other seafood in "farms" for human consumption. Brine shrimp eggs are used to feed commercially grown shrimp, prawns, and some types of fish.

Figure 3.16 Brine shrimp are microscopic animals that live in salt lakes and brine ponds. These environments are so salty that few other organisms can live there. *Brine* is a salt and water solution that contains a high concentration of salt.

Examples of Water Quality Changes

Figure 3.17 This lake has been affected by acid rain.

How many different species of plants and animals do you think live in the beautiful, clear lake in Figure 3.17? The water may look clean and pure, but this is a "dead" lake. Acid rain, caused by air pollution from factories, has changed the lake's water. The water is now too acidic to support most life. Fish and other organisms can no longer survive in it. This is one example of what can happen to living things when water quality changes.

While we often think of organisms disappearing because of water pollution, sometimes the opposite effect occurs. In Figure 3.18, the green slime is called *algal bloom*. This rapid and large increase in the growth of algae in a body of water is caused by too much fertilizer entering the water from farmers' fields. This abundant algal growth soon covers the surface, blocking out light to the plants below. The underwater plants no longer have light for photosynthesis, so they die. Because there are no more plants producing oxygen, other organisms soon die as well. So, although one organism (the algae) thrives, others die.

These are just a couple of examples of how water quality can affect aquatic organisms. You will learn more about human impacts on aquatic ecosystems in the next section.

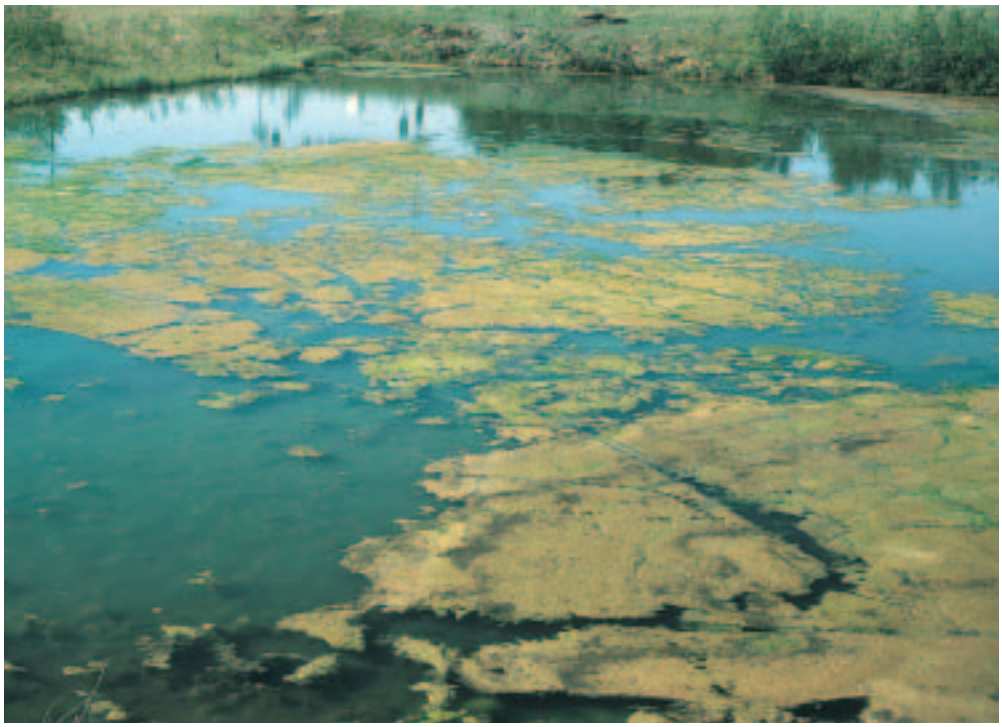


Figure 3.18 Algal bloom forms when the amount of the dissolved nutrients in the water increases greatly. This is usually caused by fertilizer runoff from farmers' fields.

rESEARCH

When Is Water Too Warm?

Thermo-electric plants generate electricity by burning coal. Much of Alberta's electricity is generated this way. These types of plants use a great deal of cooling water from nearby lakes to condense the steam from their turbines. Once this water is used, it is much warmer than the water in the lake it came from. Some plants use cooling ponds to let the water cool down before it is released back into the lake. Think about what might happen if the warm water is released directly from a plant into a lake.

- How would this warm water affect the growth of aquatic plants in a northern climate such as Edmonton has?
- How would populations of aquatic organisms be affected if the plant reduced production or shut down boilers for repairs and maintenance?
- What effect might the exhaust gases from the furnaces and boilers have on aquatic environments downwind from the plant?

Check and Reflect

1. Acid rain affects the survival of young fish and the eggs and larvae of other aquatic organisms. It does not seem to affect the adults. How do you think acid rain would affect the growth of the fish populations over time?
2. All throughout the months of our long, cold winter, snow and ice build up on the streets and sidewalks of Calgary and Edmonton. Animal waste, oil, antifreeze, and road salt collect in this snow. When spring finally arrives, snow and ice rapidly melt. How might this meltwater affect populations of aquatic organisms downstream from these cities?
3. At the beginning of this subsection, you listed some information you would need to help you decide if there is a problem with Twin Lake. What would you add to that list after reading this subsection? Why?
4. Find your concept map on water quality that you began earlier in this unit. Add information from this subsection on how aquatic organisms interact with their environment.

Experiment
ON YOUR OWN

Creating Your Own Aquarium

Before You Start ...

You are now familiar with the differences between fresh and salt water as well as with some of the methods that can be used to determine water quality. You also have a general understanding of the many factors that can affect aquatic organisms in both salt and freshwater systems. Now you have a chance to use some of this knowledge to design and set up a freshwater aquarium.

The Question

How can you set up a freshwater aquarium with the proper water quality and environmental factors to support living organisms?

Design and Conduct Your Experiment

1. Decide what organisms, materials, and equipment you will need to set up your aquarium. For example:
   a) How big will your aquarium be or, in other words, how many litres of water will it hold?
   b) What type of container will you use for your aquarium?
   c) What types of aquatic plants and animals are appropriate for the size of your aquarium?
   d) How will you control the temperature and light?
2. Design a procedure for testing water quality.
   a) What types of equipment and materials will you need to test water quality?
   b) Where can you find inexpensive water-testing materials?
3. Write up your procedure and design. Show it to your teacher for approval.
4. Set up your aquarium. (Remember that you have to do tests before and after the living organisms have been added.)

Figure 3.19 This is an example of how one group of students set up their aquarium.

5. Now perform the water quality tests before you add living organisms. Repeat these tests after the living organisms have been added. Always wash your hands after working on your aquarium.
6. Share and compare your design and findings with your classmates. Be prepared to explain:
   - why you chose the organisms you did
   - what the results of your water quality tests were (both before and after)
   - any adjustments you made as a result of the tests
7. How would you improve your design?
8. Would the same procedures that you used in setting up a freshwater system also apply to setting up a saltwater system? Why or why not?

Assess Your Learning

1. a) What does the term *diversity* in an ecosystem mean?
   b) Would a puddle have as much diversity as a pond? Why or why not?
2. Draw a sketch showing the three levels in a lake. Briefly describe each level.
3. In Figure 3.20, why do all these animals have gills? What is the purpose of gills?

Figure 3.20 Question 3

4. How is a population related to a species?
5. Give an example of some event that might cause a population of aquatic organisms to change. Describe the change. Is your example a seasonal, short-term, or long-term change? How do you know?
6. Is water quality important to fish? Explain your answer.

Focus On Social and Environmental Context

Decisions regarding science and technology involve a variety of considerations. These include social, environmental, ethical, and economic considerations. Think about what you learned in this section.

1. A community beside a large lake has been using a ferry boat system for crossing. Now it is deciding what kind of crossing to build on the lake. Residents can choose between two different technologies: a bridge or a causeway. (A causeway is a roadway built by placing rocks and gravel on the bottom of the lake. More material is added until the road is above the water surface.) What environmental considerations do you think might affect this technology decision?
2. What social and economic considerations do you think might affect the decision the community has to make in question 1?
3. Suggest some science questions that the community might want to have answered before making their decision.

4.0 Human activities affect aquatic environments.

Key Concepts

In this section, you will learn about the following key concepts:

- water quality
- human impact

Learning Outcomes

When you have completed this section, you will be able to:

- describe how humans use water and the impacts of this use
- identify practices and technologies that affect water quality
- recognize that these practices and technologies have costs and benefits
- describe how scientific research helps to measure environmental impacts
- recognize that scientific and technological knowledge alone can't solve all environmental problems

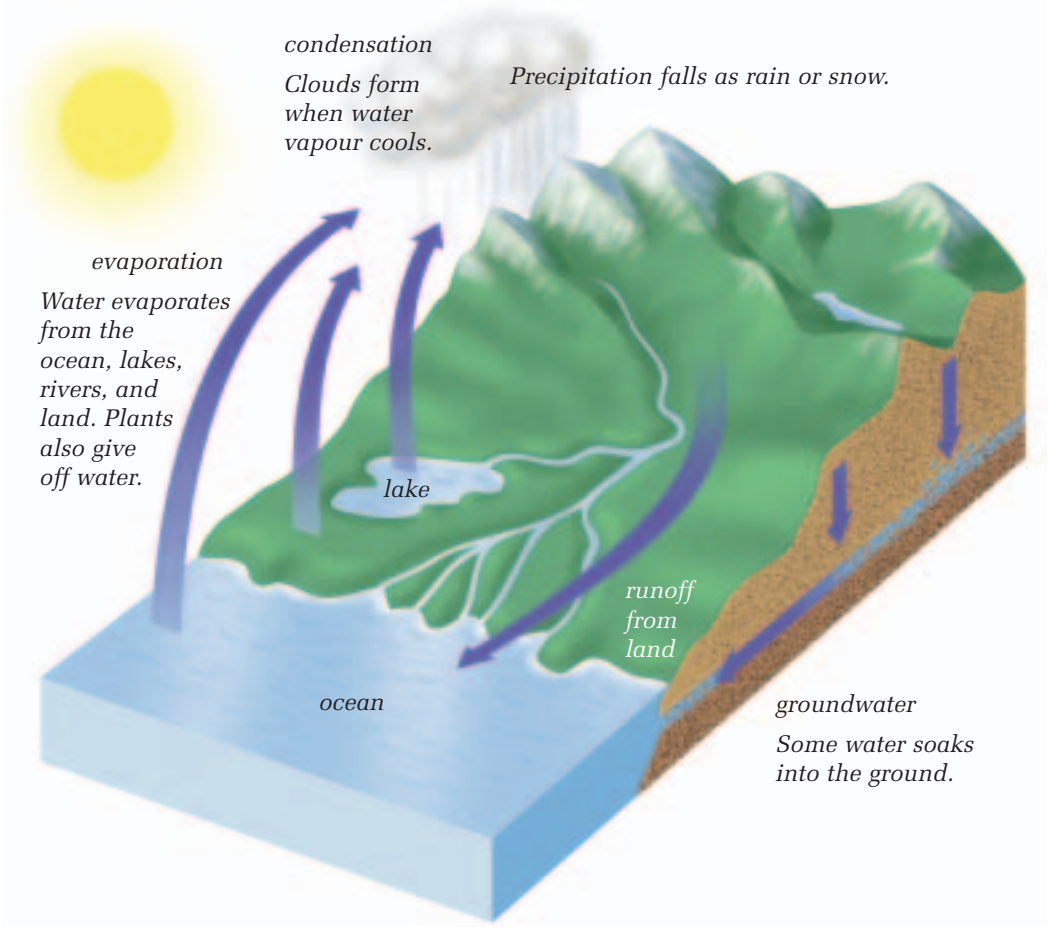


Figure 4.1 The water cycle. Water on Earth passes through many stages. The water you drink now could have been used by the builders of the pyramids.

In earlier studies, you may have learned how water cycles through the environment over and over again. The total amount of water is renewable on a world scale. However, the same amount of water isn't always available in any one place year after year. In some places, there may be droughts. In other places, there may be floods. And in some places, the water may be so polluted that it's not drinkable. All of these situations could be caused by natural events, or they could be caused by people using water.

4.1 How Humans Use Water

In the Exploring section at the beginning of this unit, you may have identified ways that you use water directly. You may also have suggested ways that you could reduce this water use. Look back at that list now. How many of your ideas for reducing water use have you been able to carry out? Your *direct* uses, like those on your list, are all called *domestic* or *personal* uses. But recall that you also use water indirectly. Your *indirect* uses reflect other uses such as those by industry and agriculture.

Many indirect uses have negative effects on Earth's water supply. These negative effects can include polluting lakes and reducing groundwater supplies. Why do we let this happen? As with many situations, there are both benefits and costs to the way we use water. Some of these are economic (for example, jobs) and some are environmental. A "+/–" (plus-minus) chart is one way of keeping track of benefits and costs. The "+" refers to the benefits, and the "–" refers to the costs. Make your own "+/–" chart as you read through this subsection. In the benefits (+) column, describe the ways in which that water use benefits people or the environment. In the costs (–) column, describe the ways in which that use is harmful or costly. After you have finished reading, work with a partner to add any other benefits or costs connected with water uses that you can think of.

Human Uses of Water		
Water Use	**Benefits (+)**	**Costs (–)**

*info*BIT

The Disappearing Sea

The Aral Sea was once one of the largest bodies of fresh water in Central Asia. Russian water diversion projects for growing cotton drained more water from the sea than was being replaced by rivers flowing into it. A strong commercial fishery no longer exists. Docks that were once right on the shore are now many kilometres away from the water's edge. Agriculture is an important source of income but so is fishing. And what kind of value can we place on all the plants and animals that can no longer live in the Aral Sea because of the lack of water?

Fifty years ago, the Aral Sea was much larger than it is today.

RESEARCH

Irrigation in Alberta

Because of Alberta's dry climate, much of its agriculture depends on irrigation. Find out what the benefits and costs of irrigation are to farmers, the environment, and the province's economy.

The Major Uses of Water

All life on Earth depends on water, but humans make the greatest use of it in the greatest number of ways. And the more people there are, the greater the amount of water that gets used. Figures 4.2 to 4.8 show the three major types of water use worldwide.

Agriculture

Of all the water used by people around the world, 73% is used in agriculture for irrigation to grow crops. Irrigation is important to the economy of many countries. It helps to provide food for the people who live there. Agricultural products grown on irrigated land can be exported to bring in money from other countries. Irrigation also helps to provide jobs for people in agriculture.

Figure 4.2 Irrigation ditch, India

Figure 4.3 Irrigation, Alberta

Figure 4.4 Salt deposits from irrigation. Irrigation must be carefully managed to prevent these.

Irrigation is important in food production in many places in the world. But it can also cause problems. Over-irrigation of the soil can dissolve salts in the soil and cause them to deposit on the soil's surface, as shown in Figure 4.4. Most plants won't grow in salty soils, so this reduces the ability to grow crops. Irrigation can also deplete groundwater supplies.

Industry

The next biggest use of water worldwide is in industry, about 22%. Industry uses water as a coolant, as a solvent, for washing, and for diluting pollutants when releasing them into the environment. Many industrial activities can affect water in the environment if the used water isn't cleaned or diluted before it is discharged.

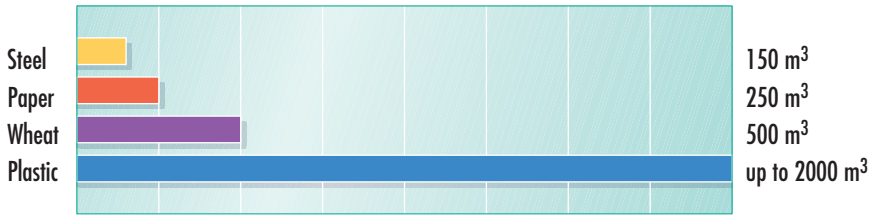


Figure 4.5 Amount of water used in producing 1 t of different products

Figure 4.6 Pulp mill in British Columbia

Different products require different amounts of water in their production. As you can see from Figure 4.5, the plastics industry is a huge user of water. This is a good example of your own indirect water use. How many items do you use that are made of plastic? Each of these products requires water in its production.

Governments control industry's water use through environmental and other regulations. They do not prevent industry from using water because industry is essential to a country's economy. It provides jobs, products, and services.

Domestic

Domestic use, or use in the home, is about 5% of total water use worldwide. Water for domestic use in developed countries like Canada is purified and piped into homes. In many developing countries, people do not have clean water piped into their homes. This may be because the distribution system doesn't exist. Or it may be because the family can't afford to pay for the pipes to bring it in. They may have to walk many kilometres to get safe water.

Figure 4.7 In Canada, we have clean water piped into our homes.

Figure 4.8 In developing countries like India, clean water isn't available for all domestic chores.

Decision Making Activity

Holding Back the Water

The Issue

Do dams have a positive or negative effect on water-system resources?

Background Information

Dams built across rivers are the oldest means of controlling water flow. Rainwater and water from melting snow that would otherwise be lost can be captured and stored in large reservoirs behind dams. It can then be released in a controlled manner as it's needed. Unfortunately, the damming of rivers, while providing many benefits, has wide-ranging environmental effects.

Advantages of Dams

Figure 4.9 The 362-km-long reservoir created by the Bennett Dam, Williston Lake, is the largest human-made lake in Canada.

Recreation. The large lake that forms behind a dam can provide many facilities for recreational activities.

Hydro-Electricity. The controlled release of water can be used to generate electricity.

Flood Protection. During times of high rainfall or heavy melting snow, water can be held back to eliminate or reduce costly flooding.

Irrigation. During periods of low rainfall, water can be released to irrigate crops.

Employment. The construction and operation of a dam provides many local jobs.

Shipping. Dams, in combination with locks, can make a once-treacherous river safe for boats to travel on.

Disadvantages of Dams

Figure 4.10 The Peace-Athabasca River delta began to shrink when the Bennett Dam was built 1200 km upstream.

Water Flow. Dams decrease the flow of water, which can shrink the size of rivers, lakes, and wetlands downstream.

Salinity. As less fresh water flows downstream, more salt water from the ocean can enter the river's mouth. This harms species that cannot tolerate higher salt levels.

Habitat. Reservoirs displace people and wildlife. They also destroy natural habitat and valuable farmland.

Migration. Migrating and spawning fish need special fish ladders to swim upstream past dams.

Sedimentation. Sediment in the river is trapped behind the dam. This sediment normally collects in river deltas and flood plains, providing important plant nutrients.

Canadian Facts about Dams

- Canada is one of the world's top 10 dam builders.
- Most of the major river systems in Canada have been dammed.
- We have over 600 large dams and thousands of small dams.
- Most large dams in Canada are built to provide hydro-electricity.
- Most of Canada's dams are in Quebec and British Columbia.
- If you combined all of the area flooded by dams in Canada, it would cover an area the size of Lake Ontario.

Figure 4.11 In the 1950s, a series of dams was built on the St. Lawrence River. The reservoir that was formed left the sites of six villages underwater. The above photo shows a house being moved away from the area about to be flooded.

Support Your Opinion

1 Imagine that a large electrical utility has proposed to build a dam at the site shown in the drawing at the bottom of the page. Draw a map to show what you think the area will look like *after* construction is complete.

2 a) What benefits will the dam provide?
b) What possible problems might it create? Can you think of ways to reduce the problems?
c) After you've examined the benefits and the problems, state whether you think the dam should be built or not.

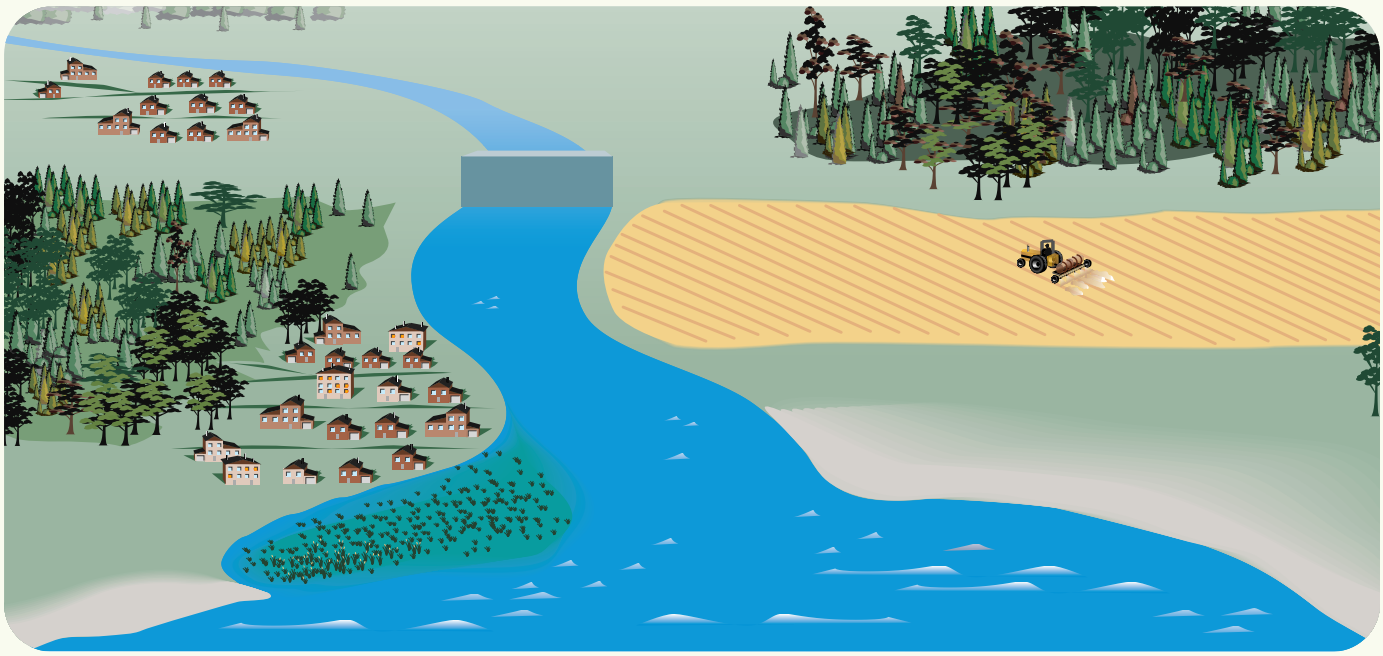
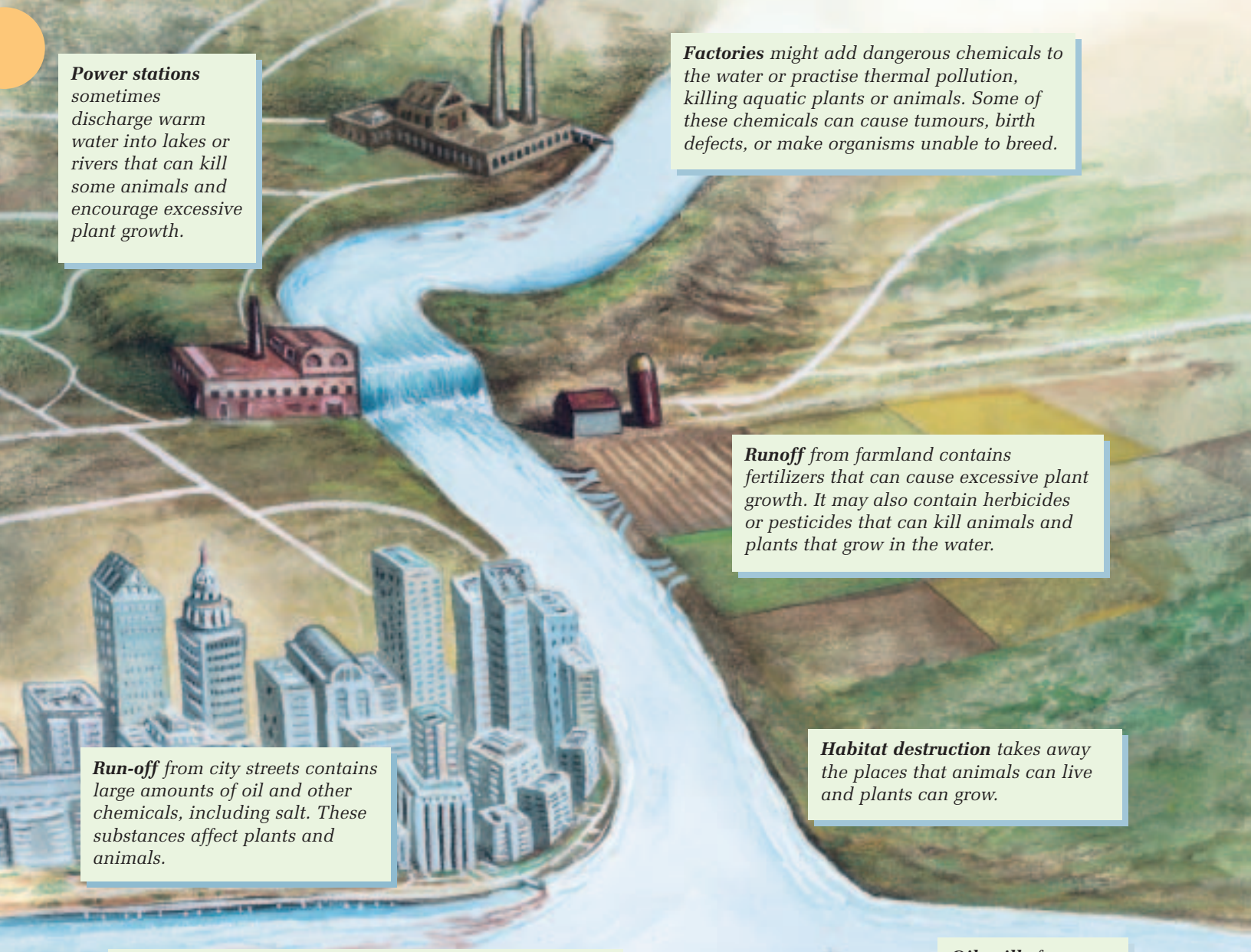


Figure 4.12 What will this area look like after the dam's construction is completed?

Practices and Technologies Affect Water Quality

In the summary of water uses on the previous pages, you saw how some of these uses can affect the overall environment. What are we doing that affects our water quality and aquatic ecosystems specifically? Many of the factors that harm aquatic organisms can result from human activities. Figure 4.13 shows some of these activities, and their effects on organisms that live in the water.

Figure 4.13 Rivers and lakes are affected by many human activities. Many of these activities can affect the ocean as well.



Check and Reflect

1. The chart below shows how much water is used in selected countries per person per day in three categories: domestic use, agricultural use, and industrial use.
   a) Which countries are most likely to rely on irrigation to grow their crops? Which countries are least likely to do so?
   b) In which countries is agriculture probably the main source of commercial income?
   c) What type of water systems are people in countries like Cambodia and Gambia likely to have in their homes?
   d) What kind of climate do you think Turkmenistan has during its growing season?
   e) Which countries probably receive the most rain during their growing seasons?
   f) Why do you think there are such large differences in water use among the countries in this chart?

Freshwater Use
(litres per person per day)

Country	Domestic Use	Agricultural Use	Industrial Use
Cambodia	6	118	1
Canada	431	313	3136
Egypt	132	1906	177
Gambia	3	39	1
Mexico	129	1849	172
Swaziland	36	1754	36
Turkmenistan	145	14 254	145
United Kingdom	110	16	424
U.S.A.	554	1942	2127
Uruguay	32	496	16

Source: *The World's Water 1998–1999: The Biennial Report on Freshwater Resources*, by Peter H. Gleick, published by Island Press, Washington, DC.

2. Describe two effects that chemical pollution could have on aquatic animals.
3. You use water directly every day at home—for example, for drinking and washing. Home use is one of the three major ways people use water.
   a) What are the other two main types of water use by people?
   b) Give two examples of how you use water *indirectly* every day. For each one, explain how you are using water indirectly.

4.2 Measuring Impacts

A micro-organism called *Giardia* causes giardiasis or "beaver fever." From time to time, the population of *Giardia* organisms increases rapidly. This parasite is usually controlled by proper chlorination and filtration of drinking water, but outbreaks can occur. A small number of people get sick, and everyone is suddenly made aware of how important safe drinking water is.

One way to help guard against problems with water quality is to monitor the water supply regularly. **Monitor** means to observe, check, or keep track of something for a specific purpose. For example, when you put water in the sink to wash your face, you monitor the water level to make sure it doesn't overflow.

*info*BIT

Technology for Monitoring

The Canadian Wildlife Service uses gull eggs to monitor toxic pollutants around the Great Lakes. Mussels, a shellfish, are used to monitor toxic substances in sediments on the east coast of the U.S. Pollutants in the water collect in these organisms. Scientists then analyze the animals' tissues. This type of monitoring helps scientists better understand how pollution is affecting organisms.

Give it a **TRY**

ACTIVITY

KEEPING OUR WATER SAFE

How can we keep our water quality levels high enough to protect ourselves? One of the ways is by constantly checking or monitoring our water to make sure no dangerous substances or organisms affect it.

- Suggest a monitoring program that you think should be in place to prevent outbreaks of giardiasis like the ones mentioned in the headlines above.
- List the tests that you think should be done, and how often they should be carried out.
- Be prepared to share your plan with your class.

Monitoring to Protect Water Quality

Town and city water supplies have to be monitored regularly to ensure that the quality of the water remains high. Water technicians regularly measure the chemicals and organisms in the water and observe how it looks and smells. In this way, they can identify possible problems and adjust the water treatment to eliminate them.

Similarly, research scientists use monitoring techniques to protect the environment. Monitoring also helps them develop appropriate technologies to help protect the environment. Think back over what you have learned about aquatic environments. You can probably list several things that scientists would monitor in a lake, slough, river, or stream. The presence of toxic chemicals in the water is one of these. Another one is the diversity of organisms in the environment.

Figure 4.14 Logging roads built in wilderness areas can threaten streams. Scientists monitor the quality of the water to make sure no damage is done to the stream or its inhabitants. What do you think should be done if a logging company's activities affect a stream?

Ongoing Monitoring

Ongoing monitoring of a site helps scientists observe change. As you saw earlier, a change in the number of species in a lake indicates that the environment has changed. This, in turn, would be compared with other monitoring information to see what else might have changed. For example, the amount of sediment in the water might have changed because of road-building along the water's edge. The water becomes cloudy. Animals and plants that cannot tolerate this condition disappear from the lake. In turn, those animals that fed on them no longer have enough food. The information from this kind of monitoring can then be used to develop regulations and technology to protect the environment.

Figure 4.15 To develop effective clean-up technology, scientists must monitor the environment. They need information on how oil affects the shoreline and how long these effects last.

Decision Making Activity

Chlorine and the Environment

The Issue

Spring runoff is a problem for many Canadian cities. Large amounts of organic material, such as leaves, collect in their watersheds during the winter and enter the waterways when the ice and snow melt. Organic matter can affect the colour and the taste of water. Additional chlorine is usually required in the spring to ensure that the water is safe from bacteria and other disease agents. Should the amount of chlorine in our water be increased at certain times of the year?

Figure 4.16 By monitoring water throughout the year, technicians in this water treatment plant know when they have to add more chlorine.

Background Information

1. Scientists have studied the influence of chlorine on organic materials in water supplies. Some of the chlorine reacts with this organic material to form chloroform and other chlorine-containing chemicals. Research has shown that some chlorine-containing chemicals can increase the risk of cancer.
2. Working with your group, find out more about the benefits and costs of using chlorine in the water supply. Have each member of your group research information on one of the following:
   a) the risk to health of not treating water supplies with chlorine
   b) the risk to health of using chlorine in water treatment
   c) alternatives to using chlorine for water treatment
   d) scientific research underway on chlorine use
   e) what (if anything) is used to treat your local water supply

Support Your Opinion

3. When you have finished your research, share your information with your group. Design a presentation to summarize your group's findings. Be prepared to share your group's findings with the rest of the class.
4. Do you think that the amount of chlorine in our water should be increased at certain times of the year? Give reasons to support your opinion.

Problem Solving Needs More Than Science and Technology

In the *info*BIT at the beginning of subsection 4.1, you read about the changes to the Aral Sea in Russia. Over the years, human uses have drained a huge amount of water from the sea. Docks that once lined the shore are now far from the water's edge as the sea shrinks. A once rich fishing industry has been destroyed. The problems with the Aral Sea cannot be solved by science and technology alone. Scientists have studied the effects of the human impact on the sea. The technology exists to solve many of these problems. What more is needed?

Problem solving requires a strong commitment from people. People must decide what needs to be done and how to do it. In many cases, they must find the money to help carry out the solutions.

reSEARCH

Protecting Watersheds

Contact the environment ministry to find out what kind of monitoring they do in your local watershed. See if you can arrange to go with a scientist on a monitoring field trip. Prepare a field trip report for presentation to your class.

A Success Story

Can huge problems in aquatic environments be solved? A good example of a success story is the famous Thames River in England. In London, the Thames used to be an open sewer. For hundreds of years, the city dumped sewage into it. Industry along its shores dumped toxic waste directly into it. Dead animals floated in it. Just the smell of the water made people sick.

Today, the Thames is so clean and clear that types of fish that had disappeared from it years ago are starting to reappear. Scientists knew for years what was wrong with the river—pollution. They also knew how to fix it—stop the pollution. The river only started to become cleaner in the 20th century. In this case, science and technology alone could not fix the problem. People finally organized and became committed to creating a solution. In this case, the reason was public health. The Thames was a hazard to people's health.

Figure 4.17 The Thames River was once so polluted that the smell of it could make you sick.

People Working Together

Think about environmental problems in water systems in your area or elsewhere. It's likely that scientific studies have been done on these problems. The technology may exist to help solve these problems. Or perhaps the technology does not exist or is too expensive. Science and technology alone cannot do what is necessary. People have to work together and look at different ways to approach problem solving.

Check and Reflect

1. Why is monitoring an important technique in environmental protection?
2. Why can't science and technology alone solve all our environmental problems?

TRY This at Home

Activity

Pollution Dilution

Many years ago, there was a slogan that said, "The solution to pollution is dilution." Some people thought that if you diluted a pollutant enough, it would no longer be harmful to the environment. You will use a non-toxic substance to represent a pollutant such as oil. Follow the instructions here, and see if that old slogan is true.

- Arrange the cups in a row on a table or counter. Put 50 mL or 1/4 cup of water into each cup. Add 1 drop of food colouring to the first cup and mix it well.
- Take 1 tsp. (5 mL) of this solution and pour it into the second cup. Mix it well.
- Take 1 tsp (5 mL) of this solution and pour it into the third cup. Mix it well.
- Continue this process up to the last cup.
- Put the 5 samples on the sheets of paper so you can see their colour more easily.
- How many dilutions did you have to do before you could no longer see any colour difference?
- Do you think the first colourless sample would be safe to drink if the food colouring was oil?
- Is it a good idea to depend on the dilution of pollution when we dispose of wastes?

Materials & Equipment

- 5 small clear containers (cups or glasses)
- measuring cup
- water
- food colouring
- stirrer
- teaspoon
- plain white paper

Caution!
Never taste water that you use in science experiments.

Assess Your Learning

1. Think about the different ways that water is used in your community. Describe two uses other than water use in the home. Do you think less water could be used in the situations you describe? How?
2. Most treatment facilities add chlorine to their water. Explain why this is a necessary step in water treatment.
3. Describe two types of water pollution that can result from industrial development.
4. Scientific research has helped us understand what causes pollution and how it affects Earth's water systems. Through technology development, devices and techniques exist to prevent polluting activities. Use your "+/–" chart from this section (page 393) to help you explain why pollution continues to occur. Think of as many reasons as you can.
5. How can ongoing monitoring of a river help scientists determine if a change in a population of fish is caused by natural events or human activities?

Focus On Social and Environmental Context

Science and technology have both intended and unintended consequences for humans and the environment. ("Intended" means "planned." "Unintended" means "unplanned.") Think back to what you learned in this section.

1. In this section, you learned that the largest use of water worldwide is in irrigation. Why do farmers use irrigation technology? (This is an intended consequence or result of the technology.) Describe two unintended consequences (results) of using irrigation technology.
2. If you did the Decision Making Activity on chlorine, did you have any difficulty finding reliable information? Do you think some of the publications or Web sites were biassed (supported one side more than another)? How do you know? Does that mean that their information is not usable?
3. Think ahead to your water e-zine/magazine project on logging in community watersheds. What did you learn in this section that you could use in advising a community on how to identify possible unintended consequences of logging?

SCIENCE WORLD

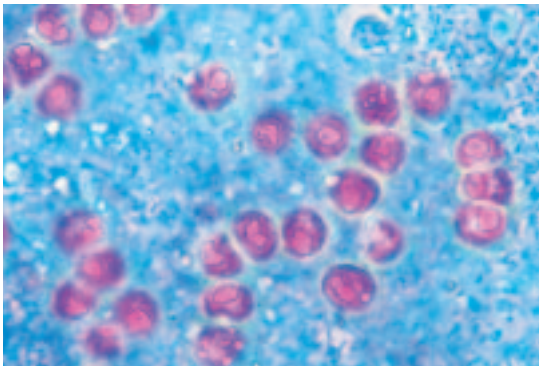
Case Study

Chemicals in Our Water Supply

The Issue

The town of Retaw is debating whether to stop adding water-softening chemicals to its water supply. Dissolved calcium and magnesium minerals are normally found in most water supplies. In some areas, like Retaw, the concentration of these minerals is so high that the water is hard. Retaw uses lime (calcium hydroxide) to soften its water. The lime reacts with the calcium and magnesium minerals so that they settle out. They can then be easily removed.

Should Retaw continue to add chemicals to soften its water supply? Look at the arguments below for and against adding chemicals to soften water.



The micro-organism *Cryptosporidium*. Water softening can make it more difficult to remove this organism from the water supply.

Retaw should continue to add chemicals to soften its water supply.	Retaw should not add chemicals to soften its water supply.
Soap works better in soft water. It creates suds more easily.	**Some soaps work in hard water.**
Soft water eliminates the problem of mineral deposits called *scale* in equipment. Kettles, hot water heaters, and other equipment can be seriously damaged by mineral buildup from hard water.	**Treating water with lime to soften it increases the cost of treating it with other chemicals.** More alum (aluminum sulphate) is needed because the lime reduces the alum's effectiveness. Alum helps remove small particles and organisms. So more chlorine is needed to kill organisms.
Soft water protects us from possible health problems associated with hard water. High levels of calcium in hard water may contribute to the development of kidney stones.	**Adding more alum and chlorine may be harmful to human health.** Aluminum in drinking water may be related to Alzheimer's disease. Chlorine compounds have been linked to increased risk of cancer.

Go Further

Now it's your turn. Look into the following resources to help you form your opinion.

- Look on the Web: Check out water softening on the Internet.
- Ask the Experts: Try to find an expert on water softening. Experts can be found in all sorts of places: your community's water department, universities, and government agencies.
- Look It Up in Newspapers and Magazines: Look for articles about water softening or chemicals in our water supplies.

In Your Opinion

Write up your point of view on water softening as one of the following:

- a letter to the editor of the Retaw newspaper
- a letter of concern to the Retaw town council
- a statement that you could read at a public forum on this issue

Unit Summary: Fresh and Saltwater Systems

Key Concepts	Section Summaries
1.0 • water quality • human impact	**1.0 Humans depend on water supply and quality.** • Most of Earth's water is in the salty oceans that cover much of the planet's surface. Of the remaining fresh water, most of it is locked in icecaps and glaciers all over the world. Our drinking water comes from groundwater and rivers and lakes. • Water in nature contains a wide range of materials including minerals, microscopic organisms, and other organic material. Water quality testing ensures that the water we use from nature is safe to drink.
2.0 • water-borne materials • erosion and deposition • stream characteristics • continental drainage systems • ocean basins • climate • glaciers and icecaps	**2.0 Water in its various states affects Earth's landforms and climate.** • Waves and tides are different types of water movement that interact with the shoreline of bodies of waters, eroding and depositing sediment. • Understanding stream and river characteristics helps us understand how erosion and deposition shape Earth's surface. • Two other important processes that shape Earth's surface are plate tectonics and glaciers. Plate tectonics resulted in the ocean basins and helped to shape the continental drainage system of North America. Glaciers have further eroded that drainage system into the distinctive pattern we see today. • Water interacts with Earth to produce the great variations in climate we experience, from desert climates to rainy ones.
3.0 • water quality • adaptations to aquatic ecosystems • human impact	**3.0 Living things in aquatic environments are affected by many factors.** • In the same way that we are affected by the air around us, living things in aquatic environments are affected by the water they live in. • The variety of organisms found in an aquatic environment depends on the water conditions of light, temperature, and depth of the water. Oceans support a greater diversity of life than freshwater systems because they contain a greater range of environments. • A population is a group of individuals of one species living in a particular area. A change in a population indicates that something in its environment has changed. • Each aquatic species is adapted to a certain quality of water. Some need very clean water with a high level of oxygen. Others can survive in murky water. No matter what their preference, a change in that quality can seriously affect them.
4.0 • water quality • human impact	**4.0 Human activities affect aquatic environments.** • Humans use water in many ways—for work, for play, for survival. Even when we aren't using water directly, we can have an effect on aquatic environments. • Our greatest use of water is in irrigation for agriculture. The next largest use is for industry. Domestic use (in the home) is third. All these uses have both intended and unintended results. Many of the unintended results are harmful to aquatic environments. • Monitoring aquatic environments helps us to understand the effects of human activities. It also helps us to develop technologies that will make our activities less harmful. • Science and technology alone cannot solve problems. People must take action and be committed to solutions.

PROJECT

To Log or Not to Log

Getting Started

You have learned in this unit that water is one of our most important resources. Here in Canada, as in other places in the world, we depend on a continual supply of fresh water. We expect clean, safe drinking water, and our agriculture and other industries depend on having large amounts of fresh water.

Our natural environment also depends on water. Our forests act as reservoirs that purify and store water. When the snow and rain fall on our watersheds, they are trapped by this ecosystem. Over time, they are slowly released into the streams and rivers that supply us with water. The trees and other organisms in these environments are affected by many factors including wastes and pollutants.

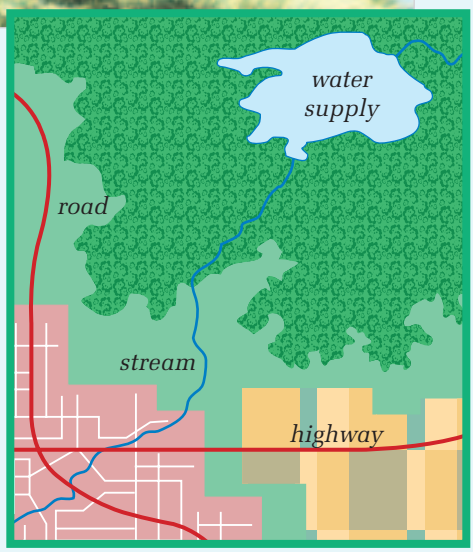
You learned that our activities directly influence water quality and availability. It is important to understand the impact that technological development has on them.

Clearcutting is the most common forestry technology used in Canadian logging.

Logging is one such activity that often stirs controversy. Wood and wood fibre are important components of many things we use. Much of northern Alberta and the eastern slope of the Rocky Mountains are heavily forested. The trees they contain are a valued source of lumber and a potential source of wood pulp for paper manufacture. But many people object to clear-cut logging, the most common logging technology. It is unsightly and can have environmental consequences, such as excessive erosion. Some people would prefer to see logging greatly reduced, but the forest industry is a major employer in Canada. In certain areas, it is almost the only employer.

In some communities, the debate about logging focusses on water quality. Should logging be allowed at all near any body of water (lake or river) that is the source for a community's drinking water? Is there some way to balance employment, environmental, and human safety considerations?

How do we protect our water supplies?



Valuable timber surrounds this community's water supply.

Your Goal

Your class will work together to design and publish a water e-zine electronically or a paper magazine that presents information and points of view about logging in a community watershed.

What You Need to Know

For the purpose of this project, assume that your community takes its drinking water from a lake surrounded by commercially valuable forests, like the one in the photograph. One of the main industries in your community and the surrounding area is forestry.

Steps to Success

1. Your class will divide up into groups to collect information, prepare articles and photos, and design and publish your e-zine/magazine. Publishing will mean either putting up a Web site or putting together a printed paper document. Articles could include news items, human interest stories, poems, fictional stories, or photo essays. Some of the topics you should cover include:
   - where your drinking water comes from
   - why water quality is important
   - how logging might affect your drinking water
   - logging technologies—clearcutting and alternatives
   - watershed protection activities
   - how logging might affect watershed ecosystems
   - importance of logging to the community's economy
   - how logging and environmental protection may be able to co-exist
   - any other related topic you think is important
2. Have other students in the school read your e-zine/magazine. If it's an e-zine, they can post their comments electronically. If it's a paper magazine, you could set up space on a bulletin board where they could post their comments on the issue.

How Did It Go?

3. Summarize the types of comments you received from other students about your e-zine/magazine. Which comments would help you improve your publication? Why?
4. If you were to produce an e-zine/magazine on another issue, what would you do differently?

Unit Review: Fresh and Saltwater Systems

Unit Vocabulary

1. Write a short story about Earth's fresh and saltwater systems using the following terms:

   potable water
   water quality
   salinity
   waves
   tides
   stream characteristics
   watershed
   glaciers
   climate
   diversity
   populations
   monitor

Check Your Knowledge

1.0

2. a) Where is most of the water on Earth located?
   b) Is this water useful to humans? Explain your answer.
   c) Describe the differences between the water in a lake and the water in the ocean.
3. What is the difference between salinity and hardness in water?
4. Even when water appears to be clear and clean, it may not be safe enough to drink. Describe two things that could make it unsafe for human use.
5. A friend of yours has moved out to the country but she doesn't like the well water there because it has a salty taste. What would you suggest your friend's family do to improve the quality of their water?

2.0

6. How do waves affect a coastline?
7. A wave is travelling at 50 km per hour across the ocean. As the wave passes your sailboat, you drop a toy boat onto it. How far will the toy boat travel in a day? Explain your answer.
8. What is the difference between a current and a tide?
9. a) What is the Continental Divide?
   b) How is it related to the watershed that you live in?
10. a) What is a glacier?
    b) How do glaciers affect the environment?
11. What effects does a large body of water have on the climate of a city on its shore?

3.0

12. Which water environment would you go to if you wanted to study as many different types of aquatic organisms as possible? Why does it have so many different types of organisms?
13. Define the term *adaptation* in your own words. Give two examples of adaptations that fish have to living in water.
14. Describe three types of human activities that can affect aquatic organisms.

4.0

15. a) Describe three major ways that people use water worldwide.

b) For each one, give an example of how this use might affect water in the natural environment.

16. What is indirect water use? Give some examples to support your explanation.

17. Agree or disagree with the following statements. Give evidence to support your decisions.

a) Because water is recycling itself all the time, we don't have to conserve it.

b) Only human activities can have negative effects on aquatic animals.

Connect Your Understanding

18. Look around your community. What evidence do you see that human activities might be harming the local water supply? What evidence do you see that efforts are being made to conserve or protect water in your area?

19. A new oceanside resort trucks in tonnes of fine, clean sand to create a beach along a rocky shoreline. In what ways could this change to the rocky shore affect the animals that live there? How do you think the wave action on the ocean's shore might affect the new beach?

20. You are out for a drive in the country, and you notice some unusual-looking hills. They are rounded and tapered at one end. You also notice snake-like ridges of gravel and sand. What is each feature called? Explain the relationship between these geological features and glaciers that covered the province in the past.

21. Imagine a glacier high up in the mountains. What do you think would happen to the glacier in each of the following situations?

a) Winter temperatures are higher than normal for 10 years.

b) Winter temperatures are lower than normal for 10 years.

c) Two winters where the same amount of snow and ice melts from the front of the glacier as falls on it farther up.

22. Ten years ago, there was only one house beside a lake. Today, there is a small community, including a marina and a campground. (A marina is a place on the waterfront where people can park their boats in the water.) Ten years ago the fishing was good here, but now very few fish are caught.

a) What factors do you think affected the fish population? (Think about factors other than overfishing.)

b) What effect do you think the change in the fish population might have on the other animals in the lake? Hint: Think about micro-organisms as well as other, large animals.

Practise Your Skills

23. Imagine that you are a journalist who will be interviewing the head of a mining company that is about to develop

a mine in a wilderness area of the province. Make a list of questions you will ask about how the development will affect water in that area.

24. Plan an experiment to determine which of three water samples is safest to drink. Hint: Limit your testing to suspended solids and organisms.

a) What are your major variables?

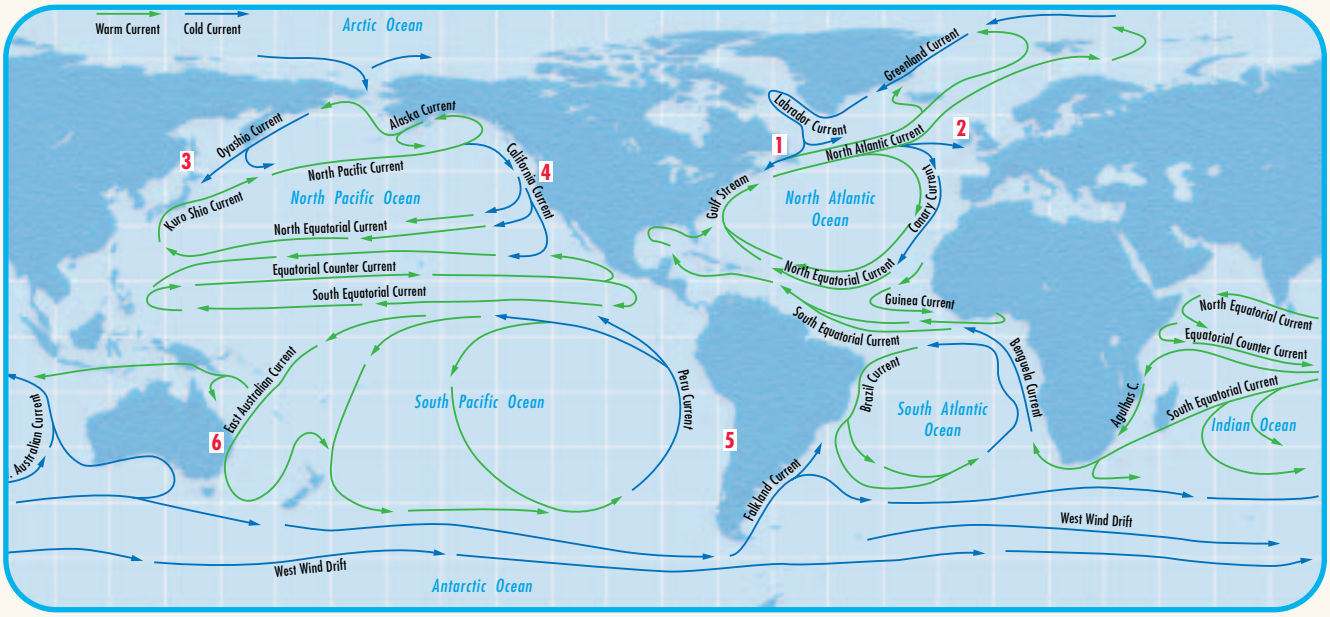
b) What materials would you need?

c) What procedure would you use?

25. On the map shown below, six cities are shown and the ocean currents that pass near them. Compare the following pairs of cities:

- (1) St. John's, Newfoundland, and (2) Dublin, Ireland
- (3) Sapporo, Japan, and (4) Vancouver, British Columbia
- (5) Santiago, Chile, and (6) Sydney, Australia

For each pair, predict which one will have a warmer climate and which one will have more rain. Explain your predictions for each one. Check your predictions by using reference books and the Internet.



Question 25. Which cities have warmer climates? Which cities have more rain?