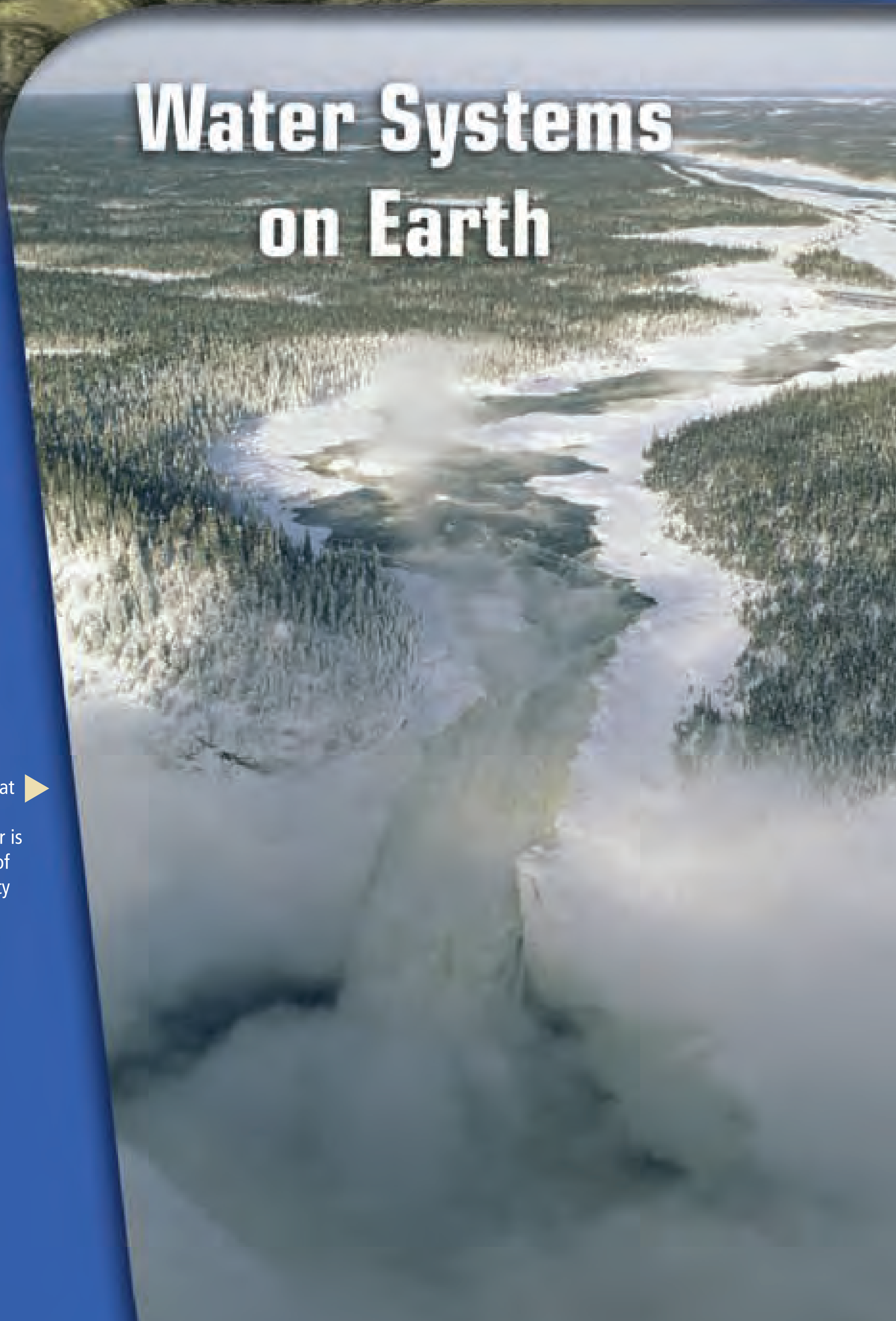
UNIT

# 1 Water Systems on Earth



The fast moving water that flowed over the mighty Churchill Falls in Labrador is now used to power one of the largest hydroelectricity developments in North America.

## Key Ideas

### 1 The water cycle plays a vital role on Earth

1.1 Distribution of Water
1.2 Comparing Ocean Water and Fresh Water
1.3 Sources of Fresh Water

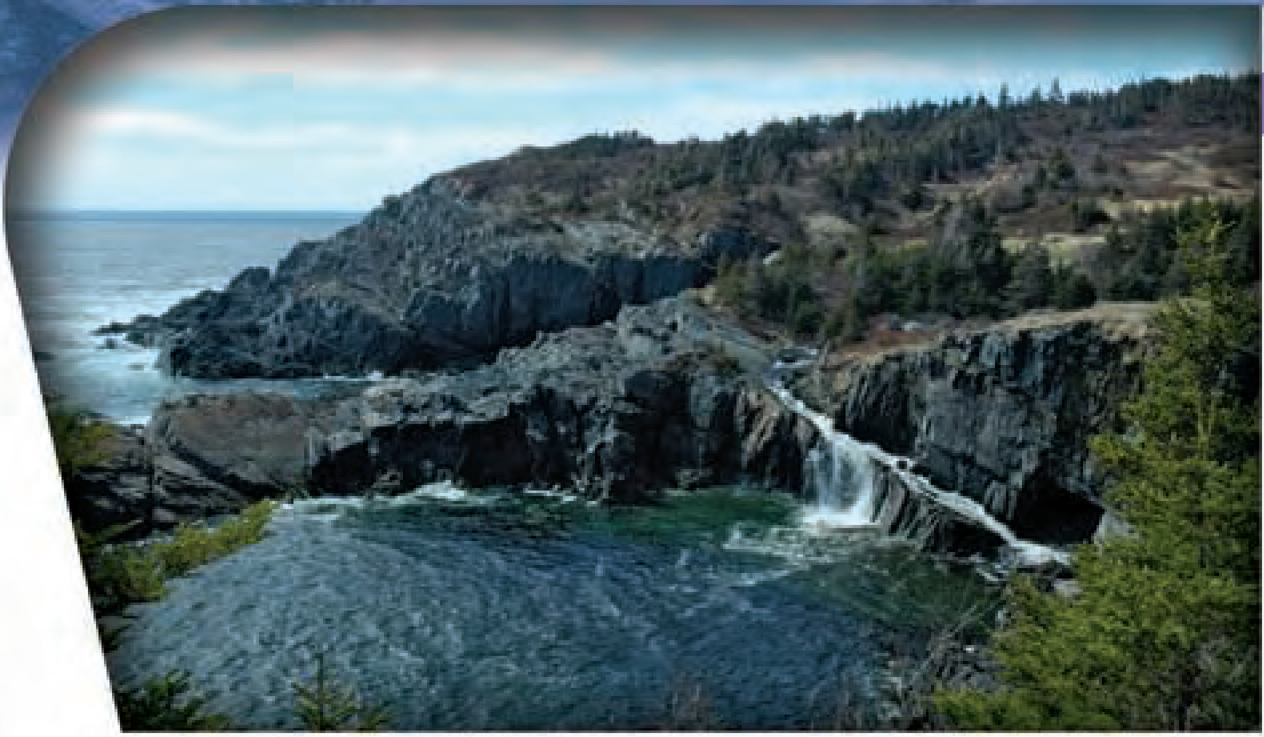
### 2 Oceans control the water cycle

2.1 Ocean Basins
2.2 Ocean Currents
2.3 Waves and Tides

### 3 Bodies of water influence climate and species distribution

3.1 Oceans and Climate
3.2 Living in Water
3.3 Human Impact on Water Systems

# Getting Started



Water not only supports life, but also shapes coastlines such as the one here in Freshwater Cove on the Avalon Peninsula.

Earth is covered in water, and because of that, life thrives in almost every location you can think of. From bugs to birds, sunflowers to spruce trees, and halibut to humans, the variety of organisms on the planet seems almost limitless. Water is a part of every living thing, and every living thing—humans included—needs water to stay alive.

Water also has a major effect in shaping the landscapes around us. Rushing rivers and pounding ocean waves, for example, can change the shape of the land overnight. As if that were not enough, water also influences climate and weather around the globe. The world's oceans are not just tubs for holding Earth's water supply: they play an essential role in keeping Earth a suitable place for life.

As you read through this unit, you will learn about how important it is for us to care for this natural resource. Humans have been altering natural water systems for thousands of years. By developing a strong understanding of Earth's water systems and what is needed to keep them healthy, we can learn how best to protect the quality of water all over our planet.

## The Many Ways People Use Water

**Find Out ACTIVITY**

In Newfoundland and Labrador, there is water all around in ponds, lakes, rivers, and the ocean. With so much water available, you might think it could never run out, and rarely pay attention to how much water you use in your daily life. In many parts of Africa, water (especially clean water) is very scarce. On average, in some African countries, a person uses about 5 L of water a day. Compare that with average daily use in Newfoundland and Labrador, which is over 400 L. That is equivalent to about 400 1 L milk cartons! Household use is just one example of how water is an essential part of our lives. The following activity will help you think about what other ways we use water in Newfoundland and Labrador.

### What to Do

1. Look at the figure below and create a mind map with "Water" as your starting term. Then, make a list of all the different ways water is being used in the figure. Try to group the items on the list into different categories. For example, you might have categories such as "household use," "personal use," and "recreational activities."

### What Did You Find Out?

1. Share your category lists with the rest of the class. Were there any differences?
2. Pick one of your categories and imagine that the water uses listed under it were not available to you anymore. Write a brief paragraph about how your life would be affected.

Chapter 1

# The water cycle plays a vital role on Earth.

Earth has been called "the blue planet." From space, its surface appears to be mostly oceans of liquid water. There is no doubt that water is everywhere on Earth. Water vapour is found in Earth's atmosphere. Frozen water occurs on moutaintops and at the North and South Poles. The bodies of animals and plants consist mainly of water. In fact, sixty-five percent of your body mass is water.

Water is always on the move. It evaporates into the air and falls from clouds as rain or snow. The best way to understand Earth's water supply is to study it as a system — a system in which water constantly moves around between sea, sky, land, and life. It is one of our most precious resources on Earth.

## What You Will Learn

In this chapter, you will

- **describe** how water exists in various states on Earth's surface
- **explain** how water is distributed around the planet
- **describe** how water circulates between land, ocean, and atmosphere
- **identify** why water systems are closely connected

## Why It Is Important

By studying Earth's water systems, you will better understand the importance of water in our lives and to all life on the planet.

## Skills You Will Use

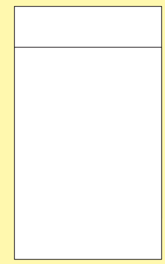
In this chapter, you will

- **study and interpret** maps and tables of water systems
- **communicate** your understanding of the water cycle
- **design** a model of the water cycle
- **investigate** the effect of salinity on water density

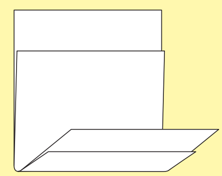
**FOLDABLES™**
Reading & Study Skills

**Make the following Foldable to demonstrate your learning in Chapter 1.**

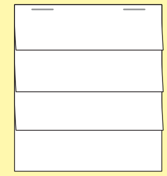
**STEP 1** **Collect** 2 sheets of letter sized paper and layer them about 2.5 cm apart vertically. Keep the edges level.



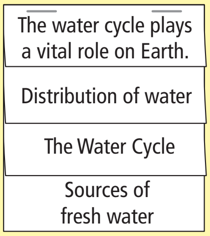
**STEP 2** **Fold** up the bottom edges of the paper to form 4 tabs.



**STEP 3** **Fold** the papers and crease well to hold the tabs in place. **Staple** along the fold.



**STEP 4** **Label** the tabs as shown. (Note: the first tab will be larger than shown here.)




**Show You Know** As you read the chapter, take notes under the appropriate tab to *describe* the distribution of water on Earth, *illustrate* the water cycle, *compare* ocean water and fresh water, and *identify* sources of fresh water on Earth.

# 1.1 Distribution of Water

There is hardly a place on Earth where water cannot be found in some form or another. Whether it is frozen in small spaces between tiny particles in rock or floating as invisible droplets in the air, water is everywhere on our planet. With this being the case, you might think that humans could never run out of water to drink. Yet, if you have ever swallowed seawater, you know that not all the water on Earth is drinkable.

**Key Terms**

atmosphere
hydrosphere
lithosphere
water cycle

In terms of the amount of water on this planet, the water you need to survive is actually in very short supply. The vast majority of water on Earth, about 97 percent, is salt water (see Figure 1.1). You cannot drink salt water. Neither can other land-living organisms.

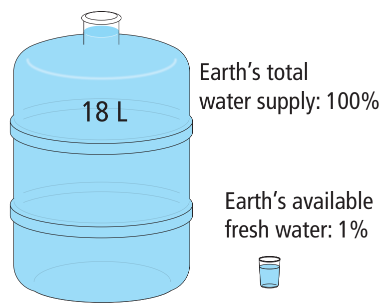



**Figure 1.1** Earth's total water supply compared with the distribution of available fresh water.

**Word Connect**

The word "aquatic" means watery, and comes from the ancient Latin word aqua, which means water. Some words we use today have the root word "aqua," such as aquarium.

Only 3 percent of the planet's water is "fresh water," meaning it does not contain salt. That may still seem like a lot of fresh water, but two thirds of that fresh water supply is frozen in large masses of ice. These frozen masses of water form ice sheets at the North and South Poles, and glaciers in the high mountaintops. That leaves less than 1 percent of Earth's water as liquid fresh water. This tiny remainder must supply hundreds of billions of other organisms with the water they need to survive. This includes over six billion humans.

With all of these organisms consuming water, why have we not yet run out of fresh water? To answer this question, we need to examine the water cycle.

**Figure 1.2** Two-thirds of Earth's fresh water is frozen.

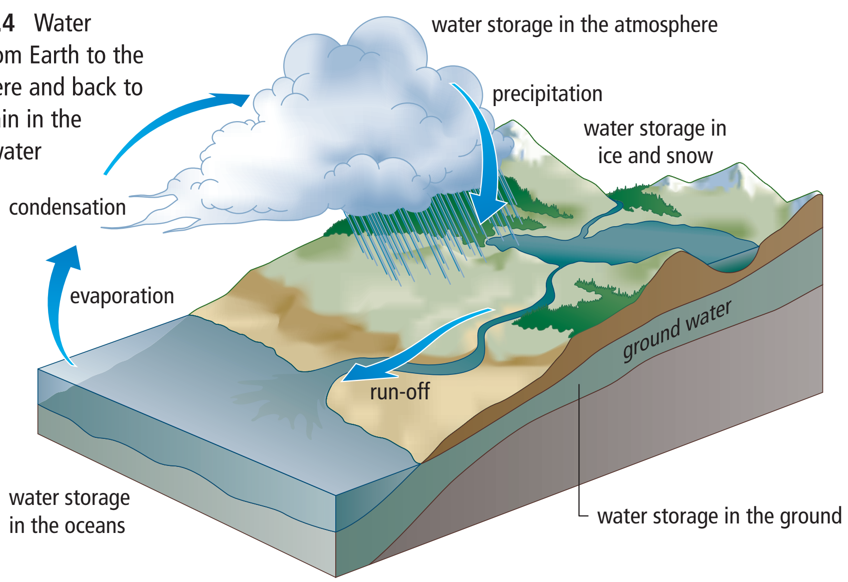
## The Water Cycle

Have you ever gone for a walk in your neighbourhood just after a heavy rain? What do you notice? Water drips from leaves and runs along gutters or drainage ditches. There are puddles in parking lots, and footpaths across a playing field are muddy. A few hours later, the puddles are gone and the sidewalks are dry. What has happened to the water?

Each drop of rain that falls must go somewhere. Some runs off the land into the streams, rivers, ponds, lakes, and then pours into the oceans. Some soaks, seeps, and flows into Earth's **lithosphere**—the solid rocky ground of Earth's crust. Some appears to just "vanish" into Earth's **atmosphere** – the environment surrounding the planet. All of the water on Earth, be it in the atmosphere, lithosphere, or on Earth's surface, is called the **hydrosphere**.

The ability of water to "disappear" and to reappear somewhere else is not magic. It is the result of two common changes of state: evaporation and condensation. Evaporation is the change of state from a liquid to a gas. Evaporation converts liquid water from Earth's surface into gaseous water vapour. There is always some water vapour in the atmosphere. Condensation is the change of state from a gas to a liquid. Gaseous water vapour remains in the atmosphere until it cools. As it cools, water vapour condenses to form clouds. Liquid and solid water fall from the clouds as precipitation—rain and snow. These two changes of state make the **water cycle** possible. A cycle is a series of events that repeat themselves over a period of time, where the events or steps always lead back to the starting point. In the water cycle, there is no beginning or end. Water is just constantly changing form.

**Figure 1.4** Water moves from Earth to the atmosphere and back to Earth again in the endless water cycle.




The Sun's energy drives the water cycle. Each year, about 520 000 km$^3$ of water from Earth's surface evaporates to form water vapour. That is enough water to fill over 208 000 Olympic-size swimming pools! Water vapour does not remain in the atmosphere for long, though. After being carried by winds to other places on Earth, it eventually condenses and falls to Earth, and the water cycle is repeated.

## Word Connect

The root word *hydro* is Greek for "pertaining to water." A *hydrologist* a person who studies Earth's water systems and helps find solutions to problems of water quality and quantity. What other terms can you think of that begin with *hydro*?

**Figure 1.3** These water droplets will either fall and soak into the ground, or will evaporate in the air as part of the water cycle.

## internet connect

If all the water in the atmosphere rained down at once, it would only cover the ground with a depth of 2.5 cm. Find out more about each part of the water cycle. Go to **www.discoveringscience8.ca** to find out where to go next.

# 1-1A A Water Cycle Model

Find Out ACTIVITY

Reading about the water cycle can introduce you to the scientific ideas behind this important process. However, actually seeing the changes of state in water can give you a much better understanding of how the water cycle works.

## Challenge

Water is the only substance on Earth that can exist naturally in all three states: solid, liquid, and gas. Design a model to show water changing from a liquid to a gas, and then back again. Then, change the water to a solid and back again to a liquid.

## Safety

- Be careful—you will be working with hot water and steam.
- Wear your safety glasses, lab jacket, and heat-resistant gloves.
- Only do this investigation under the supervision of your teacher.

## Materials

- electric kettle
- bowls of various sizes
- oven mitts or heat-resistant gloves
- ice
- hot plate
- modelling clay
- sand
- soil
- water
- refrigerator
- freezer

## Design Specifications

A. Your model must demonstrate how water can exist in all three states.

B. Your model must demonstrate how water can change from a liquid to a gas, from gas to a liquid, from liquid to a solid, and from a solid to a liquid.

C. Your model does not need to be all in one location.

## Plan and Construct

1. With your group, plan how you will cause water to change state.
2. Draw a labelled sketch of your model, indicating what materials you will use.
3. Obtain your teacher's approval. Then, construct your model.
4. Demonstrate how your model works.
5. Wash your hands after you complete this investigation.

## Evaluate

1. (a) Did your model work as you expected?
   (b) What adjustments did you make so it would work, or work better?
2. (a) What scientific knowledge did you use to help you develop your model?
   (b) What scientific knowledge did your model help you develop?
3. How did the models constructed by other groups work? Did other groups have ideas that you would like to use? Did your group have ideas that others wanted to use?
4. What part did heat energy play in this investigation? What part does it play in the water cycle?

# Wild, Weird, Wonderful

www Science

## The Salty Facts about Penguins

Our bodies rely on sources of fresh water to keep us healthy and alive. Drinking ocean water can make you very sick. But what about for other living creatures who eat and swim in nothing but salt water? Does the ocean water make them sick? One interesting animal has its own way of removing salt from water – the penguin.

Penguins spend half of their lives, swimming and feeding in the ocean on fish, krill, squid, and other small aquatic creatures. Because of this, they digest a large amount of salt water in the process of eating. In order to get rid of the salt, penguins have an organ called the supraorbital gland that collects and excretes the salt, thus keeping it out of the penguin's bloodstream.

The supraorbital gland is located just above the penguin's eye and is connected to capillaries. The gland functions a little like our kidneys, in that it cleans the blood and gets rid of the wastes. To get rid of the salt that the gland collects, the penguin excretes a salty liquid through nasal passages in its bill, which often makes them look like they have a runny nose.

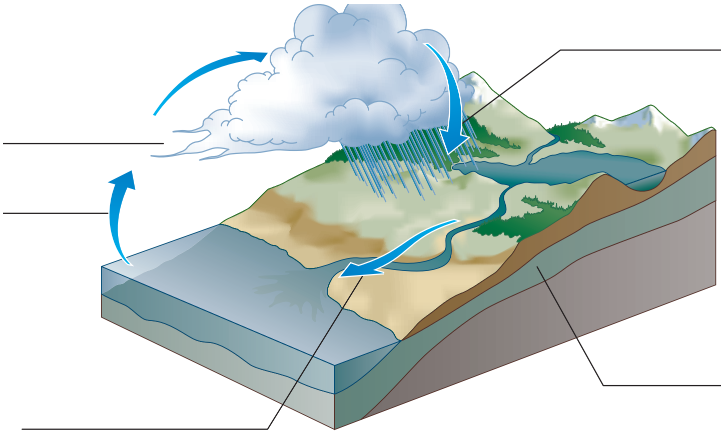
Isn't it amazing that humans have to design systems to take the salt out of water while the penguin naturally has its own built-in removal system!

There are approximately seventeen different species of penguins. All of them have the supraorbital gland that removes salt from their bodies. Supraorbital comes from supra = above, and orbital = orbit of the eye (eye socket).

# Check Your Understanding

## Checking Concepts

1. What percentage of water on Earth is salt water?
2. Where is most of the world's fresh water found?
3. Why is less than one-third of fresh water available for use by humans?
4. What has to happen in order for water to change from one state to another?
5. Sketch the diagram of the water cycle below into your notebook and label the parts.



## Understanding Key Ideas

6. Name the three states in which water occurs and describe where you would find a naturally occurring example of each state.
7. For each of the following descriptions, decide whether they demonstrate evaporation or condensation:
   (a) after wiping a chalkboard with a wet sponge, the board is dry an hour later.
   (b) the dew on the grass early in the morning.
   (c) your breath on a window on a cold day.
   (d) clothes drying on a clothesline
8. If water moves in a cycle, why might activities in one place pollute water in a different place?

### Pause and Reflect

Whether you get your drinking water from a tap, from a well, or from bottled spring water, it is all recycled. In your notebook, write a paragraph or poem, or make a drawing that expresses the idea of water moving endlessly through the phases of the water cycle.

# 1.2 Comparing Ocean Water and Fresh Water

Salt water differs from fresh water in several major ways. The main one is in its salinity. This characteristic gives ocean water a different density, freezing point, and boiling point than fresh water. Even though salt water and fresh water are connected, they play different roles in the water cycle.

**Key Terms**

density
freezing point
salinity

Although fresh water has tiny amounts of salt, ocean water is more than 200 times saltier. The amount of salt dissolved in a specific amount of water is called **salinity**. The average salinity in all the world's oceans is about 35 parts per thousand. This is the same as if you mixed 35 g of salt in 1 L of water. Salinity in sea water can differ depending on the location. Close to the equator, the salinity is high because of high rates of evaporation. When the water in the ocean transforms into vapour in the air, it leaves the salt behind. Water is very salty near the North and South Poles as well because when water freezes and changes into ice, it also leaves the salt behind. Near continents, the salinity is usually lower than in the middle parts of the ocean. The reason is that the fresh water from the rivers empties into the ocean and dilutes the salt water.

**Did You Know?**

Ocean water contains valuable minerals such as gold, copper, and uranium. However, before you consider mining the ocean's water, you should know that there is only about 1 part gold for every 250 billion parts of sea water. In other words, if you wanted a gram of gold, you would first have to make 250 thousand tonnes of ocean water evaporate.

**Figure 1.5** Intense evaporation in tropical climates is the reason for high salinity in ocean waters near the equator.

# 1-2A Mini Distillation

**Find Out ACTIVITY**

Have you ever walked along an oceanside beach on a sunny day and noticed patches of white on the sand where the tide has gone out? The white material is salt crystals that have been left behind after water has been evaporated by the Sun. Separating salt from salt water is a process called desalination. In this activity, you will simulate what happens when salt water evaporates.

## Safety

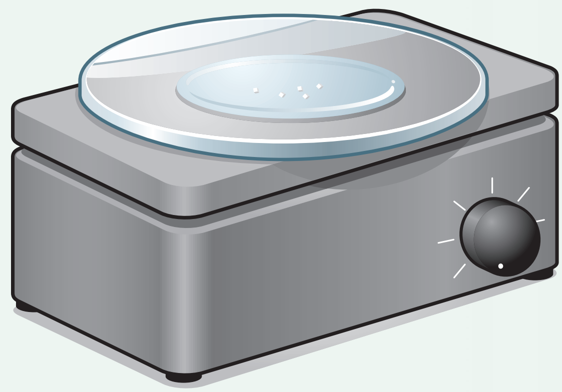
- Be careful when handling glass.
- Be careful when handling hot equipment.

## Materials

- 4 g salt
- microscope or magnifying glass
- watch glass
- laboratory balance
- 10 mL distilled water
- stirring rod
- 50 mL beaker
- 5 mL measuring spoon
- tongs
- hot plate or other heat source

## What to Do

1. Observe a small sample of the salt under the microscope or magnifying glass. Describe the appearance of the crystals. Sketch one of the crystals in your notebook.
2. Measure and record the mass of the watch glass.
3. Put 1 g of salt into the beaker and add the distilled water. Stir until the salt is completely dissolved.
4. Carefully pour 5 mL of the solution into the watch glass.
5. At medium temperature, heat the watch glass on the heating plate (see below). Continue heating until the water has disappeared. Describe the appearance of the material left on the watch glass. This material is called "residue."



6. Wait until the materials have cooled down, and then measure the mass of the watch glass and the residue combined.
7. Clean up and put away the equipment you have used.

## What Did You Find Out?

1. (a) Describe the residue left after the water had evaporated.
   (b) What is the name of the residue?
2. Observe the residue under the microscope or magnifying glass. Is the residue's appearance any different from that of the original salt?
3. (a) To determine the mass of the residue alone, subtract the mass of the watch glass by itself from the mass of the watch glass and the residue. How does this amount compare with the original amount of salt?
   (b) Is this what you would expect? Explain.
4. Describe how this method can be used to purify water.

## Where Does the Salt Come From?

Salt arrives in the oceans from several different sources. As you read in Section 1.1, when the rain falls on the land, most of it seeps into the ground, and then eventually into streams and rivers. From there it travels to the ocean. Moving over and through the ground, the water picks up materials from the rocks. These materials are called dissolved solids, and you cannot see them even with the help of a microscope. They get carried by the water from the land and into the ocean (Figure 1.6).

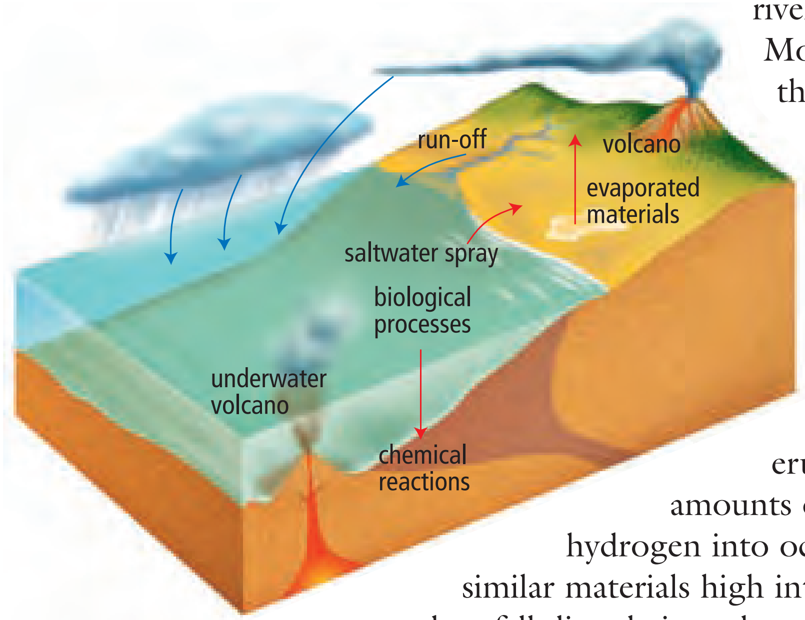



**Figure 1.6** Dissolved solids reach the ocean from several different sources on Earth.

Volcanoes contribute some chemicals as well. Undersea volcanic eruptions from the sea floor release large amounts of sulphur, fluorine, chlorine, and hydrogen into ocean water. Eruptions on land spew similar materials high into the atmosphere. These materials then fall directly into the ocean, or onto Earth's surface from where they get carried to the ocean as run-off.

By far the most common material that is deposited into the ocean is sodium chloride, which is the chemical name for salt. This the same chemical substance as the table salt you use to season food. Sodium chloride accounts for over 85 percent of all the dissolved solids in the ocean. Because there is so much sodium chloride, the water is salty.

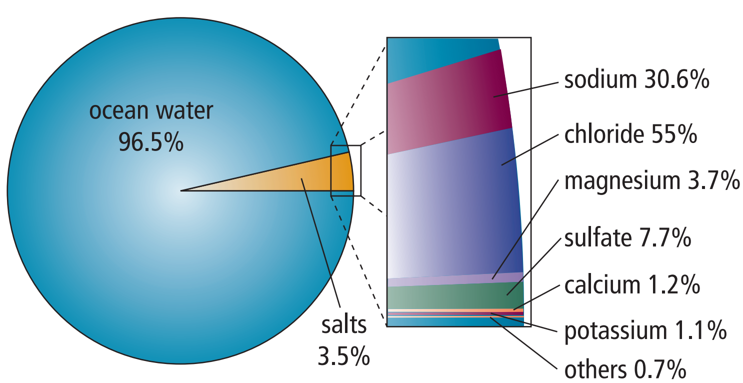



**Figure 1.7** Ocean water contains about 3.5 percent salts. Traces of almost every chemical substance on Earth can be found in seawater, including gold and silver. Most of these substances, however, occur in extremely small quantities.

## Density of Salt Water and Fresh Water

**Density** is the amount of mass of a substance in a certain unit volume. Think of density as being a measure of how tightly packed together that material is in the substance. Imagine two objects of equal size, such as a bowling ball and a volleyball. If you put the bowling ball on a pile of fluffy snow, it will sink into the snow because its density is greater than snow's (the bowling ball has a lot of mass in a small volume). The volleyball will likely sit on top of the snow because its density is less than the snow's (the volleyball has a small mass compared with its volume).

Because of the amount of salt in it, ocean water is denser than fresh water. There is more mass in 1 L of ocean water than there is in 1 L of fresh water. Ocean water has a density of 1027 kg/L and fresh water has a density of 1000 kg/L. That is why you may notice that it is much easier to float in salt water than it is in fresh water. The higher density of salt water helps to hold your weight up in the water. In some extremely salty oceans, such as the Dead Sea in southwestern Asia, you can float very easily. Water in the Dead Sea is nearly 9 times saltier than ocean water!

### Did You Know?

If all the water could be boiled out of the oceans, the salt left behind would be enough to cover Earth in a layer 154 m thick, which is similar to the height of a 50-storey building.

## Freezing Point of Salt Water and Fresh Water

Another difference between salt water and fresh water is their freezing points. The **freezing point** of a liquid is the temperature at which it freezes. As you know, the freezing point of fresh water is 0°C. Because ocean water contains far more dissolved salt than fresh water, its freezing point is different from that of fresh water. Salt water has a freezing point of about –1.9°C.

**Figure 1.8** The high density of salt in the Dead Sea makes it easy for a person to float.

### Reading Check

1. What is salinity?
2. Why is ocean water saltier near the equator?
3. Name two sources of ocean salt.
4. What is density?
5. Why is ocean water more dense than fresh water?

**Suggested Activity**

Investigation 1-2B and C on pages 18-21.

# 1-2B Salinity's Effect on Water Density Core Lab

**SkillCheck**

- Observing
- Measuring
- Modelling
- Evaluating information

## Safety

- Be careful when handling glass

## Materials

- 250 mL beaker or large jar
- 5 samples of clear water, prepared by your teacher:
  – tap water (colourless)
  – tap water (blue)
  – slightly salty water (red)
  – very salty water (colourless)
  – very salty water (green)
- medicine dropper or pipette
- plastic spoon

The greater salt content in ocean water makes it much denser than fresh water. Different parts of the ocean also vary in their salinities (the amount of salt in a certain volume of water). In this activity, you will investigate how the two types of water, with their different properties, interact.

## Question

How does salinity change the density of water?

## Procedure

1. Your teacher will provide you with a table to record your observations for this experiment.

**Test 1**

2. Fill the beaker about two thirds full with colourless tap water.
3. Fill the medicine dropper with very salty water (green). Place a few drops of this water into the beaker. Record your observations.
4. Empty the contents of the beaker and rinse it and the medicine dropper thoroughly.

**Test 2**

5. Fill the beaker about two thirds full with very salty water (colourless).
6. Fill the medicine dropper with blue tap water. Place a few drops of this water into the beaker. Record your observations.
7. Again, empty the contents of the beaker and rinse it and the medicine dropper thoroughly.

Test 3

8. Fill the beaker half full with very salty water (green). Holding the plastic spoon just above the very salty water in the beaker, gently and slowly pour colourless tap water over the spoon. The objective is to make a layer of colourless water at least 3 cm thick on top of the very salty green water. Using the spoon will prevent the water from mixing. Record your observations.

Test 4

9. Fill the medicine dropper with slightly salty water (red). Place a few drops of this water into the very salty water (green) layer in the beaker. Record your observations.

Test 5

10. Refill the medicine dropper with slightly salty water (red). Place a few drops of this water into the colourless tap water layer in the beaker. Record your observations.

Test 6

11. Using the plastic spoon, stir the waters in the beaker together. Record your observations.
12. Clean up and put away the equipment you have used.

## Analyze

1. When you put the very salty water (green) into the colourless tap water, which one sank? Explain why this happened.
2. When you put the blue tap water into the very salty water, which one floated on the other? Explain why this happened.
3. (a) What happened when you added the slightly salty water (red) to the:
   (i) very salty water (green) layer?
   (ii) colourless tap water layer?
   (b) Why did the red water do this?
4. Why did the different types of water not mix by themselves?

## Conclude and Apply

1. How does the amount of salt dissolved in water affect its density?
2. Explain how waters with different densities will act when they meet.
3. Describe what happens when fresh water from a river meets salty ocean water.
4. What causes salt water and fresh water to mix in the ocean?
5. Describe environments on Earth where fresh water would meet salt water.

## Career Connect

### Oceanographer

Dr. Anna Metaxas is a biological oceanographer at Dalhousie University in Nova Scotia. She studies the larvae of invertebrate creatures (organisms without spines) that live on the ocean floor. Her research takes her all over the world and to the bottom of the ocean.

**Q.** What is an oceanographer?

**A.** An oceanographer is a scientist who studies aspects of the oceans. Oceanographers are concerned with the biology, chemistry, geology, physics, and mathematics of the oceans.

**Q.** Of all the organisms you could study in the ocean, how did you choose invertebrate larvae?

**A.** The more I learned about the ocean, the more I realized how little is known or understood about the early stages of life of marine invertebrates. Unlike a lot of organisms where the young are geographically near their parents, invertebrate larvae are carried by currents to completely different areas. There are so many questions to be answered. "Where do they go?" "How many survive?" So much is unknown about these tiny but important organisms. That's what fascinates me.

**Q.** Why is it important to study invertebrate larvae?

**A.** With any species, it is important to know the rate of survival among the young to ensure that a species exists in healthy numbers. Many invertebrates, such as sea urchins and shrimp, are part of the fishing industry in different countries. We need to understand how the larvae survive and return to replace the adult population. If we don't know the rate of or the factors that affect replacement, we could lose these industries, or even worse, the entire species.

**Q.** Where does your research take you in the world?

**A.** Both short and long-term research projects take me from waters right here off the coast of Nova Scotia, to tropical waters in Palau (a tiny island in the Pacific Ocean, 800 km east of the Philippines), to the dark, exciting depths of the ocean floor.

**Q.** You have been in a submersible and travelled over 2250 m beneath the surface to the ocean floor. What was it like?

**A.** The first thing you notice is how long it takes to reach the bottom – about two hours. It's dark for the most part, but then you see these flashes of bioluminescent creatures out your window! At that depth of the ocean, the creatures can be pretty bizarre looking, too. It's such an amazing feeling being so far down and remote from people. I've even had the opportunity to see an underwater volcano erupting.

**Q.** You also study organisms that live around hydrothermal vents in the ocean floor. What is a hydrothermal vent, and what lives there?

**A.** A hydrothermal vent is a crack in the Earth's surface where super-hot water that is heated from Earth's molten rock comes out. The vents are covered in strange organisms, such as giant clams, tubeworms with no mouths, shrimp, mussels, and crabs. It is a completely different world.

**Q.** What do you like most about your job?

**A.** There are two wonderful aspects about my job. The first is that I get the opportunity to travel and do research in places where very few people have ever been, including the ocean floor. The second important aspect is having students. I get to both teach my students and to learn from them and their research. My career is more like being an explorer – it's always a new adventure.

# Check Your Understanding

## Checking Concepts

1. What is the main difference between ocean water and fresh water?
2. What dissolved chemical occurs in the greatest amount in ocean water?
3. Where does the salt that gives the ocean its salinity originally come from?
4. Fresh rainwater that falls on land eventually makes its way back to the ocean. If that is the case, then why is ocean water salty?
5. (a) Which is more dense: ocean water or fresh water?
   (b) What is the reason for the difference in their densities?
6. What does the addition of salt do to the freezing point of water?

## Understanding Key Ideas

7. Ocean water contains many valuable minerals that humans use, including gold and copper. Why don't people try to "mine" these minerals from ocean water?
8. Describe a method you would use to separate dissolved solids from ocean water.
9. Why do oceans in tropical areas have high salinities?
10. Why do oceans around the North and South Poles also have higher salinities?

### Pause and Reflect

Are the oceans becoming saltier over time? The answer depends on which ocean you mean. High rates of evaporation in the tropics mean that the remaining ocean water is saltier. At the same time, melting ice in the polar regions causes more fresh water to enter the oceans, making ocean waters less salty in northern and southern parts of the globe. Think about what other factors might increase or decrease the saltiness of ocean water. Write a paragraph describing those factors and how they affect salinity.

# 1.3 Sources of Fresh Water

Only about 1 percent of all of Earth's fresh water supply is easily accessible. Most of the fresh water is trapped in ice, in Greenland and Antarctica, and not readily available for human use. The fresh water that is available is found wherever water falling as rain and snow runs off the land and is collected in lakes, rivers, streams, and underground.

## Key Terms

crevasse
drainage basin
glacier
global warming
gravity
ground water
iceberg
run-off

## Lakes, Ponds, and Wetlands

A lake and a pond are basically large holes in the ground, filled with standing water (see Figures 1.9A and B). In general, lakes tend to be larger and deeper than ponds, although sometimes there are cases where a pond is bigger than a lake. There are no strict guidelines that differentiate between a lake and a pond, and often they were named by the early settlers who lived near them.

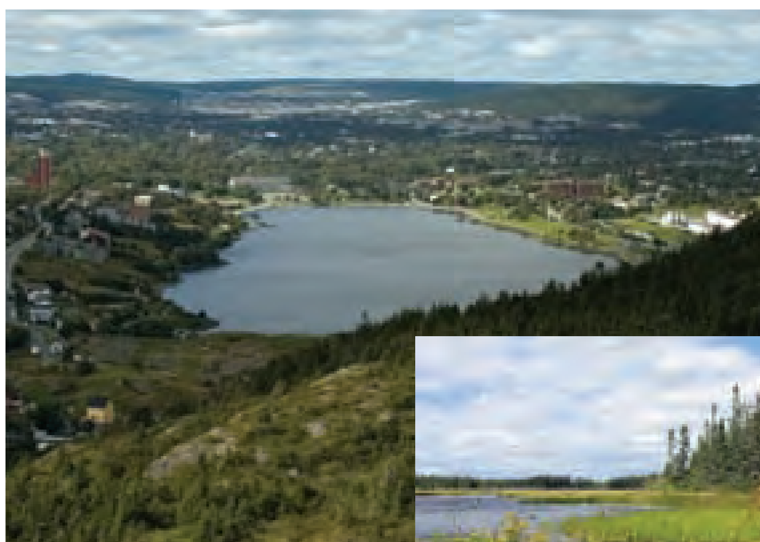


**Figure 1.9A** Some lakes, like Quidi Vidi Lake in St. John's, can be right in the middle of communities.

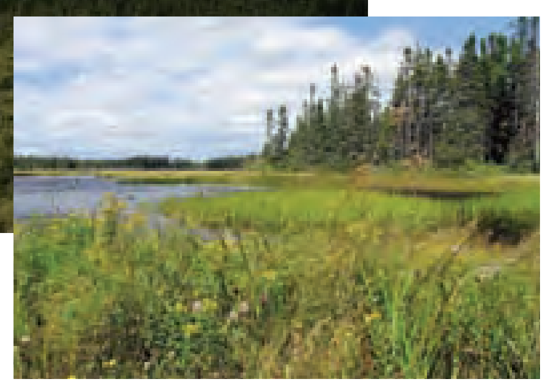


**Figure 1.9B** Cobb's Pond in Gander, Newfoundland and Labrador

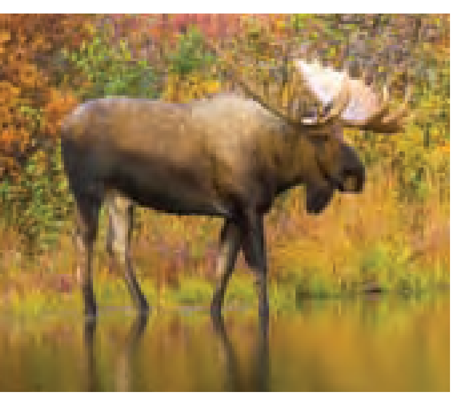


**Figure 1.10** Wetlands in Newfoundland and Labrador are an important feeding area for moose, and nesting area for many ducks.

Wherever there is a low area in the land, wetlands can occur. There are many different types of wetlands. However, they have one characteristic in common. They are saturated with water all or much of the time. Marshes, for example, are shallow water wetlands (less than 1 m in depth). They usually remain wet throughout the year. All wetlands provide habitats for an astounding diversity of plants and wildlife.

## Streams and Rivers

Streams and rivers are both fast-flowing waterways. However, their individual characteristics vary a great deal. Flowing waters differ greatly in speed, temperature, and clarity. They also differ in the nature of their banks and bottoms. All these factors affect the types of plants and animals that live in them. Fast-flowing waterways are usually rich in oxygen, which fish and other animals need to survive.

## Ground Water

While it is easy to see the many sources of fresh water on the surface of Earth, another important source of fresh water lies beneath the surface. Most of the precipitation that falls on land sinks out of sight and is called **ground water**. Below the surface, ground water trickles downward through connected pores and cracks (see Figure 1.11). Eventually, it reaches a layer of bedrock, such as granite. This bedrock forms a barrier, preventing the ground water from flowing down any further. Since it cannot move any deeper, it begins to back up and fill the pores in the material above the bedrock. It is in this layer that people will drill down into to make wells. They then pump the water to the surface for use as drinking water, for factories, or for watering crops and livestock.

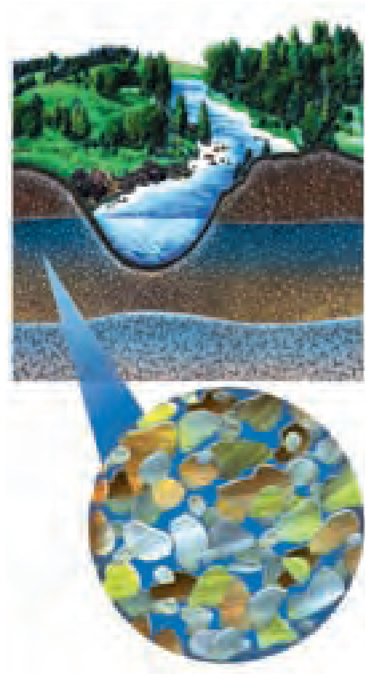


**Figure 1.11** Ground water is found under Earth's surface in small spaces between bits of soil and rock.

## Glaciers

In some areas of the world, it is so cold that snow remains on the ground year-round. When snow doesn't melt, it begins piling up. As it accumulates, the weight of the snow becomes great enough to compress the bottom layers into ice. Eventually, the snow can pile so high that the pressure on the ice on the bottom causes partial melting. Then, the ice and snow begin to slide downhill. This moving mass of ice and snow is called a **glacier**. Almost two thirds of the world's fresh water today is trapped in glaciers.

**Figure 1.12** These Emperor penguins and their chicks live in Antarctica, where massive continental glaciers exist.

### Did You Know?

The amount of fresh water underground is about 37 times the amount on the surface in rivers and lakes. About half of this underground water saturates the rock and soil to a depth of nearly 1 km. The remaining half of the water is even deeper—trapped 1–5 km below Earth's surface.

**Word Connect**

The cryosphere refers to the parts of Earth's surface where water is in its solid form. The term comes from the Greek word *kyro*, meaning "cold."

A glacier will continue to slide down a slope until one of two things happens. If the glacier reaches an ocean, the ice will start to slowly spill over the edge of the land mass toward the water. Deep cracks called **crevasses** will begin to form across the front of the glacier. Under gravity's pull, large pieces of the glacier will eventually break off and crash into the ocean. These big chunks of ice are called **icebergs** (see Figure 1.13).

**Figure 1.13** The east coast of Labrador and Newfoundland is known as Iceberg Alley. The icebergs that travel down through Iceberg Alley come from Greenland. To keep shipping lanes and oil rigs safe, sometimes icebergs have to be towed to a different location as shown here.

### Glaciers and the Water Cycle

Glaciers and the year round snows in high mountains act as natural reservoirs. These reservoirs collect snow throughout the fall, winter, and spring. They gradually release this reserved water as meltwater in summer.

Glaciers exert a direct influence on the water cycle by slowing the passage of water through the cycle. Glaciers are excellent storehouses of vast quantities of fresh water. They release this water when it is needed the most, during the hot, dry summer months.

Besides their importance as fresh-water storehouses, glaciers provide important clues to the past. Because of the way glacial ice accumulates and endures, glaciers offer an excellent source of information about Earth's past climates.

**internet connect**

In some areas in the Antarctic, the ice is over 4 200 m thick. Learn more interesting facts about glaciers. Go to **www.discoveringscience8.ca**

### Ice Ages

Over the last several million years, Earth has had at least seven major periods of cooling called ice ages. The most recent ice age began about 120 000 years ago, and ended only 11 000 years ago. During this period, the climate was very different from what it is today. Glaciers covered as much as 28 percent of land on Earth.

During the last ice age, much of North America was as cold as Greenland is today. That means the average temperature was near 10°C. Glaciers covered the land from the Arctic to as far south as below the Great Lakes (see Figure 1.14).

## Glaciers and Global Warming

You have probably heard a lot about global warming. **Global warming** refers to the increase in the average temperatures of Earth's near-surface air and oceans. In the last 100 years, the average surface temperature on Earth has increased 0.5°C. Although that may not seem like very much, it is enough to have an effect on the glaciers and polar ice caps. Most glaciers in the world today are receding, meaning that they are melting and shrinking. For example, the Athabasca Glacier in Alberta has receded 1.5 km since 1843, and it continues to recede today at a record pace. The importance of this cannot be underestimated as the Athabasca Glacier is a key source of water for Alberta, the Prairies, and many states in the western United States.

Although scientists are still studying glaciers to gather as much information from them as possible, there is a general agreement among them that glaciers around the world are melting at a quicker pace than ever recorded before. Scientists are also trying to predict some of the consequences of the shrinking glaciers. Ocean waters may rise, which can be disastrous for coastal communities. As glaciers melt, the water could flood rivers that are important sources of water for people all over the world. If a glacier completely disappears, these crucial rivers would dry up. Because of their importance, glaciers continue to be closely studied and monitored by scientists.

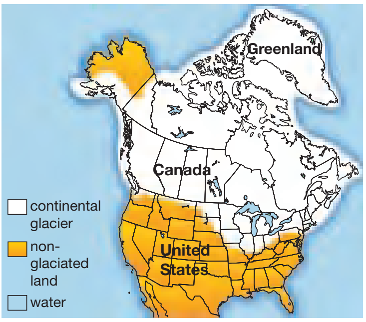



**Figure 1.14** During the last ice age, glaciers in North America covered an area three times as large as they do today. Northern sections of the Yukon and Alaska remained free of glaciers because they were too dry.


**Figure 1.15** Signposts leading up to the Athabasca Glacier show how much bigger the glacier used to be in certain years.

**Suggested Activity**

Find Out Activity 1-3B on page 30.

**Did You Know?**

The Athabasca Glacier is 6 km long and its average width is 1 km. In some places, this glacier is 300 m deep, which is as tall as the Eiffel Tower in Paris.

## Reading Check

1. Name four sources of fresh water on Earth.
2. What is groundwater?
3. How is a glacier formed?
4. When did the last ice age end?
5. How is global warming affecting glaciers?

## Fresh Water System Links

After learning about the different sources of fresh water, it is important to learn how they are all linked together. As you learned with the glaciers, damage to one system can cause damage to another. By understanding these links, we can take steps to try to minimize damage and maintain healthy water systems—for us as well as for other living things.

### Did You Know?

The Churchill River in Newfoundland and Labrador has a drainage basin that is 79 800 km$^2$. That is 20 percent of the province's size!

### Drainage Basins

Water is always on the move in the never-ending water cycle. No matter where a raindrop lands, it will eventually end up somewhere else. The same is true of ice and snow that melts. All fresh water on Earth—whether surface water or ground water —is part of a drainage basin. A **drainage basin**, or watershed, is the area of land that drains into a body of water, such as a river, pond, lake, or ocean. The area of land within a drainage basin can be large or small. Within large drain basins, there are many smaller ones. For example, every stream is part of a large drainage basin. A small stream in your neighbourhood flows until it meets other small streams. The streams join larger rivers. Large rivers merge into major waterways.

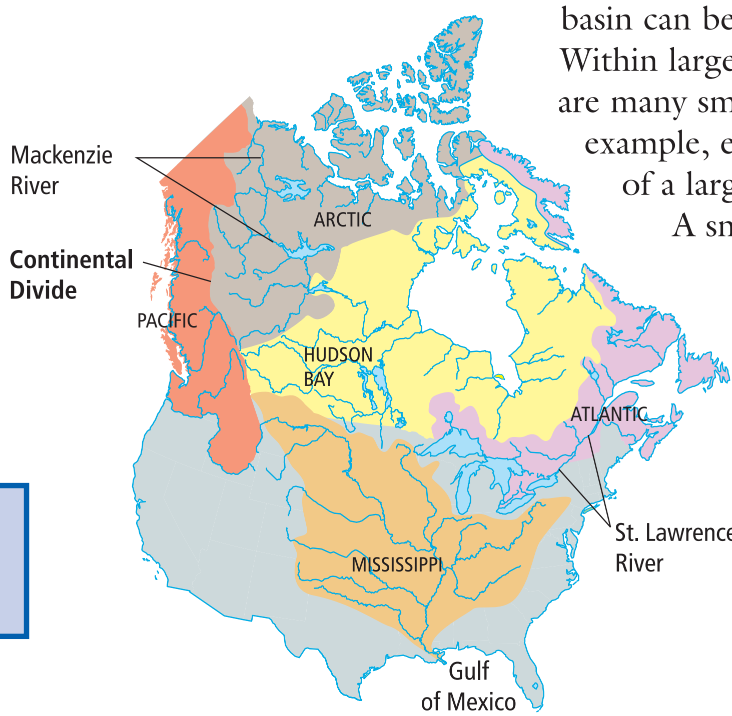



**Figure 1.16** Canada has five major drainage basins. Most precipitation falling on Canada drains into the Pacific, Atlantic, and Arctic Oceans, and Hudson Bay. Interestingly, some of Canada's river water also ends up in the Gulf of Mexico.

### Suggested Activity

Investigation 1-3C on page 31.

What usually separates one drainage basin from another is called a divide, an area of very high ground. The Rocky Mountains are part of a long chain of mountains that extends down the length of North America. These mountains form the Continental Divide that separates the Pacific drainage basin from drainage basins to the east of the Rocky Mountains (Figure 1.16)


**Figure 1.17** Newfoundland and Labrador has 6 major drainage basins. In which drainage basin is your community located?

## Run-off

You may have noticed that after heavy rainshowers, mini-rivers of water wash over sidewalks, driveways, and roads. Where does this vast amount of water go? Some of it evaporates or soaks into the ground, but a lot of it simply flows over the surface of the ground and "runs off" into streams, rivers, other water bodies, and even city sewer systems. Water that does not soak into the ground or evaporate but instead flows across Earth's surface is called **run-off**.

If you overfill a glass of water, the extra water will behave like run-off. It will flow down over the side of the glass and will not stop until it reaches the lowest point that is possible. The force pulling it down to the lowest point is **gravity**, the same force that keeps us on the ground. Under gravity's influence, run-off will flow along the ground until it hits a low point on the surface or finds its way into a stream.

## Factors Affecting Run-off

Run-off is essential for filling the lakes, streams, and rivers that in turn help to keep the oceans filling with water. In this way, run-off plays a vital role in the water cycle. The amount of run-off is higher in some areas than in others. It can also vary in the same area, depending on different conditions. Run-off is affected by the following factors:

- **The nature of the ground material:** If the ground is covered in rock, it will not absorb the surface water easily. This results in an increase in run-off. If the ground is mostly soil, it will be able to absorb water and the amount of run-off will decrease.

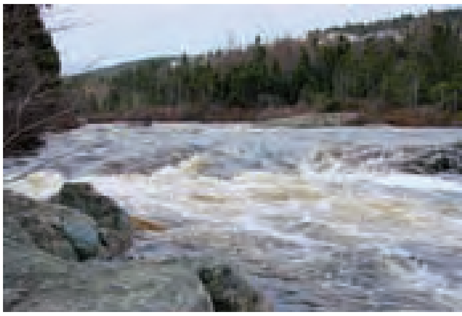


**Figure 1.18** The Humber River rises and flows more quickly in springtime as run-off from the melting winter snow reaches its banks. This water will soon reach the Atlantic Ocean.

- **The amount of rain:** If it rains heavily, the ground may quickly become saturated (it cannot absorb anymore water). This means that the unabsorbed water will become run-off.
- **The length of time it rains:** If it rains for long periods of time, the ground may become saturated, as described above. This results in an increase in run-off.
- **The slope of the land:** The steeper the land is, the faster the water will flow downhill. When water moves too fast, it cannot be easily absorbed into ground. This results in an increase in run-off. Slow-moving water on gently rolling land has more time to be absorbed. This results in a decrease in run-off.
- **The amount of vegetation:** Grass, trees, and shrubs absorb water along with the soil, so areas with little vegetation will have a greater amount of run-off than an area with a lot of vegetation (see Figure 1.19).

**Figure 1.19** When there is little vegetation on a hillside, such as in a clearcut like this, precipitation is not absorbed as quickly and so run-off increases.

- **The amount of development in the area:** Wherever there is a lot of pavement or concrete on the ground, water is usually channelled immediately into storm sewers (see Figure 1.20). This results in an increase in run-off. Areas with little development, and therefore more bare ground to absorb water, will have less run-off.

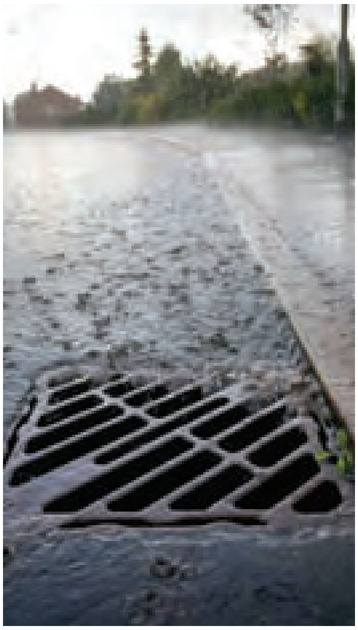


**Figure 1.20** Water pooling in areas of development means that less water will be absorbed into the ground and more will end up in sewers as run-off.

## Reading Check

1. What is a drainage basin?
2. What is the Continental Divide?
3. Explain what run-off is.
4. What force pulls run-off to the lowest possible point?
5. Name four factors that affect run-off.

## 1-3A Tracking Run-off

Find Out ACTIVITY

Whenever people change Earth's surface, they change a natural balance. Therefore, if they are planning a development and want to clear land for it, they must first consider the long-term effects their actions may cause. Imagine you have been hired by a community that has several plans for development in the area shown below. Your job is to review what the community plans to do and help it identify any run-off–related consequences that could result from their development. Here is the list of community plans:

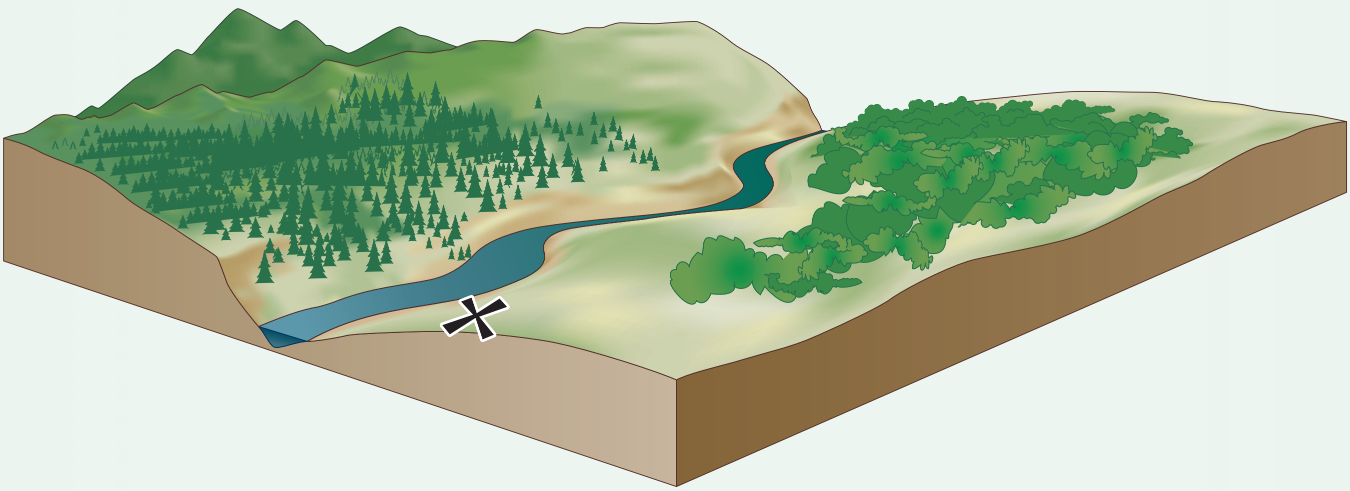
- A small group of houses will be built on the bank of the river, near the area marked with an X.
- The forest on the far slope of the river will be clearcut (entirely logged) and then replanted.
- The bushes to the right of the forest will be removed.
- The area to the bottom right will become a shopping mall with a parking lot.

### What to Do

1. Make a simple three-column table by drawing two lines down a page in your notebook. Print "Proposed action by the community" at the top of the left column, "Possible consequences related to run-off" at the top of the middle column, and "Possible solutions" at the top of the right column.
2. Study the sketch. Fill in your table with any concerns you have about the community plans and how the proposed actions might affect run-off.

### What Did You Find Out?

1. What consequences do you predict if the community goes ahead and carries out all of its plans for development?
2. Should anything in the plan be changed? If so, what, and why would you recommend that it be changed?



# 1-3B How Can Global Warming Be Slowed?

**Find Out ACTIVITY**

Human activities affect the air in our atmosphere. Burning fossil fuels and removing vegetation are examples of two such activities. Both activities add carbon dioxide to the atmosphere and may contribute to global warming. How can we help reduce the amount of carbon dioxide in the atmosphere?

## Procedure

1. In a group, brainstorm ways in which we rely on energy from burning fossil fuels in our community. You might need to do some research in the library or on the Internet.
2. Now brainstorm some ways in which we can change our daily activities to reduce our reliance on energy from burning fossil fuels. (Hint: Think about transportation and how we heat and cool our homes, for example.)
3. Design a brochure or a website informing people about steps we can take in our daily lives to slow down global warming.

## Extension

1. Research what actions people and the government in Newfoundland and Labrador have undertaken to reduce the amount of carbon dioxide in the atmosphere. Prepare a report and share your findings with your class.

What kind of changes in transportation could we make to avoid traffic jams like this and to reduce the amount of fossil fuels that we burn?

# 1-3C How Much Water?

Think About It

Grey River, Newfoundland and Labrador

Study the table below. It lists the sizes of Canada's five major drainage basins and the volumes of water that flow from each river into the oceans. The volume of water flowing from a river into an ocean is called the **mean discharge**.

Canada's Major Drainage Basins

| Drainage | Area ($km^2$) | Mean Discharge (L/s) |
|---|---|---|
| Pacific | 1 009 064 | 24 100 000 |
| Arctic | 3 583 265 | 16 400 000 |
| Hudson Bay | 3 860 136 | 30 900 000 |
| Gulf of Mexico | 26 677 | 25 000 |
| Atlantic | 1 570 071 | 33 400 000 |

## What to Do

Rank the drainage basins in order of

(a) size (area in $km^2$), from 1 (largest area) to 5 (smallest area)

(b) mean discharge, from 1 (largest volume) to 5 (smallest volume)

## Analyze

1. Explain the difference in rankings.
2. To which coastline does most of Canada's water flow—north, east, or west?
3. What percentage of the total flow goes in this direction?

# Science Watch

## Turning on the Fog Faucet

Humans have adapted to living in many difficult environments around the world, from scorching deserts to frigid mountains. In many such places, a serious problem is the lack of a safe water supply. This problem may have developed because people are using existing water sources faster than the supply can be replaced naturally. Other reasons might be that the water has become polluted and unsafe to use, or that the local climate is too dry to produce enough water in the form of precipitation.

Think how convenient it would be if water could be collected from the air as easily as it can be collected when it falls from rain clouds.

At the beginning of this chapter, you learned that the atmosphere contains small amounts of water. A group of clever Canadians has developed ways to "harvest" that water so that it provides a useful supply of fresh water for people living in otherwise dry areas. Working with scientists in Chile (a country that lies along the southwest coast of South America), the non-profit organization FogQuest has designed a system for collecting the small droplets of water that form in the air when water vapour comes in contact with objects. The mist and fog we often see in Newfoundland and Labrador, for example, are really just low clouds of water droplets that have condensed on particles in the air. This may seem like a small amount of water, but it can be collected in reasonably large amounts in areas that often have fog and heavy morning dew.

The fog collectors shown here are large rectangular panels made of nylon netting. The nets are set up so that the moisture-carrying wind hits them directly. Each collector panel measures 2 m by 24 m. As the water condenses on the nets, it drips down along the panel and is collected in a series of pipes and storage tanks. The collectors can be adjusted to suit weather conditions and water needs. The system is simple and easy to set up and maintain, and it does not cost a lot of money to operate. This makes it an ideal way to help people obtain a safe supply of water where it would be too expensive to do so by other methods.

### Questions

1. How do fog catchers work?
2. What climatic conditions would be necessary in order for a fog catcher to be useful?
3. Would producing water from fog catchers be useful in your area? Explain why or why not.

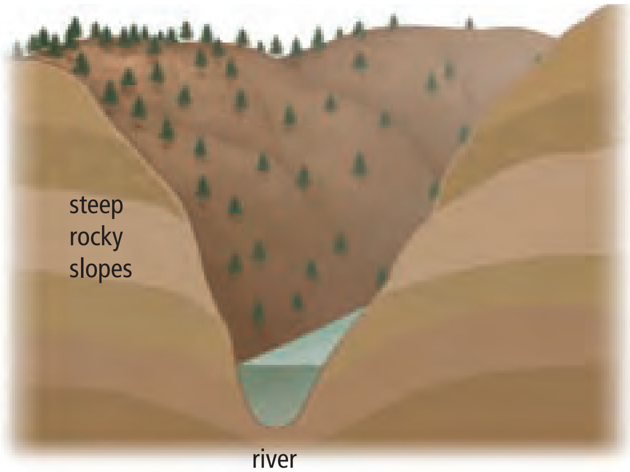
# Check Your Understanding

## Checking Concepts

1. Explain how a glacier is formed.
2. After a heavy rain, you notice a large amount of water flowing down a hillside. What could be a possible explanation for why it has not soaked into the ground?
3. How is run-off an important part of the water cycle?
4. "No matter where a raindrop lands, it will eventually end up somewhere else." What is meant by this sentence?

## Understanding Key Ideas

5. For each of the following activities, state whether the activity would lead to an increase or decrease in the amount of run-off entering the river in the diagram below. Explain your answer.
   (a) planting trees along the slopes
   (b) removing material to make the slopes less steep
   (c) developing the area on one side of the river (for example, building roads and parking lots)




6. Using your knowledge of drainage basins, explain how water pollution in one part of the province could affect water supplies in another part.
7. List three reasons why glaciers are important to all living things.

### Pause and Reflect

Canada has about 1300 glaciers. Since 1850, these glaciers have lost between 25 percent and 75 percent of their mass. The total amount of ground covered by glaciers in Canada is the lowest it has been since the last ice age, 10 000 years ago. How do you think this might be affecting the water cycle? Write a paragraph summarizing your ideas.

# Chapter Review

## Prepare Your Own Summary

In this chapter, you investigated the water cycle and the essential role it plays on Earth. Create your own summary of key ideas from this chapter. You may include graphic organizers or illustrations with your notes. Use the following headings to organize your notes:

1. Water Cycle
2. Differences Between Ocean and Fresh Water
3. Sources of Fresh Water

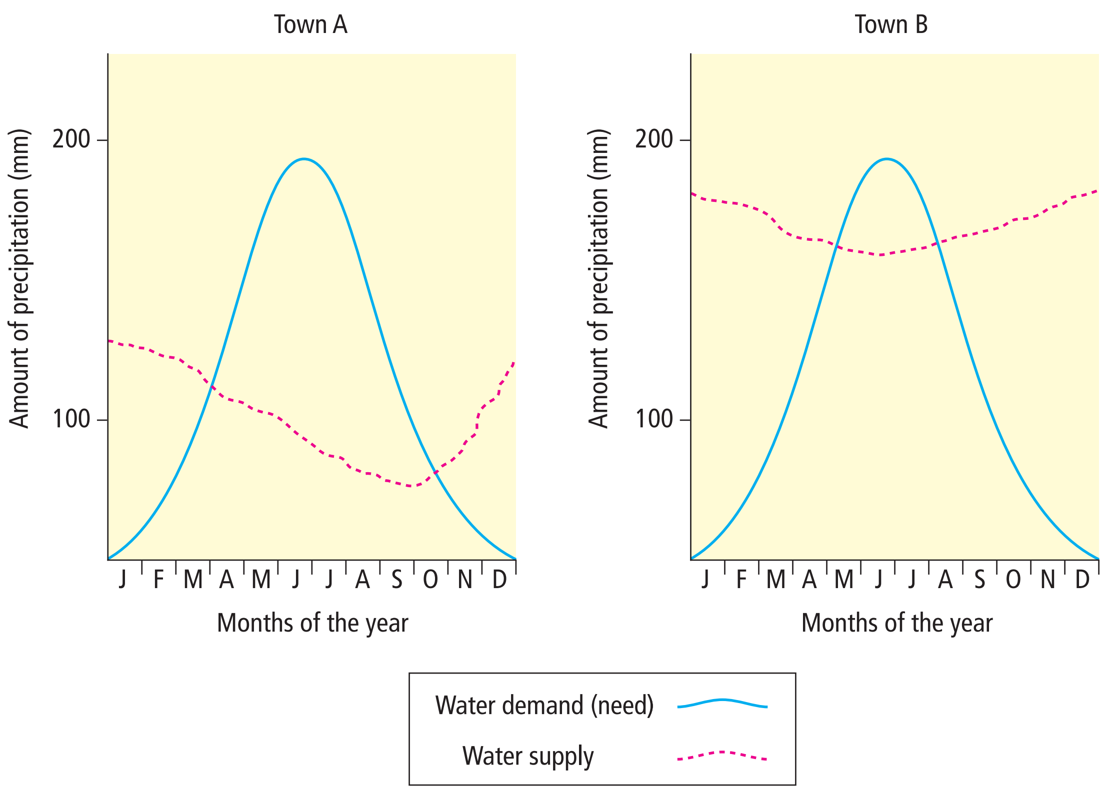
## Checking Concepts

1. (a) What percentage of Earth's surface is covered in water?
   (b) How much of that water is fresh?
2. What supplies the energy for the water cycle?
3. What is the name given to a person who studies water systems and helps solve problems related to controlling the quality and quantity of water?
4. Why is it so easy to float in the Dead Sea?
5. What separates one drainage basin from another?
6. Most of the world's glaciers are receding.
   (a) What does receding mean?
   (b) What effect could this start having on sea level?

## Understanding Key Ideas

7. Make a flow chart to illustrate the events in the water cycle in sequence, beginning with precipitation falling to Earth.
8. Describe how each of the following would affect the local water cycle.
   (a) construction of a large shopping mall
   (b) building a subdivision for 200 houses with families
   (c) logging a large forest in a hilly area
9. When constructing roads in hilly areas, trees and bushes are stripped from steep banks exposing soil underneath. Should these banks be covered with rocks or should plants be used to replace the trees and bushes that were removed? Explain your answer.
10. Why would you want to control the amount of run-off in an area?

11. The graphs below show how much water residents in two different mythical towns take from their water supply (demand) and how quickly each water supply refills from precipitation (recharge).




Analyze the data shown on the graphs and answer the following questions:

(a) Which town will most likely have a shortage of water in the summer? Explain.

(b) When is water demand lowest in both towns? Explain.

(c) (i) At what times does the water supply drop for both towns?
(ii) Why do you think this occurs?

12. Approximately 29 percent of Newfoundland and Labrador's population relies on groundwater as a source of drinking water. With your knowledge of the water cycle, what possible dangers must the government watch out for to keep this water safe?

## Pause and Reflect

Recent climate change around the world is causing areas that are covered in ice to melt at an increasing rate. Large pieces of Antarctic ice are breaking off and floating away from the continent. How could an event like that, so far away, affect Newfoundland and Labrador? Think about all you learned in this chapter and describe as many effects as you can.