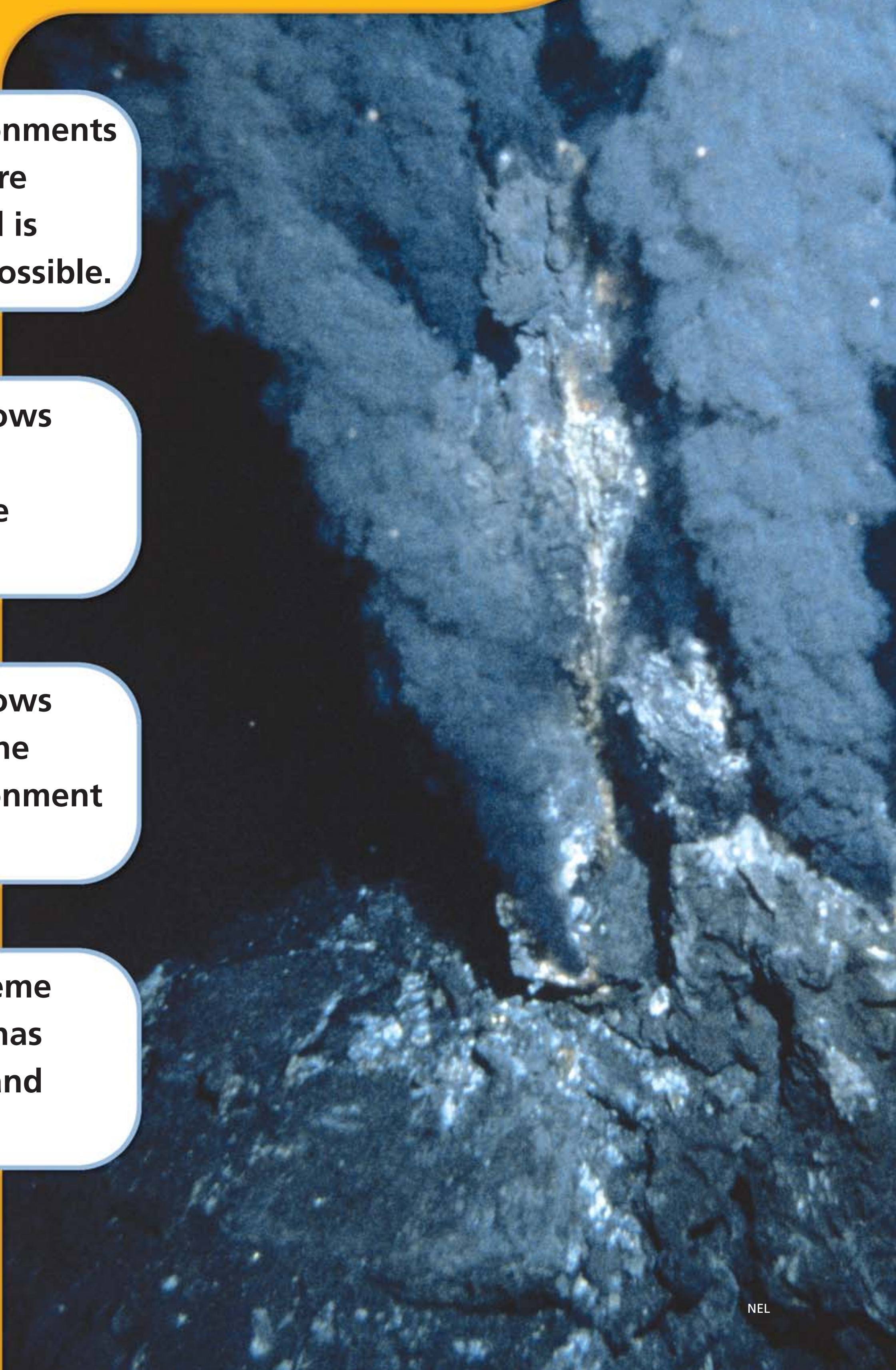
UNIT C

EXPLORING EXTREME ENVIRONMENTS



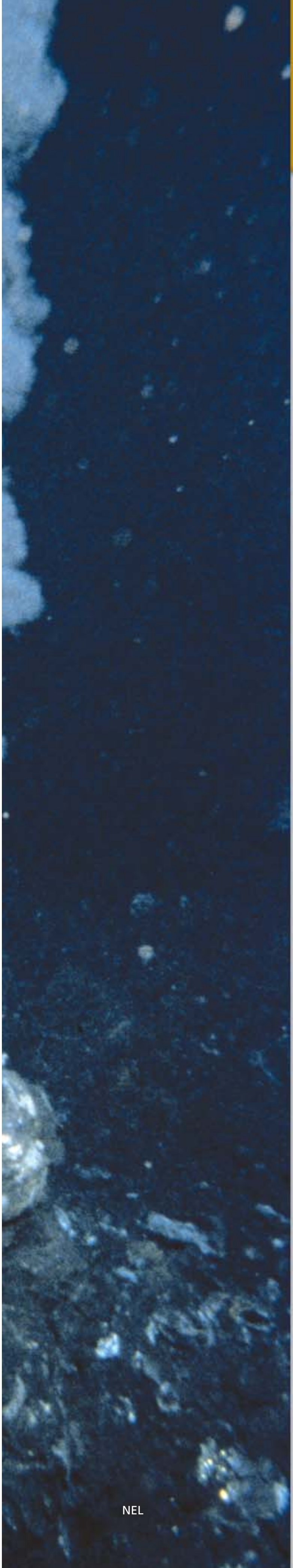
CHAPTER 9
Extreme environments are places where human survival is difficult or impossible.

CHAPTER 10
Technology allows us to explore Earth's extreme environments.

CHAPTER 11
Technology allows us to explore the extreme environment of space.

CHAPTER 12
Exploring extreme environments has both benefits and costs.

Preview



Imagine giant plumes of smoke-like clouds and volcanic ash, towering "black smoker" chimneys spewing black water, and clumps of strange-looking tube worms. These were just three of the spectacles witnessed by two Canadian scientists who were part of an expedition to a chain of underwater volcanoes, called the Ring of Fire, in the Pacific Ocean. The international expedition used a Canadian-made submersible to explore the marvels of deep ocean volcanoes. What they discovered astounded them—spectacular creatures and sights that had never been seen before, including an underwater volcano erupting. According to one of the scientists, "We all sat there for five minutes saying 'Wow, this is really cool,' until someone said, 'I think it's erupting!' When they called this trip an exploration, they weren't kidding."

The depths of the oceans are just one of the extreme environments—on Earth and beyond—that scientists explore. In this unit, you will learn about these environments, what makes them "extreme," and the reasons people explore them. You will learn about the technology that allows people to explore places where survival is difficult or impossible, and the important role of Canadian scientists in developing and testing exploration technology. In addition, you will also do some exploring yourself, using your scientific skills to observe, record your data, and make decisions about what you discover—just the way scientists do.

TRY THIS: THINK ABOUT EXTREME ENVIRONMENTS

Skills Focus: questioning, communicating

Working in a group, choose an environment that you think is extreme. The environment could be a polar region, a desert, a volcano, the deep ocean, or outer space.

1. Brainstorm what you already know about this environment and what you would like to know. Use questions like these: What makes survival difficult in this environment? How are scientists able to explore this environment? How do they use technology?
2. Create a concept map of your ideas. Use words or pictures, or both to summarize what you know and what you would like to learn about the environment.

"Black smoker" chimneys on the floor of the South Pacific Ocean.

CHAPTER 9

Extreme environments are places where human survival is difficult or impossible.

KEY IDEAS

- Living things can inhabit extreme environments.
- Extreme environments include polar regions, deserts, oceans, volcanoes, and space.
- People explore extreme environments to find resources and to better understand our world.
- Technology allows humans to survive in extreme environments.

Earth may be the only place in the universe that can support life, but it is not actually a very welcoming place for humans. Most of the planet is covered with vast oceans. Of the part that is land, large areas are either too cold or too hot for humans to survive easily.

However, people do live in places where survival is difficult, such as deserts and the Arctic. Scientists live in research stations in the extreme conditions of Antarctica, shown above. People have even explored uninhabitable areas, such as volcanoes, oceans, and outer space. Humans have been able to explore and settle in environments far beyond where they could survive unaided because they have developed the technology to overcome the obstacles to survival.

In this chapter, you will learn about extreme environments. You will learn why people explore these environments and how people use technology to survive extreme conditions. You will even get to plan your own extreme expedition!

What Are Extreme Environments?

9.1

TRY THIS: DESCRIBE YOUR ENVIRONMENT

Skills Focus: observing, inferring

How hot does it get in summer where you live? How cold does it get in winter? Your answers describe the extremes of temperature in your environment. But what would happen if the temperatures became even more extreme?

1. Describe how hotter or colder temperatures would affect the way you live. Think about the effect on your outdoor activities, the clothing you would need, and the home you live in.
2. What would you and your community have to do to adapt to the changes in temperature?

You are surrounded by your **environment.** Other living organisms, non-living objects, such as soil and buildings, and even the weather all make up your environment. To survive, you, like all living things, must be able to meet your basic needs for water, food, air, and shelter within your environment (**Figure 1**).

Figure 1
Winter can be severe in the northern town of Stewart and other parts of British Columbia. However, people survive extreme temperatures by building structures that withstand the cold and snow, and by wearing protective clothing.

LEARNING TIP

Review this section to identify the main ideas. Can you identify the most important idea? If anything isn't clear to you, reread the section.

Some environments have very harsh conditions. They may be extremely hot or extremely cold, there may be no water, or there may be no air to breathe. These **extreme** conditions make it difficult, and in some cases impossible, for humans to survive. For humans, these are **extreme environments.**

However, not all organisms need the same living conditions as humans do. Living things are found everywhere on Earth—in the hottest deserts, in the coldest oceans, and even deep inside Earth! There are heat-loving bacteria that thrive in hot springs and volcanoes. Many organisms, including fish and giant squid (**Figure 2**), are found in the deep sea. In fact, scientists recently discovered 38 000 new species of ocean life in just four years of research!

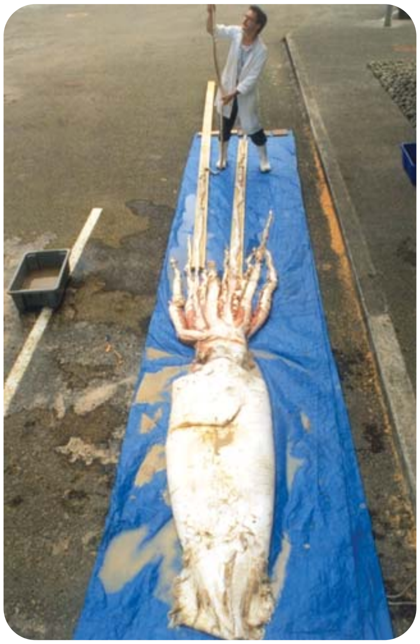


Figure 2
Scientists recently discovered a giant squid, nicknamed "Colossal Squid," living deep in the ocean. It weighed over 150 kg and was over 5 m long.

These organisms can survive conditions that are considered extreme for humans because they have adapted to the conditions. Obviously, to these organisms, the conditions are not extreme, but are just right.

CHECK YOUR UNDERSTANDING

1. What makes an environment extreme?
2. What conditions would make life difficult or impossible for humans to survive?
3. Why can some bacteria live in volcanic vents?

The Extreme Environments of Earth and Beyond

9.2

For humans, an extreme environment is a place where the conditions are so harsh that human survival is difficult or impossible. Polar regions, deserts, oceans, volcanoes, and space are examples of extreme environments. Although each environment is different, they are all characterized by extreme conditions, such as very hot or very cold temperatures, little or no water, crushing pressure, or no air.

Figure 1 is a map of the world showing the locations of extreme environments.

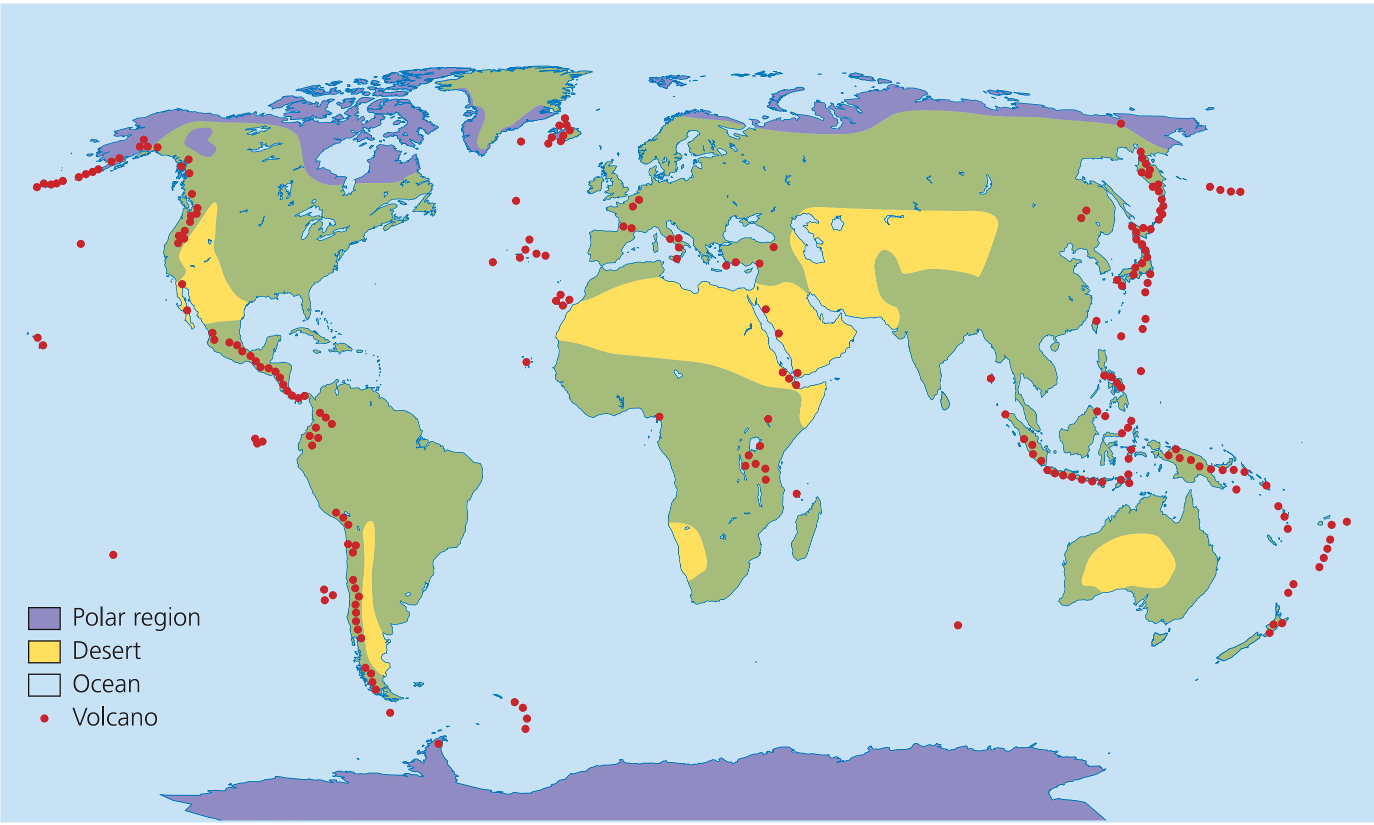


Figure 1
Polar regions (in purple), deserts (in yellow), oceans (blue), and volcanoes (red dots) are extreme environments.

LEARNING TIP

Look through the headings in this section. Before you read the section, predict what makes each of these environments extreme.

Polar Regions

There are two polar regions: the Arctic and Antarctica. The Arctic is the cold area around the North Pole. It includes the Arctic Ocean at the centre and the land that surrounds the Arctic Ocean. It is usually identified as the area north of the Arctic Circle. The average annual temperature is 0 °C. The Arctic is home to many animals, such as polar bears, arctic foxes, arctic wolves, walruses, seals, and whales. These animals have developed adaptations to the frigid conditions. People, such as the Inuvialuit [in-oo-vee-AL-oo-it], also live in the Arctic (**Figure 2**). They have survived by developing the technology to protect themselves from the extreme cold.

Figure 2
The town of Inuvik, Northwest Territories, is the largest town north of the Arctic Circle. The extreme minimum temperature is −56.7 °C. Inuvik receives 56 days of total sunlight in summer and 30 days of total darkness in winter.

Antarctica is a continent that is located almost entirely within the Antarctic Circle. It is the coldest, highest, and windiest place on Earth, and holds the record for the coldest temperature: −89.2 °C. Since Antarctica is mostly covered with ice, most of the animals that live on land are microscopic animals and insects. The penguins that live on the coasts are the one exception. In comparison to the land, the ocean surrounding Antarctica supports a wide variety of life, such as zooplankton [ZOE-eh-PLANK-tuhn], penguins, seals, whales, and dolphins. Antarctica is the only continent that has no permanent population of humans. However, scientists from all over the world, including Russia, Japan, the United States, Australia, and New Zealand, work and live in scientific stations in Antarctica.

Deserts

Deserts are very dry areas that get less than 25 cm of rain a year (**Figure 3**). Most people think that deserts are hot places, but deserts can also be very cold. Both the Arctic and Antarctica are deserts. The Atacama desert in Chile is the driest place on Earth. It receives less than 0.01 cm of rain per year. Some deserts are sandy, but most are wildernesses of rock and stone. Animals and plants that live in deserts have special adaptations that allow them to survive, despite the lack of water. People also live in some deserts. For example, the Afar people of Ethiopia, Africa, live in one of the hottest place on Earth, where temperatures are between 35 °C and 40 °C year-round. The living conditions are harsh, but the Afar have found ways to survive.

Figure 3
The "Pocket Desert" near Osoyoos, in the South Okanagan Valley, British Columbia, gets less than 20 cm of rain a year. About one-fifth of Earth's land surface is desert.

Oceans

Most of Earth's surface (about 71%) is covered by oceans. Even though people can travel on the surface of the ocean, the deepest parts of the ocean are very hard to explore. The ocean depths are pitch black. There is no air to breathe, and the crushing pressure increases the deeper you go. **Figure 4** shows some of the amazing creatures that live in the ocean depths.

Figure 4
Life near thermal vents in the Mariana Trench, the deepest part of the ocean. This photo was taken by ROPOS, a Canadian robotic submersible.

Volcanoes

Volcanoes are vents in Earth's surface where molten rock from below the surface can rise up and spill over (**Figure 5**). Volcanoes are particularly dangerous because they are unpredictable. Some volcanoes are dormant, or sleeping, and do not erupt. Active volcanoes produce hot lava, steam, and ash, which can destroy the surrounding area. Today, there are over 1000 active volcanoes on land and many more in the oceans. Volcanologists study volcanoes to predict when they may erupt and to understand what causes them to erupt.

Figure 5
Kilauea, in Hawaii, is the world's most active volcano. Lava erupts frequently, which poses a danger to the surrounding area and the people who live there.

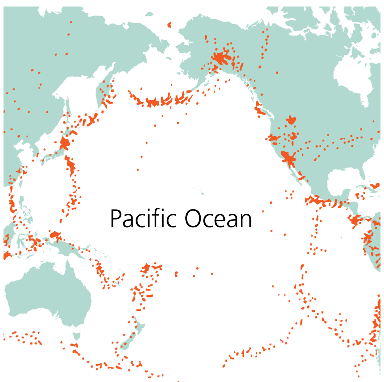


Figure 6
Ring of Fire

Volcanoes are located in specific parts of the world. One of the most important areas that scientists are exploring is a chain of volcanoes that encircles the Pacific Ocean. This chain is known as the Ring of Fire (**Figure 6**). Indonesia has the most active volcanoes. Scientists believe, however, that there are probably more volcanoes on the ocean floor than there are on land.

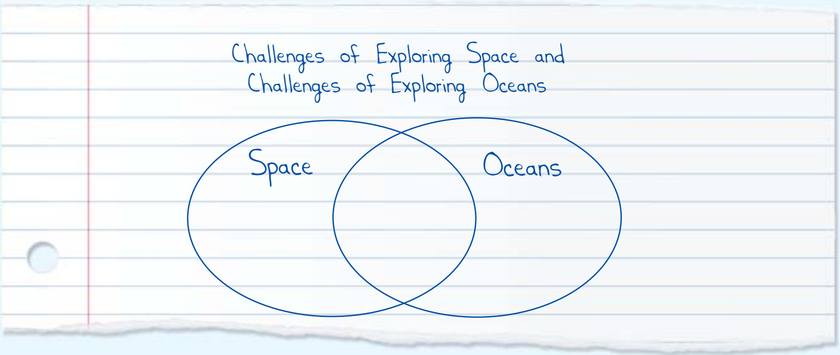
Outer Space

For centuries, people have looked up into the sky and imagined travelling through space (**Figure 7**). Space is the region beyond Earth's atmosphere [AT-muhs-FEAR]—the ultimate extreme environment. The temperatures are *really* extreme—from boiling hot in the light of the Sun to freezing cold in the shadow of Earth—and there is no air to breathe. As well, space is close to a vacuum. Space contains atoms and particles of dust, but they are spread so thinly that space is considered to be empty.

Figure 7
People have always wondered about what is in space. However, it is only in the past 50 years that people have been able to travel to and survive the extreme conditions of space.

CHECK YOUR UNDERSTANDING

1. What are some characteristics of an extreme environment?
2. What is the main characteristic of a desert? Is a desert always a hot place? Explain why or why not.
3. Why do oceans present such a challenge for human exploration?
4. Create a Venn diagram to compare and contrast the challenges of exploring in space with the challenges of exploring the oceans.



5. Choose one extreme environment. Discuss the conditions in this environment that affect human travel.

9.3 Why Do People Explore Extreme Environments?

LEARNING TIP

Before you read section 9.3, see if you can answer the question in the title at the top of the page. As you read, check to see if your answer was correct.

Why would anyone want to go to the cold polar regions, hot deserts, deep oceans, dangerous volcanoes, or even space? After all, these are harsh places for humans to live. But as long as humans have existed, they have gone on **explorations,** or voyages into unknown territory to investigate new frontiers and to search for new discoveries. Let's look at some of the reasons people explore extreme environments.

Exploring to Find New Places to Live

As populations grew, ancient peoples explored to find new places to live. They also explored to find food, water, and other resources. Today, people explore to learn about the world and the universe, rather than to find a new place to live. However, some scientists and politicians talk about having a human colony on the Moon or Mars some day.

TRY THIS: LOOK AT KWADAY DAN TS'INCHI

Skills Focus: observing, inferring

Ancient peoples faced danger when they travelled away from their home settlements. In 1999, the frozen remains of a male Aboriginal, from about 500 years ago, were discovered in a glacier in British Columbia. The discovery was named Kwaday Dan Ts'inchi, which means "long ago person found" in the Southern Tutchone language. Scientists and members of the Champagne and Aishihik First Nations are studying the remains and the items that were found with him. These items include a carved walking stick, a knife-like tool in a hide and fur sheath (**Figure 1**), a fur robe, a woven hat, a bead on a thong, and dried salmon.

1. Look at the list of items that were found near the frozen remains of the long ago person. What do you think he was doing? What are some of the dangers he might have faced?
2. Why would dried salmon be a good thing to carry?
3. What can we learn from the man's possessions?

Figure 1
This knife-like tool was found with Kwaday Dan Ts'inchi, along with the hide and fur sheath that held it.

Exploring to Understand Our Past

We explore extreme environments to learn about our history, the history of other living things, and the history of Earth itself. For example, deep-sea divers look at the remains of shipwrecks (**Figure 2**). Paleontologists [PAY-lee-on-TALL-uh-jist] look for fossils of extinct creatures. Archeologists [ARE-key-ALL-uh-jist] study ancient civilizations to understand how people lived in the past. Scientists study the layers of ice in Antarctica to learn how Earth's atmosphere has changed over time.

Figure 2
A diver explores a shipwreck off the coast of Florida.

Exploring to Find New Plants and Animals

When explorers travelled to new lands, they often found plants and animals that were different from the plants and animals at home. Today, we explore extreme environments to discover new species of plants and animals. For example, scientists have discovered new species of corals and sponges on the ocean floor (**Figure 3**). Scientists have also discovered life in volcanic vents, in hydrothermal vents on the ocean floor, and in desert rocks.

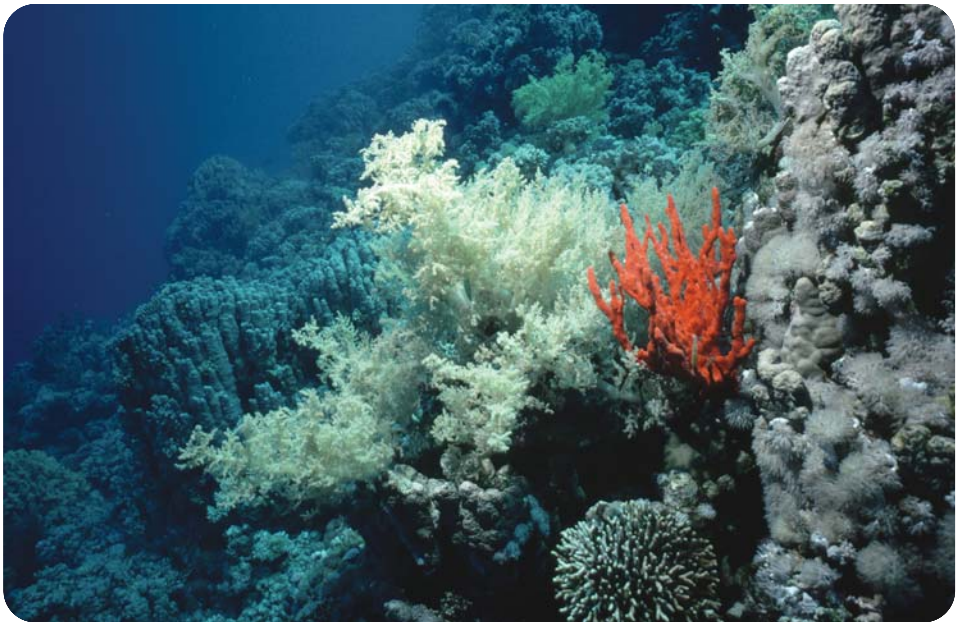


Figure 3
Scientists hope that species of sponges and corals, newly discovered on the ocean floor, may be used to develop medicines to treat human diseases.

LEARNING TIP

Some terms in this unit, like *fossil fuel* and *insulator*, are used in other units in this book. Use the index at the back of the book to find other mentions of a word. Or look the word up in the glossary if it is defined in another unit.

Exploring to Find Resources

The ocean beds contain vast reserves of fossil fuels, such as natural gas and oil (**Figure 4**). We use fossil fuels to power our cars, heat our homes, and produce electricity. Because the current reserves of fossil fuels are running out, scientists are looking for new reserves. Ocean exploration has led to the discovery of fossil fuel reserves beneath the ocean floor. The Arctic is another environment that is being explored for its fossil fuel reserves.

Figure 4
Semi-submersible oil rigs, like this one in Hibernia, are used to drill for oil in the ocean floor.

Exploring to Understand and Protect Our World

In the past, explorers searched for new lands and easier sea routes. Today, people explore to understand and protect our world. For example, scientists have been able to track elephants moving through the Sahara Desert using satellite images (**Figure 5**). They have learned that these elephants survive the hot, dry desert by moving from one watering hole to the next at just the right time. Scientists can use this knowledge to protect the elephants.

Figure 5
By tracking the movements of these elephants through the desert, scientists can learn how to protect them.

CHECK YOUR UNDERSTANDING

1. Why did ancient peoples explore?
2. Use a Venn diagram to compare the reasons why ancient peoples explored with the reasons why people explore today.
3. Give an example of how satellite images can help scientists protect endangered animals.
4. Work with a partner to brainstorm a list of explorations you know about from previous learning. In each case, try to identify the reason for the exploration.

9.4 Using Technology to Survive

Humans do not have the adaptations that allow other organisms to survive extreme environments. Instead, humans have developed the tools, or the **technology,** to make it possible to survive in challenging environments. For example, Aboriginal peoples have used technology for thousands of years to survive the challenging conditions in the northern areas of Canada.

Let's take a closer look at some of the ways that the Inuit were able to survive in the extreme conditions of the Arctic.

Snow Houses


Figure 1

The Inuit snow house is an engineering marvel (**Figure 1**). It was constructed in the form of a dome, using blocks of snow. To make sure that the snow was strong enough to be cut into blocks and stacked, the Inuit tested it using a long probe made of antler. A snow house had a fireplace in the centre, surrounded by sleeping platforms. It also had a window to let in sunlight. The floor and living areas were covered with animal skins, making them warm and comfortable. Today, some Inuit still build and live in snow houses for a short time.

Snow Sleds


Figure 2

The best way to travel across ice and snow is to use a komatik [COME-uh-tick], or Inuit sled (**Figure 2**). A komatik could carry an entire household to better hunting and fishing grounds. Traditional komatiks were made of wood and hide, and were pulled by dogs. Modern komatiks are made of metal and plastic, and are pulled by snowmobiles.

Snowshoes


Figure 3

Have you ever tried to walk in deep snow? You probably did not get very far before you sank! Aboriginal peoples invented snowshoes, which allowed them to travel on top of the snow rather than through it (**Figure 3**). Snowshoes spread the wearer's weight over a large area so that the wearer does not sink into the snow. Snowshoes were originally made from bent pieces of wood, with crisscrossed pieces of animal hide. Today, many snowshoes are made using a metal frame.

Parkas

The Inuit understood the way that heat moves and designed their clothing to protect them from very cold temperatures. They made clothing from animal hides and fur. They wore parkas—tight-fitting, double-layered, hooded jackets—to prevent their body heat from escaping into the icy environment (**Figure 4**). Inuit garments were tight around the neck and waist to prevent heat loss, but were open at the bottom. This opening allowed moist air to escape and prevented the wearer from getting sweaty.

Figure 4

Sunglasses

The glare from the Sun, as it reflects on the snow, is very intense. Without protection, human eyes can be damaged, causing temporary "snow blindness." Aboriginal peoples used a piece of bone with a small slit as sunglasses (**Figure 5**). Although low tech compared with the sunglasses used today, these sunglasses reduced the amount of light that entered the eye.

Figure 5

Oil Lamps

Aboriginal peoples of the Arctic have been making oil lamps out of soapstone for at least 2500 years (**Figure 6**). The oil lamp was usually one metre long. It burned oil from melting blubber and used a dried grass wick. The oil lamp had a huge impact on life in the Arctic because it provided light during the winter darkness. It also provided heat for soapstone cooking pots.

Figure 6

CHECK YOUR UNDERSTANDING

1. Why was the invention of the komatik important to the exploration of the Arctic?
2. How does wearing snowshoes prevent you from sinking into deep snow?
3. What extremes in the Arctic environment have the Inuit overcome with technology?

9.5 Solve a Problem

Figure 1
Michael Schmidt is a scientist who works in remote places, such as the top of Mount Logan in the Yukon Territory. He sets up Global Positioning System (GPS) receivers to study and learn about earthquakes. GPS receivers work with satellites that revolve around Earth. They can locate where something is on Earth, within a few metres.

Planning for an Extreme Environment Expedition

Problem

You are part of a team of scientists that will join Dr. Schmidt on a 30-day expedition to Mount Logan (**Figure 1**). Mount Logan is 5959 m high. It is Canada's highest peak and the second highest peak in North America. What will you need to take on your expedition?

LEARNING TIP

For a review about solving a problem, see the Skills Handbook section "Solving a Problem."

Task

Create a list of items you will need for your expedition.

Criteria

You need air, warmth, food, and water. To be successful on your expedition, your list must include

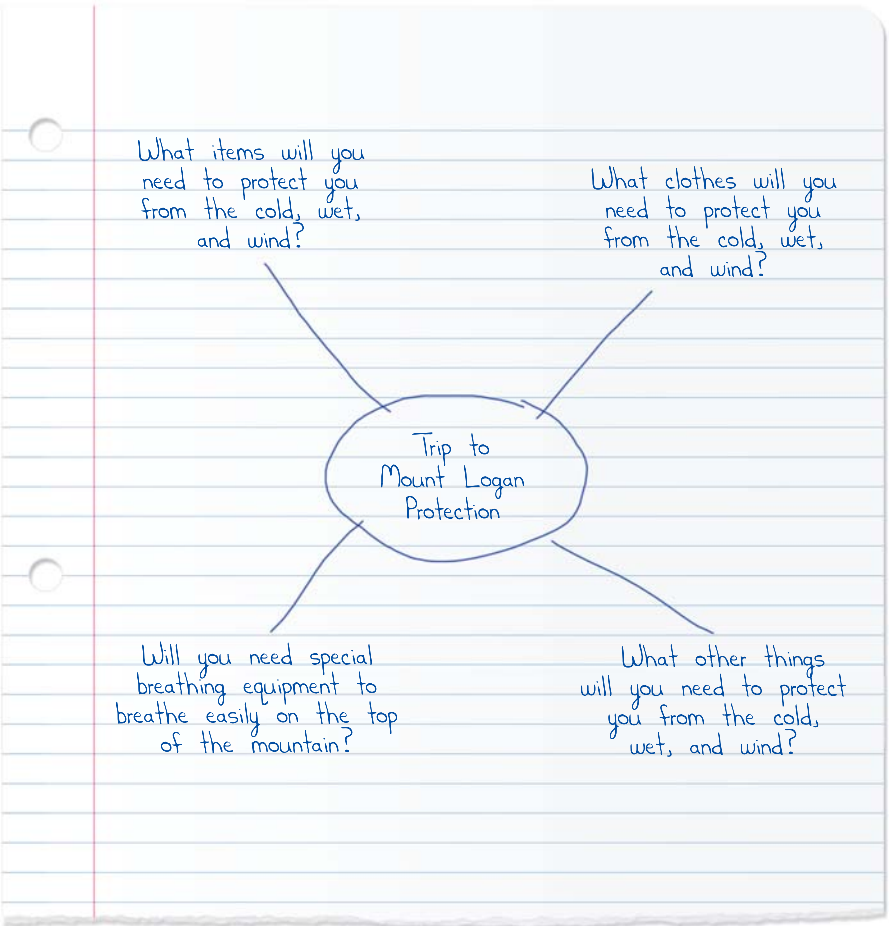
- equipment to help you breathe at the top of the mountain where the air is thinner
- ways to protect yourself from the cold, wet, and wind
- food and water, as well as ways to cook the food
- ways to transport yourself and any equipment you may have
- equipment for communication

Plan and Test

1. You will work in teams of four. Each member of your team will list the items needed for one of the four needs below.

- *Protection:* What clothes or items will you need to protect you from the cold, wet, and wind? Will you need special breathing equipment to breathe easily on the top of the mountain?
- *Energy:* What food and water will you need? What equipment will you need for cooking?
- *Transportation:* How will you carry all your equipment?
- *Communication:* What equipment will you need for communicating with other scientists and your family?

2. Create a word web like the one below for your portion of the travel plan.



LEARNING TIP

Word webs are a type of concept map. Think about other ways you could organize your ideas about the items you need for your expedition.

3. Use your web to make a list of things you will need.

4. Find a partner on another team who is working on the same topic. Compare your lists. How are your lists similar? How are they different?

Evaluate

5. Together, make a new list that combines the best of your two lists.

Communicate

6. Gather with your original team members. Share your lists (**Figure 2**). Put together all four lists of things needed for the expedition.

Figure 2
This group of students used their lists to develop a dramatization of an expedition to Mount Logan.

CHECK YOUR ***UNDERSTANDING***

1. Did comparing your list with your partner's help both of you to make a better list? Why or why not?

2. What are the benefits and challenges of working in groups in science? Do you think scientists face the same challenges and experience the same benefits? Why or why not?

3. In this activity, you made decisions about the types of equipment you would need for an expedition. When you make a decision, there is always more than one option you must consider. Why is it important to think about the consequences of each option before making a decision? What can happen if you make a decision without thinking about the consequences?

A Cool Job

How would you drill through thick glacier ice to reach the rock surface below? This was a problem that Dr. Garry Clarke, a glaciologist, and his team had to solve while studying Trapridge Glacier in the Yukon Territory.

To drill a hole in the ice, the team changed a carpet steam-cleaner into a hot-water drill (**Figure 1**). The team placed sensors in the hole to measure how fast the glacier was moving and how it moved over the land. The sensors were connected to data loggers that recorded data. The data loggers were powered by solar panels.

Figure 1
This hot-water drill can make a 70-m deep hole in the ice in about one hour.

Dr. Clarke's team lived beside the glacier for one month (**Figure 2**). Because the glacier is hundreds of kilometres from the nearest settlement or road, the team needed to bring all their supplies. They brought clothing, food, tents, fuel, safety equipment, communication equipment, and all the scientific equipment for their investigations.

Figure 2
This camp is where the members of Dr. Clarke's team cook their food and store their portable computers. They also wash their laundry and hang it to dry.

Dr. Clarke hopes that looking through a hole in the ice will help him learn what Canada was like during the Ice Age and how our climate is changing today.

These are just some of the things that a glaciologist does. Find out more by doing an Internet search. Share what you learn with your classmates.

www.science.nelson.com GO

9 Chapter Review

Extreme environments are places where human survival is difficult or impossible.

Key Idea: **Living things can inhabit extreme environments.**

Giant squid live in the deep ocean.

Vocabulary

environment p. 165

extreme p. 166

extreme environments p. 166

Key Idea: **Extreme environments include polar regions, deserts, oceans, volcanoes, and space.**

Polar regions

Deserts

Oceans

Volcanoes

Space

Key Idea: **People explore extreme environments to find resources and to better understand our world.**

We explore to find resources.

We can learn to understand the world.

Vocabulary

explorations p. 172

Key Idea: **Technology allows humans to survive in extreme environments.**

Snow houses and komatiks are just two examples of Aboriginal technology.

Vocabulary

technology p. 176

Review Key Ideas and Vocabulary

When answering the questions, remember to use the chapter vocabulary.

1. Give five examples of living things that inhabit extreme environments.
2. Give an example of an extreme environment, and then explain what makes this environment extreme.
3. Describe all the reasons why people explore extreme environments.
4. List two resources that have been found in extreme environments.
5. Give six examples of technology that enabled Aboriginal peoples to survive in the Arctic.

Use What You've Learned

6. Why was finding the frozen remains of Kwaday Dan Ts'inchi helpful to scientists and members of the Champagne and Aishihik First Nations?
7. Scientists tell us that the temperature in the Arctic has been rising in the past few years. This is causing the sea ice to melt and affecting the lives of the organisms that live in the Arctic, including humans. Imagine that you are part of a Canadian scientific exploration team that is studying the changing Arctic temperature. Work in a group to brainstorm some questions that the exploration team might want to answer.

Think Critically

8. In the past 20 years, what new technology do you think has most drastically changed our world? You may want to use the Internet to research important inventions. Defend your choice.

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9. Why do you think a changing climate would force people to move?

Reflect on Your Learning

10. What are the benefits and challenges of working in collaboration with other scientists, as you did when planning an expedition to Mount Logan?

11. What is the most important idea you learned about extreme environments? Explain why you think this idea is important.

CHAPTER 10

Technology allows us to explore Earth's extreme environments.

KEY IDEAS

- Technology allows us to navigate Earth's extreme environments.
- Technology allows us to survive extreme temperatures.
- Technology allows us to explore the ocean depths.
- Canadians make important contributions to ocean exploration.

Earth's extreme environments are some of the most fascinating places for humans to explore. But just getting to these places can be difficult and dangerous. Surviving once you're there can be just as challenging, if not impossible.

Humans do not have the adaptations that allow some organisms to survive extreme conditions. Instead, we rely on technology to make possible things that would otherwise be impossible—things like exploring an erupting volcano (as shown in the above photo), living in the frigid cold of Antarctica, or travelling to the deepest ocean depths. In this chapter, you will look at the technology that allows humans to travel to and survive in Earth's extreme environments.

Finding Our Way

10.1

Early peoples and explorers used the Sun and stars to guide them on their journeys. For example, the Inuit relied on their detailed knowledge of the night skies and the position of the Sun to help them navigate. After the compass was invented, explorers used it to find out where they were. Today, people use technology, such as radar, satellites, and sonar, to explore and navigate extreme environments.

TRY THIS: USE RADAR TO "SEE"

Skills Focus: creating models, measuring, inferring

In this activity, you will use the concepts of radar to find out the shape of an object in a box. Your teacher will give you a box that has a grid taped to the top. Inside the box is an object. Working in a group, use a nail to poke a hole through the grid. Then use a wooden skewer to probe for the object. When you feel the skewer touch the object, stop and measure the distance, in centimetres, from the top of the box to the end of the stick as shown in **Figure 1**. Record the distance in a table. Repeat this process until you have recorded all the measurements.

Figure 1

1. Create a graph or contour map of your data. If you have access to a computer, you can use a spreadsheet program to create a surface graph.
2. Based on the picture you created, what object is inside the box?

LEARNING TIP

Pause after each paragraph on this page and see if you can define the highlighted word in the paragraph.

Radar, which stands for **ra**dio **d**etection **a**nd **r**anging, uses radio waves to help people explore. Radio waves are invisible waves that carry voices, music, pictures, and signals through the air. A radar set picks up any echoes that are bounced back off an object and uses the echoes to tell the distance, speed, direction of motion, and shape of the object. Radar systems are used on boats and ships to search for land, ice, and other boats or ships.

Satellites use radar to relay signals for cell phones and television signals. A **satellite** is an object in space that revolves around Earth or any other planet. One of the most important satellite technologies that is used today, for both land and sea navigation, is the Global Positioning System, or GPS. GPS has 24 orbiting satellites that send out radio signals. The boat in **Figure 2** has a GPS receiver that can detect these signals. Signals from three satellites are used to tell exactly where the boat is and how fast the boat is moving. GPS is a good navigation system for environments, such as oceans and deserts, that have few features to use as a reference point. GPS is used in cars, boats, helicopters, ships, submarines, and airplanes, as well as in small handheld receivers that are carried by hikers and explorers.

LEARNING TIP

Look closely at **Figure 2**. Then reread the paragraph above it. Now look again at each part of the diagram and check that you understand what it shows about how GPS works.

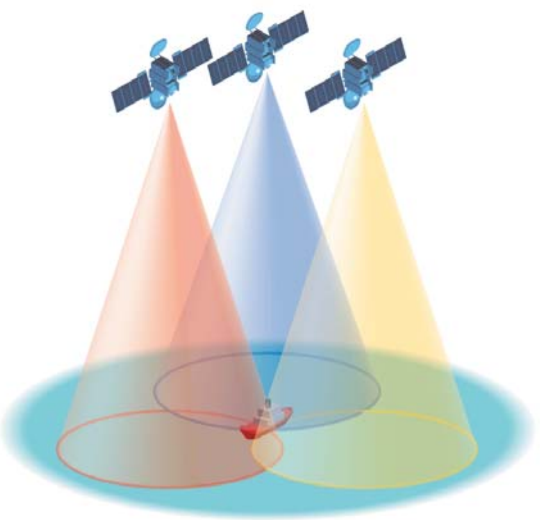


Figure 2
Using radar, GPS satellites can pinpoint the exact location of this boat.

Did you know that ships use sound to chart the depths of the oceans? **Sonar,** which stands for **so**und **na**vigation and **r**anging, works by using the echoes of sound waves. First, a device sends a sound wave into the ocean. The sound wave bounces off the ocean floor. This creates an echo, just like when you shout into a canyon or an empty room. A receiver on the ship can figure out how far away the ocean floor is by measuring the time it takes for the echoes to return to the ship (**Figure 3**).

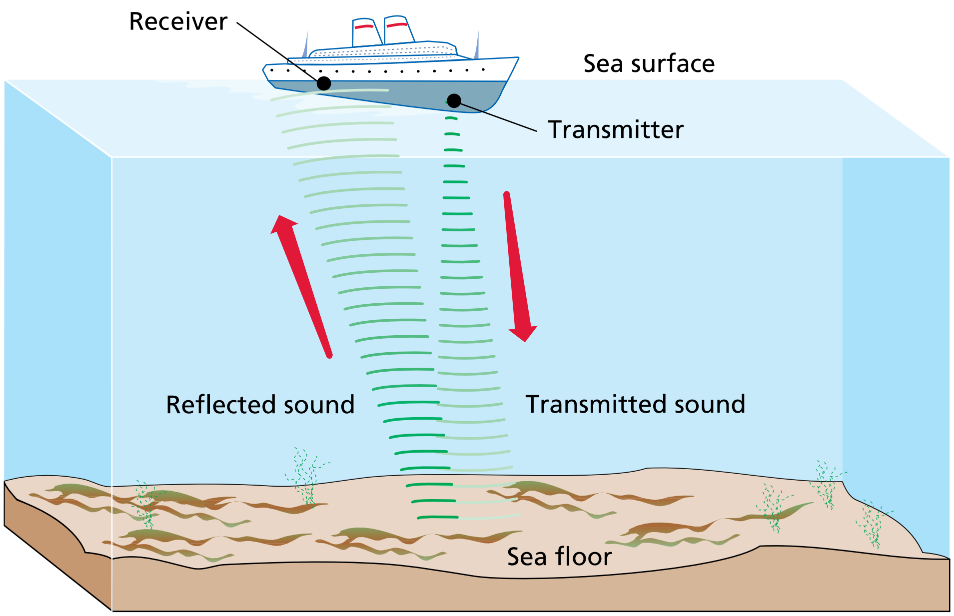


Figure 3

A sonar transmitter underneath a ship sends sound waves down through the water. The time it takes for the sound waves to bounce off the floor and back to a receiver on the ship is used to figure out the depth of the ocean and to create maps of the ocean floor.

Sonar is used to map the ocean floor and to determine the locations of underwater objects—from shipwrecks to submarines. As well, sonar is used to help ships and submarines navigate through shallow and rocky waters.

CHECK YOUR UNDERSTANDING

1. What does the word "radar" stand for? How does radar work?
2. Compare the GPS system with the navigation systems of the Inuit.
3. Why is GPS such a valuable technology for explorers to use?
4. How is GPS used in everyday life?
5. Bats and dolphins use a technique called echolocation to navigate and to locate prey. They emit sounds and listen for the echoes. Explain how echolocation is similar to sonar.

LEARNING TIP

Look at the highlighted words *sonar* and *radar*. They are formed from the first letters of the words they stand for. Words like these are called acronyms. Other examples in this unit include *scuba* and *NASA*.

10.2 Protection from Extreme Temperatures

A polar bear has a nice thick fur coat to keep it warm in extremely cold temperatures (**Figure 1**). But humans do not have natural adaptations to keep them warm. So before humans could travel to and explore very cold or very hot places, they had to develop clothing that would protect them from the extreme temperatures. For example, a winter coat keeps you warm in cold temperatures because it is a good **insulator.** This means that it stops the heat of your body from moving into the surrounding air. Heat is the movement of energy from a warm object to a cool object.

Different materials have different insulating properties. For example, metals are not good insulators because they move heat away from a warm object. Fur is a good insulator because it traps small pockets of air. Trapped air is an excellent insulator because air does not conduct heat very well. Feathers also trap air (**Figure 2**), and so do wool fibres. This is why wool sweaters keep you so warm.

Figure 1
Polar bears keep warm in the cold Arctic temperatures because they have thick fur and a thick layer of fat under their skin. Fur and fat are good insulators because they stop body heat from going into the environment.

Figure 2
The Emperor penguin's feathers provide insulation against the bitter cold of Antarctica. Penguin chicks have fluffy feathers that trap even more air to hold in the heat from the chick's body.

TRY THIS: FEEL HOW BLUBBER WORKS

Skills Focus: observing, inferring

Some animals that live in the Arctic have a thick layer of fat, or blubber, under their skin. To see how well blubber insulates, make a "blubber mitt" by filling a large plastic bag about halfway with vegetable shortening or lard (**Figure 3**). Put an empty plastic bag on your hand so that you are wearing it like a mitten. Slide your hand into the shortening-filled bag. Mush around the shortening until it surrounds your hand. Plunge your other hand (your bare hand) into a bucket of ice water. Be careful not to keep your hand in the ice water for too long. Now plunge your blubber mitt into the ice water. What do you notice about your hands?

Figure 3
A "blubber mitt"

CHECK YOUR UNDERSTANDING

1. How does insulation keep you warm?
2. Explain how polar bears can survive in the extreme cold of the Arctic.
3. Explain how scientists use observations of nature to develop insulating materials.

10.3 Design Your Own Experiment

SKILLS MENU

○ Questioning	● Observing
○ Predicting	● Measuring
● Hypothesizing	○ Classifying
● Designing Experiments	● Inferring
● Controlling Variables	● Interpreting Data
○ Creating Models	● Communicating

Testing Materials for a Polar Suit

Scientists who work in Vostok, Antarctica, experience the world's lowest temperatures. To survive and work in temperatures as low as −88 °C, scientists need clothing that keeps them warm and dry, and protects them from the wind.

In this investigation, you will test different materials that could be used to make a polar suit for scientists who work in Vostok.

Question

What is the best insulating material for a polar suit?

Hypothesis

Write a hypothesis that states which material(s) would make the best insulator(s). Complete your hypothesis with a short explanation of your reasons. Write your hypothesis in the form "If … then … because … ."

Materials

- apron
- 2 or more baby-food jars
- 2 or more lids for baby-food jars, with a hole in the middle large enough for a thermometer to fit
- scraps of fabric or other materials
- hot and cold water
- rubber bands
- thermometer

apron

baby-food jars with cut-out lids

scraps of fabric or other materials

hot and cold water in beakers

rubber bands

thermometer

Thermometers are fragile and expensive. Be careful when handling a thermometer.

Decide what other materials you will need. Check with your teacher to make sure that these materials are safe for you to use.

Procedure

- Design a procedure to test the insulating properties of different fabrics. A procedure is a step-by-step description of how you will conduct your experiment. It must be clear enough for someone else to follow and do the exact same experiment.
- Submit your procedure (including any safety precautions), to your teacher for approval. Also submit a diagram, at least half a page in size, showing how you will set up your equipment.

Data and Observations

Create a data table to record your observations. Record your observations as you carry out your experiment.

LEARNING TIP

For help with your experiment, read the Skills Handbook sections "Designing Your Own Experiment," "Writing a Hypothesis," "Controlling Variables," and "Writing a Lab Report."

Analysis

1. What did you learn about the insulating properties of different materials?
2. Compile the findings of all the groups in your class. Which materials provided the best insulation?
3. Can you use a graph to represent the findings of your class? Try it and see.

Conclusion

Go back to your hypothesis. Did your observations support, partly support, or not support your hypothesis? Write your conclusion.

Applications

1. Most polar suits contain several layers of different materials. Which combinations of materials do you think would produce an even more effective insulator? If there is time, test your ideas.
2. Would the materials you tested be practical for Arctic explorers (for clothing or protective equipment)? Explain.

CHECK YOUR UNDERSTANDING

1. Which variable did you change (your independent variable)?
2. How did you measure the change in temperature (your dependent variable)?
3. Were other groups testing the same hypothesis as your group? How were their results the same or different from yours?

10.4 Exploring Beneath the Ocean

TRY THIS: MAKE A DEEP-SEA DIVER

Skills Focus: observing, communicating

Make a "diver" out of a plastic pen cap by putting a ball of modelling clay on the end of the cap. If there are any holes in the tip of the pen cap, seal them with modelling clay. Put the cap in a glass of water. Add more modelling clay until the cap just floats on the surface.

Fill a 500-mL or a 2-L plastic bottle with water. Gently put the diver into the water bottle as shown in **Figure 1**. Without squeezing the water bottle, put on the lid and tighten it.

1. What happens to the diver when you squeeze the water bottle? Why do you think this happens?
2. What happens to the diver when you release the water bottle? Why does this happen?
3. What happens if you add more modelling clay to your diver?

Figure 1

LEARNING TIP

The first paragraph in this section describes three obstacles to ocean exploration. Turn these into three questions that you should be able to answer after reading the paragraph.

The oceans are the last unexplored place on Earth. Even though most of Earth is covered with water, only a small fraction has been explored. There are many obstacles to ocean exploration. Divers need to be able to breathe underwater and to control their floating and sinking. They also need to be able to overcome the enormous and rapid change in pressure when travelling deep underwater.

The Challenge of Breathing Underwater

The possibility of finding treasure in sunken shipwrecks prompted many inventions that allowed divers to work underwater. In the early 1800s, divers wore a heavy copper helmet attached to a canvas suit. Air was pumped through a long hose that was connected to the helmet. If someone accidentally stepped on the hose, or if the hose got caught on something, the diver's air supply was cut off.

The invention of the **s**elf-**c**ontained **u**nderwater **b**reathing **a**pparatus, better known as **scuba,** allowed divers to carry their air supply on their backs. Ocean explorers Jacques Cousteau and Émile Gagnon improved the scuba system by inventing the Aqua-Lung.

The Aqua-Lung allows a diver to breathe air at a regulated pressure using a mouthpiece. The mouthpiece supplies just the right amount of air from a pressurized tank strapped to the diver's back. With an Aqua-Lung, a diver can safely go down 75 m while breathing compressed air and oxygen (**Figure 2**). Today, anyone can scuba dive and explore underwater areas that were once thought to be impossible to explore.

Figure 2
A scuba diver wears a metal tank that is filled with compressed air. A regulator attaches to the tank. To breathe, the diver inhales air from the regulator, which reduces the pressure of the air to match the surrounding water pressure.

Floating and Sinking—Controlling Buoyancy

Imagine swimming or even floating in a bathtub. The ability to float is called **buoyancy** [BOY-uhn-see]. If you hold your face out of the water and breathe normally, you float at the top of the water. This is because air is lighter, or less dense, than water. The air in your lungs makes you buoyant. If you blow out some of the air, you will sink (**Figure 3**).

Figure 3
When your body has less air and your density is greater than the water, you sink in the water.

A boat floats because its density is less than the density of the water. The water exerts an upward buoyant force on the boat. The boat sinks down into the water until it has displaced, or pushed aside, a volume of water that has the same weight as the boat (**Figure 4**). An object has neutral buoyancy if it neither floats nor sinks.

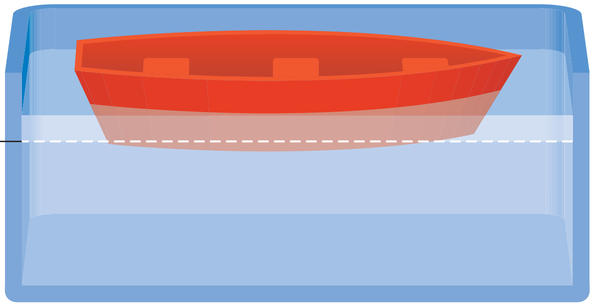


Figure 4
A boat that weighs 1000 kg will sink into the water until it has displaced 1000 kg of water.

TRY THIS: WHY DOES IT FLOAT?

Skills Focus: observing, inferring

Fill a large plastic cup about half full with water. Place the cup on a flat surface, and mark the level of the water. Place a piece of wood in the cup, and again mark the water level.

1. What happens to the water level when the wood is in the cup? Why does this happen?
2. What does this tell you about buoyancy?
3. What would happen to the water level if you used different types of wood of equal volume, such as maple and pine? Try this to find out.

Using Technology to Control Buoyancy

If you want to explore underwater, you have to be able to sink and to come back to the surface. To dive under the water, a scuba diver wears a belt that contains weights. They also wear a buoyancy compensator. A buoyancy compensator is a vest that can hold air. To sink, the diver releases air from the vest. To rise again, the diver blows air from the compressed air tank into the vest, filling it with air. This causes the diver to float back up to the surface.

Submarines sink and rise in the water in a similar way. Special tanks, called ballast [BAL-uhst] tanks, in the outer compartment of a submarine can be filled with water or air (**Figure 5**). When the ballast tanks are filled with water, the submarine sinks. When compressed air is pumped back into the ballast tanks, the submarine floats to the surface.

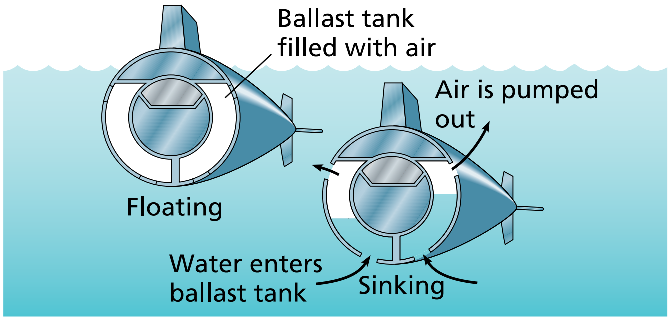


Figure 5
Ballast tanks control a submarine's buoyancy.

Surviving Water Pressure in the Ocean Depths

Have you ever felt your ears pop when you dived underwater or swam to the bottom of a pool? This happens because the water above you presses on your body, squeezing the air out of places such as your ears and sinuses. The **water pressure** increases as you go deeper underwater. At just below 10 m, the pressure of the water on your body is twice what the air pressure, or atmospheric pressure, is at the surface. As you go deeper, the pressure continues to increase.

Underwater vehicles must have very strong bodies, or hulls, to withstand the tremendous water pressure at great depths. Submersibles, such as submarines, are pressurized vehicles that have normal air pressure inside. The outside of a submersible is made of titanium [ti-TAY-knee-um]. Titanium is a very strong metal, which is also used to make spacecraft.

Some submersibles, such as the *Alvin* shown in **Figure 6**, can take scientists to a depth of 4500 m. Other submersibles, called remote operated vehicles, or ROVs, do not carry passengers. An ROV is operated with a joystick by an oceanographer on board a large research vessel.

Figure 6
The *Alvin* carries one pilot and two scientists. It has underwater cameras, lights, a television system, and instruments to collect samples from the water.

Canada's Contributions to Ocean Exploration

Canada has a special interest in ocean exploration because of its access to three oceans: the Atlantic, the Pacific, and the Arctic Oceans. Canada has developed technology for exploring its oceans, including a specialized diving suit called a Newt Suit and a submersible called Deep Worker. Canada, along with the United States, is also developing an underwater observatory called the Neptune Project.

The Newt Suit is built to withstand the pressure of deep water (**Figure 7**). Developed by Vancouver diver Phil Nuytten, it looks like something an astronaut would wear underwater. Two electric thrusters are attached to the suit, to move the diver forward. The suit is very heavy out of the water, but nearly weightless underwater. A person wearing the suit can work at 305 m below the surface for up to 8 h.

Figure 7

The Newt Suit is worn by divers who are drilling for oil or gas, or building pipelines for communication companies.

The Deep Worker is a Canadian-designed one-person submersible used to explore the underwater world (**Figure 8**). The Deep Worker is so small that it has been described as an underwater sports car. Explorers are able to go deeper underwater and spend more time underwater than they can with traditional scuba gear.

Figure 8
The Deep Worker can take photos and collect samples from the bottom of the ocean.

Canadian and American scientists are working together on the Neptune Project, which will give scientists a new understanding of deep ocean activity in the Pacific Ocean (**Figure 9**). This new knowledge can be applied to many global issues, such as predicting earthquakes, tracking marine life, understanding climate change, and discovering new energy sources. One of the goals of the Neptune Project is to become a global centre for ocean research.

Figure 9
The Neptune Project will study the diversity of deep-sea life.

CHECK YOUR UNDERSTANDING

1. What three obstacles make ocean exploration difficult?
2. Why is it important for humans to explore the depths of the oceans?
3. What types of technology have been developed by Canadians to explore the ocean depths?

10.5 Solve a Problem

Figure 1
Giant tube worms can be over 1 m long.

Designing a Sample Collector

One of the most extreme environments on Earth is the ocean floor. In some places, incredibly hot water erupts from cracks, or vents, along the ocean floor. The water can get as hot as 400 °C. Mineral deposits build up around the vents forming stacks. Scientists call these vents black smokers because they look like they are producing black smoke.

Extraordinary creatures, such as giant tube worms (**Figure 1**), live around black smokers. A tube worm has no mouth or gut, but feeds on the bacteria that live inside it. These bacteria can live without oxygen. They do not depend on the Sun for food, since sunlight does not reach the bottom of the ocean. Instead, they break down chemicals from the black smokers to make food for themselves and the tube worms.

Problem

Imagine that you have just joined a team of oceanographers investigating a newly discovered thermal vent ecosystem. You need to design a device for collecting samples from the ocean floor for further study.

Figure 2
ROPOS uses its manipulator arm to collect fluid samples from between rocks on the ocean floor.

Task

Design a device for collecting samples from the area around a thermal vent. Draw a plan for your design and explain how it would work.

Criteria

To be successful, your design must

- show how the device would function under the extreme conditions (such as darkness, and high temperatures and pressures) in and around a thermal vent
- show how a sample would be collected from the ocean floor
- show how the sample would be transported to the surface
- show how the device would be connected to an ROV (**Figure 2**)

Plan and Test

1. Give your device a name.
2. Describe how your device works.
3. Draw a picture of your device, and label all the parts. Describe the function of each part.
4. Decide what samples your device could collect. How would it collect samples in a way that does not disrupt the environment?
5. Describe how the samples would be transported to the surface.
6. Describe any special features you have included to make sure that your device would survive the trip to the bottom of the ocean and back.
7. Explain how your device would be connected to an ROV.

Evaluate

8. Consider the list of criteria. Does your design meet the criteria? Explain.
9. Re-evaluate your design. Are there any changes you would make to your design? Why or why not?

Communicate

10. How will you share your design? You could build a model of your device using simple craft materials or modelling clay. Perhaps you could create a video or computer animation to promote your device.

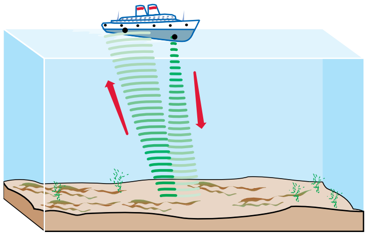
CHECK YOUR UNDERSTANDING

1. Why are the criteria listed important when designing a new device?
2. What questions should scientists ask before they collect live samples of plants or animals?
3. Explain why it is important to test and re-evaluate your design.

10 Chapter Review

Technology allows us to explore Earth's extreme environments.

Key Idea: Technology allows us to navigate Earth's extreme environments.



Sonar is used to map the ocean floor and to help ships navigate through shallow and rocky waters.

Vocabulary

radar p. 186
satellite p. 186
sonar p. 186

Key Idea: Technology allows us to survive extreme temperatures.

Vocabulary

insulator p. 188

Key Idea: Technology allows us to explore the ocean depths.

Scuba gear and submersibles are two types of technology that were developed to explore the oceans.

Vocabulary

scuba p. 192
buoyancy p. 193
water pressure p. 195

Key Idea: Canadians make important contributions to ocean exploration.

The Newt Suit and the Deep Worker are examples of Canadian technology.

Review Key Ideas and Vocabulary

When answering the questions, remember to use the chapter vocabulary.

1. Describe two technologies that have enabled humans to navigate in extreme environments.
2. Draw and label a diagram to show how sonar is used to map the ocean floor.
3. Think about a very cold winter day. Based on your understanding of insulation, what materials would you wear?
4. Describe two Canadian technologies that allow scientists to explore the ocean depths.
5. What do you think is the most important invention for allowing humans to explore underwater? Explain your choice.

Use What You've Learned

6. What are some of the things that humans hope to discover by exploring the ocean? How will these discoveries help society?
7. What is known about the ocean environment? What are some of the unknowns?

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8. Make a time line of the various types of technology that are used to explore the oceans.

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9. Some Inuit clothing is made from caribou skins. The long, hollow caribou hair is good insulation from the cold. As well, Inuit clothing often has fur on the inside to prevent body heat from escaping into the icy environment. For the same reason, Inuit boots are insulated with fur. Based on what you know about insulation and heat loss, explain why the Inuit use these designs for their clothing and boots.

Think Critically

10. What do you think scientists should consider before they collect living samples from any environment? Explain why.
11. What special features would a deep-ocean collecting device need to have to survive the extreme pressures and temperatures, and to be able to function in the dark?
12. When inventing a new device, it is important for the engineer to know what function the device needs to perform. How was the *form* (the design) of your collection sampler affected by the *function* you wanted it to perform?

Reflect on Your Learning

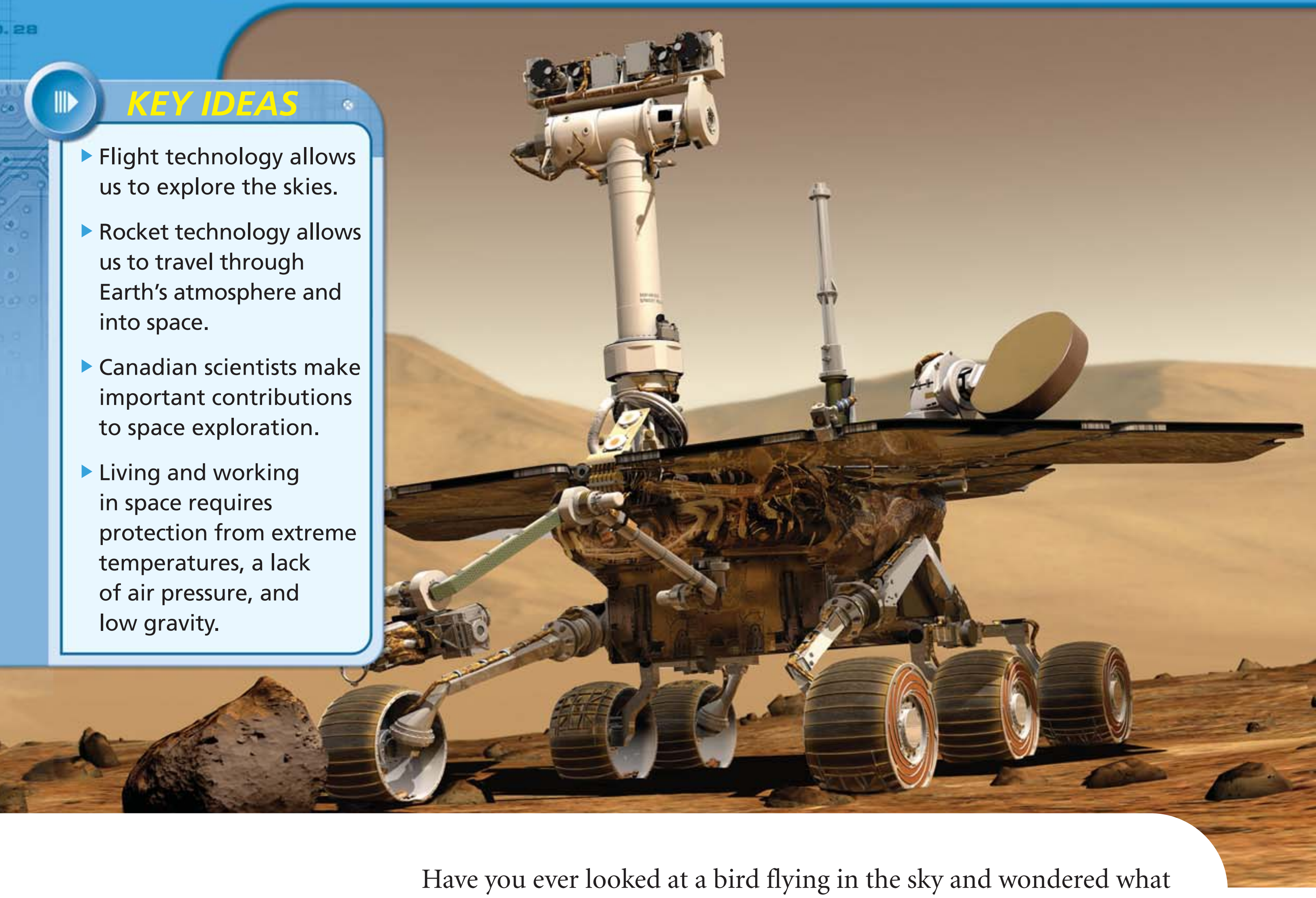
13. Which of the hands-on activities in this chapter did you find the most interesting? What did the activity help you learn?

CHAPTER 11

Technology allows us to explore the extreme environment of space.

KEY IDEAS

- Flight technology allows us to explore the skies.
- Rocket technology allows us to travel through Earth's atmosphere and into space.
- Canadian scientists make important contributions to space exploration.
- Living and working in space requires protection from extreme temperatures, a lack of air pressure, and low gravity.



Have you ever looked at a bird flying in the sky and wondered what it would feel like to fly? People have always been fascinated with flying and with exploring the vast space beyond Earth. But it is only in the last 100 years that these dreams have become possible. Today, technology allows us to travel in and explore the skies. We have even been able to use technology to explore other planets, such as Mars, using robotic rovers like the one shown above.

In this chapter, you will learn about the technology of flight and space exploration. You will also discover the important role that Canadian scientists play in exploring space.

Up, Up in the Air 11.1

Since ancient times, humans have dreamed of soaring like birds. Hot-air balloons (**Figure 1**), hydrogen balloons, and gliders got people off the ground. Flight depended on the weather, however, and the pilot could not control where the balloon or glider went.

Everything changed in 1903, when Orville and Wilbur Wright achieved the first controlled flight with the *Flyer* (**Figure 2**). A small gasoline motor, attached to the *Flyer's* propellers, moved the plane forward. The Wrights made a total of four flights in the *Flyer*. The longest flight lasted 59 s and covered 260 m. After the final flight, the *Flyer* was overturned by a gust of wind and destroyed.

Figure 1
In 1793, the Montgolfier brothers made a huge paper balloon and filled it with hot air. Since hot air is lighter than cool air, the balloon rose into the sky.

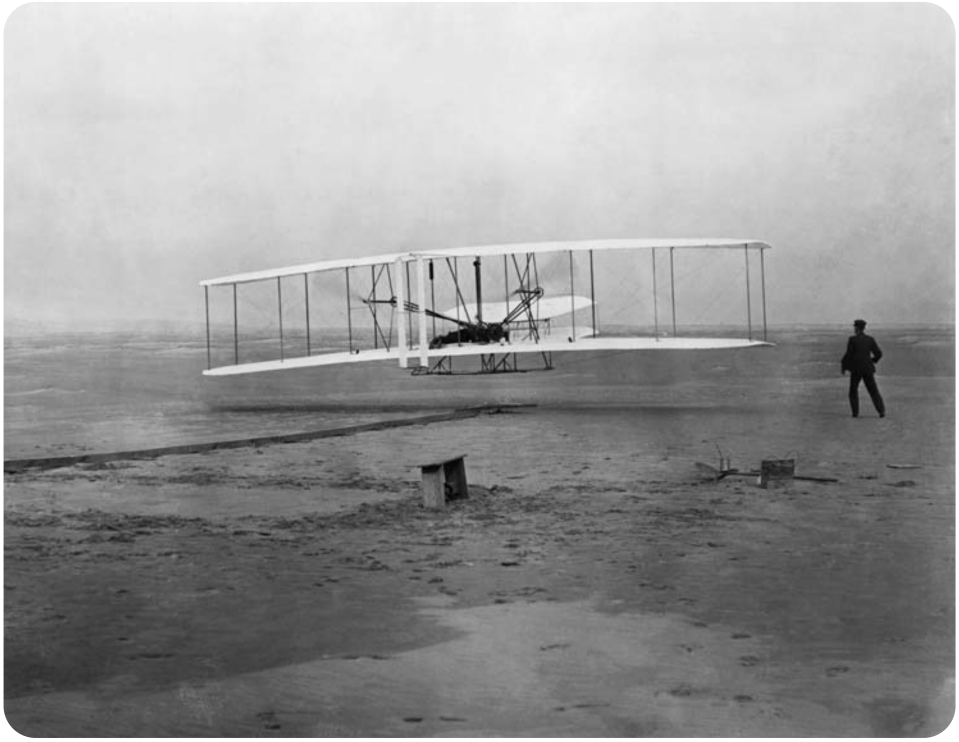


Figure 2
The *Flyer* takes off with Orville Wright at the controls while Wilbur looks on.

After the Wright brothers made their historic flight, different airplane designs made air travel safer and faster. Today, airplanes are made of lightweight metals. They have a streamlined shape and retractable landing gear to reduce air resistance. Millions of people travel the world in high-speed jets. Hot-air balloons and gliders are now used only for recreation.

TRY THIS: HOW DO THE CANS MOVE?

Skills Focus: observing, inferring

Place six straws parallel to each other on a table as shown in **Figure 3**. Space the straws about 2 cm apart. Place two empty aluminum cans on top of the straws. The cans should be about 4 to 6 cm apart. Kneel down so that you are 20 cm from the cans and at eye level with the centre of the cans. Predict what will happen if you blow air in the space between the two cans, using another straw.

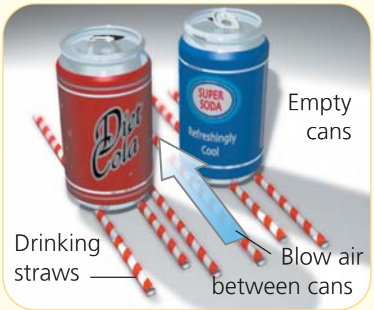


Figure 3

Do not share straws. Each student should use her or his own straw.

1. What happened to the cans? How did they move?
2. Is this what you predicted would happen? Why or why not?
3. Explain why the cans moved the way they did.

Wing Shape and Flight

How does the shape of an airplane's wings help the airplane fly? Imagine that the curve of the aluminum can in the Try This activity is the shape of the top of a wing. Air rushes over the top curve of the wing faster than it moves over the flat bottom surface of the wing. This creates low pressure over the wing, compared with the high pressure under the wing. The high pressure under the wing pushes the wing up and forces the plane upward (**Figure 4**). This is called **lift.** Lift allows people to explore Earth's atmosphere. However, more than lift is needed to get beyond Earth's atmosphere.

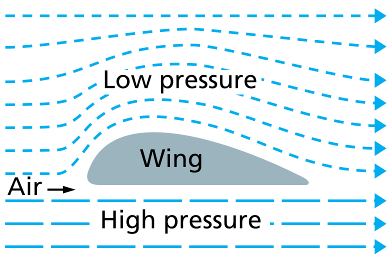


Figure 4
The movement of air over the wings of an airplane produces lift.

LEARNING TIP

After reading "Wing Shape and Flight" on this page, describe to a classmate how wing shape helps an airplane fly. If you have trouble, reread the paragraph and look carefully at **Figure 4** to see how lift is produced.

CHECK YOUR UNDERSTANDING

1. "The Wright brothers' invention of the airplane changed the world." Do you agree or disagree with this statement. Explain.
2. What do you think is happening to the air pressure between the two aluminum cans when you blow air between them?
3. Why are airplane wings curved?
4. What is lift?

Designing a Super Flyer

Scientists and inventors are problem solvers. The Wright brothers were very good problem solvers. To figure out how to fly, they studied flight, built and rebuilt models, or prototypes, of flying machines, tested and retested their ideas, and redesigned their aircraft. The Wright brothers based their 1903 *Flyer* on their 1902 glider (**Figure 1**).

LEARNING TIP

Prototypes are often full-scale working models that help inventors discover what improvements their designs need.

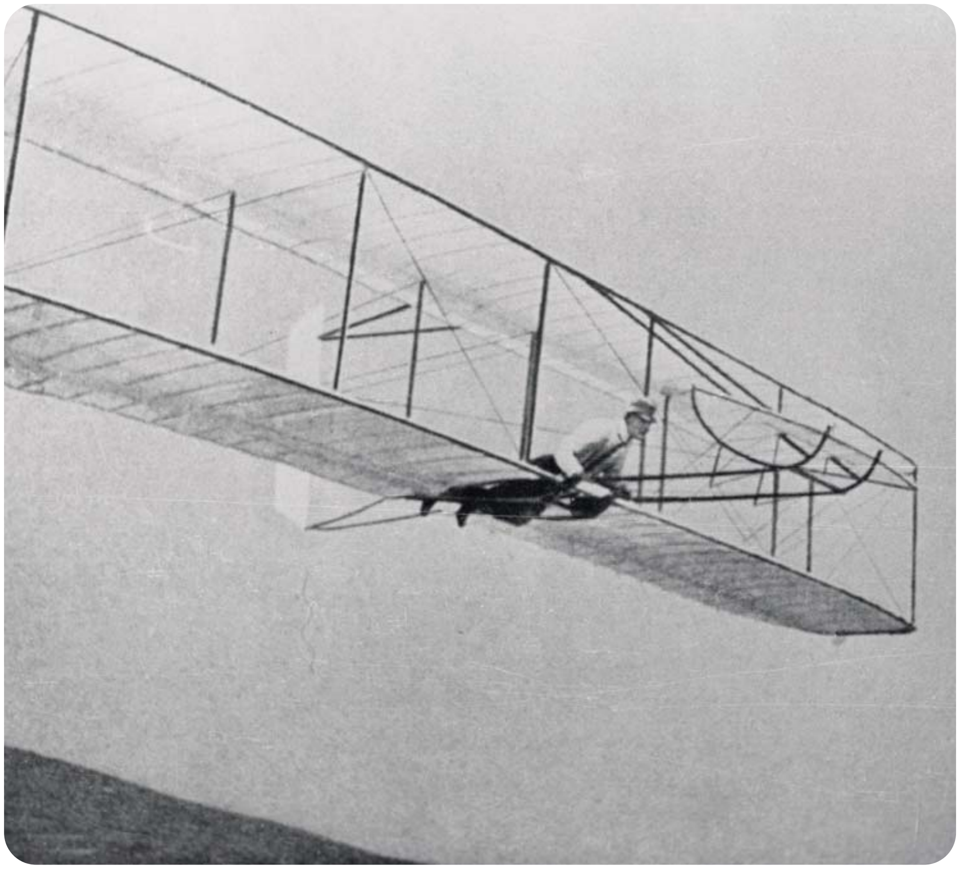


Figure 1
The Wright 1902 glider was the first controllable aircraft that flew.

In this investigation, you will design, build, test, and redesign a Super Flyer paper airplane.

Problem

How can observations from nature help you design a better paper airplane?

LEARNING TIP

For a review about solving a problem, see the Skills Handbook section "Solving a Problem."

Task

Think about how different animals fly through the air. Then think about how different things in nature, such as seeds, move through the air. How are these things designed to fly? Compare the examples in **Figure 2** with the airplanes in **Figure 3**. How can you use your observations of flight in nature to design an improved paper airplane?

Figure 2
Types of flight in nature

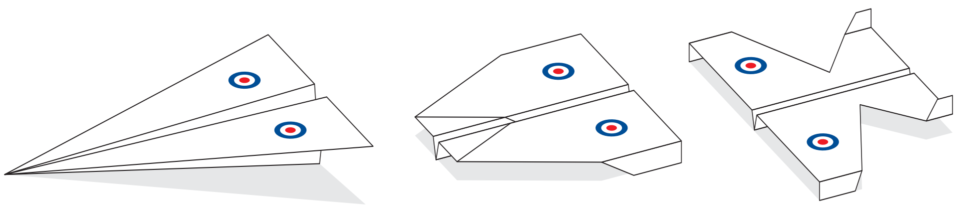


Figure 3
Different designs of paper airplanes

Criteria

To be successful, your final model must

- fly straight for 2 m
- fly at a height of at least 2 m
- be made using the materials you decide upon as a class (e.g., paper, glue, and thin wood)
- incorporate changes based on observations you made when testing and retesting your designs

Plan and Test

1. Work with a partner and design a paper airplane, based on one of the paper airplanes in **Figure 3** or your own ideas. Draw your design.
2. Explain how your airplane will fly. Also explain why you chose to design your airplane the way you did.
3. Prepare a set of instructions for how to build your paper airplane. Use your instructions to build it.
4. Decide how you will test the performance of your paper airplane. For example, consider the following questions:
   - How many times will your repeat your flight tests?
   - What do you plan to observe?
   - What do you plan to measure?
5. Design a table to record your measurements and other observations.
6. Test your paper airplane.

Evaluate

7. How did your airplane do? Based on its performance, design a new airplane that you think will fly farther and straighter. What parts of your design have changed? Why did you change these parts? Modify your diagram and your instructions.
8. Your airplane will participate in a class Paper Airplane Challenge to determine which airplane flies the highest, which airplane flies the farthest, and which airplane flies the straightest.
9. How is your model like a real airplane? How is it different?

Communicate

10. Prepare a labelled diagram, describing how to create your final paper airplane. Include instructions for building your airplane. Give your airplane a catchy name.

CHECK YOUR UNDERSTANDING

1. What is a prototype? Why is it used?
2. What did you learn in your flight tests that helped you design your final airplane?
3. Why was it important to repeat your tests?

11.3 Rocketing into Space with Technology

The invention and development of the airplane meant that people could explore the skies. Travelling beyond Earth's atmosphere, however, was still not possible. Space is a near vacuum, which means that it contains few oxygen or nitrogen molecules. Since airplane engines need oxygen in the air to burn fuel, airplanes could not be used to explore space.

To explore space, a vehicle that could travel in a vacuum was needed. The vehicle also had to carry its own fuel and source of oxygen. As well, it had to be able to travel fast enough to escape Earth's force of gravity, which pulls things down. The development of rockets, like the one shown in **Figure 1**, and other spacecraft made space exploration possible.

Figure 1
In 1926, Dr. Robert Goddard launched the world's first liquid-fuelled rocket from his backyard.

Before sending people into space, scientists sent unpiloted spacecraft, or probes, into space to gather information and to see what dangers lay ahead. The Russians developed the R-7 rocket to launch the first satellite, *Sputnik I*, into space in 1957. One month later, they launched the first space traveller, a dog named Laika. Then, in 1961, they launched the first human space traveller, Yuri Gagarin. Space technology continued to improve and, in 1969, two American astronauts, Neil Armstrong and Edwin "Buzz" Aldrin, became the first humans to land on the Moon.

Eventually, engineers invented a reusable spacecraft—the space shuttle shown in **Figure 2**. The space shuttle is designed to go into space and then re-enter Earth's atmosphere and land safely. The shuttle commander has only one chance to land successfully. There is only enough fuel to get home and not enough to try the landing again. When the space shuttle touches down, a parachute opens to create drag, or resistance, which helps it stop.

Figure 2
The shuttle is a piloted spacecraft that is launched into space using a rocket.

Payloads and Rockets

Anything that is launched into space, such as a satellite or space shuttle, is called a payload. A launcher carries the payload into space. The main part of the launcher is a rocket.

TRY THIS: ***BLAST OFF!***

Skills Focus: creating models, observing, inferring

Blow up a long and skinny balloon, and hold the end closed. Tape a straw along one side of the balloon in a straight line. Feed a piece of fishing line through the straw. Get two assistants to stretch the line across the room and hold the ends tight. Launch the rocket balloon by letting go of the balloon (**Figure 3**).

1. What happens to the balloon? Why does this happen?
2. Compare the rocket balloon with a rocket powered by chemical explosions.

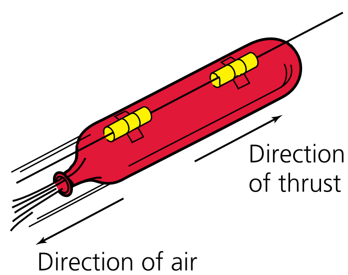


Figure 3

A rocket has an opening at one end, like the balloon in the Try This activity. The force of the air escaping from the open end of the balloon moved the balloon forward. In a rocket, the engine mixes fuel with oxygen and produces exhaust gases. The quick release of these gases downward creates an upward force, or **thrust,** on the rocket (**Figure 4**).

Figure 4
The force of the exhaust gases shooting out in one direction causes the thrust of the rocket in the other direction, launching the payload into space.

LEARNING TIP

As you read, ask yourself questions to check your understanding: What did I just read? What did it mean? Try to put the information in your own words.

Satellites in Space

Did you know that when you make an overseas phone call, use a cell phone, check the weather forecast, watch TV, or use the Internet, you are using a satellite?

A satellite is an object in space that travels in an orbit around another object. The Moon is a natural satellite of Earth. Human-made satellites are artificial satellites.

Satellites do more than just travel around Earth. Communication satellites receive and transmit television program signals and telephone signals so that you can see and hear about events as they happen, anywhere in the world. For many years, Canada has been an international leader in satellite communication. When the Telesat satellite Anik A1 was launched in 1972, Canada became the first country with its own commercial, domestic communication satellite in orbit. In July 2004, Telesat launched the world's largest commercial communication satellite, Anik F2 (**Figure 5**).

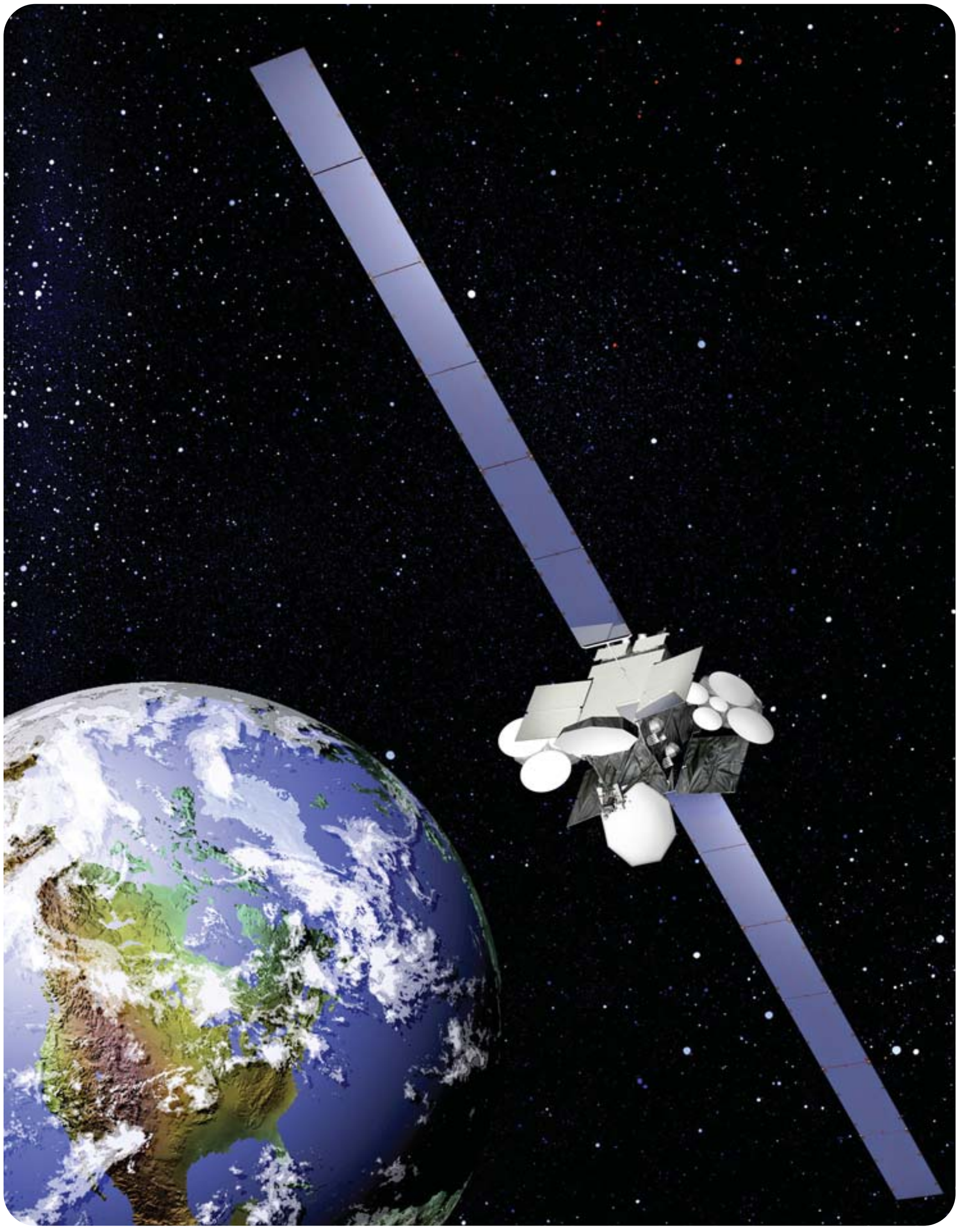


Figure 5
Anik F2 was launched in July 2004. Canada's Telesat communication satellites have all been named Anik, which in the Inuit language means "little brother."

Figure 6
RADARSAT orbits Earth at an altitude of 796 km. It circles Earth 14 times a day. Each orbit takes just over 100 min to complete.

There are many other types of satellites, including navigation, weather, and space research satellites. Some countries even have spy satellites that are used to keep an eye on other countries. Satellites are also used to take pictures of Earth. For example, RADARSAT is a satellite that the Canadian Space Agency developed and operates. RADARSAT provides images of Earth so that scientists can monitor flood damage, soil humidity, forests, and crop conditions, and locate oil spills on the oceans. Images are also used to find surface features that are associated with resources such as oil, water, and minerals. **Figure 6** shows an image of a flooded area of Manitoba, taken using RADARSAT.

Canadian Robots in Space

Canada has made important contributions to space exploration. The Shuttle Remote Manipulator System, commonly known as the **Canadarm,** is a robotic manipulator arm. It was developed by scientists at the Canadian Space Agency and first used on a space shuttle in 1981 (**Figure 7**). An astronaut from inside the space shuttle controls the arm. Over the years, the Canadarm has been changed to adapt to new technology. The Canadarm has been used to send satellites into their proper orbit and retrieve broken satellites for repair, to support space walks by space construction workers, and even to knock ice off the shuttle's wastewater vents.

Figure 7
The Canadarm is 15 m long.

One important job of the Canadarm was the 1993 repair of the Hubble Space Telescope (**Figure 8**). After the Hubble Space Telescope was launched, scientists realized that the photos it took were fuzzy. Using the Canadarm, Hubble was repaired and placed back in orbit to observe the universe.

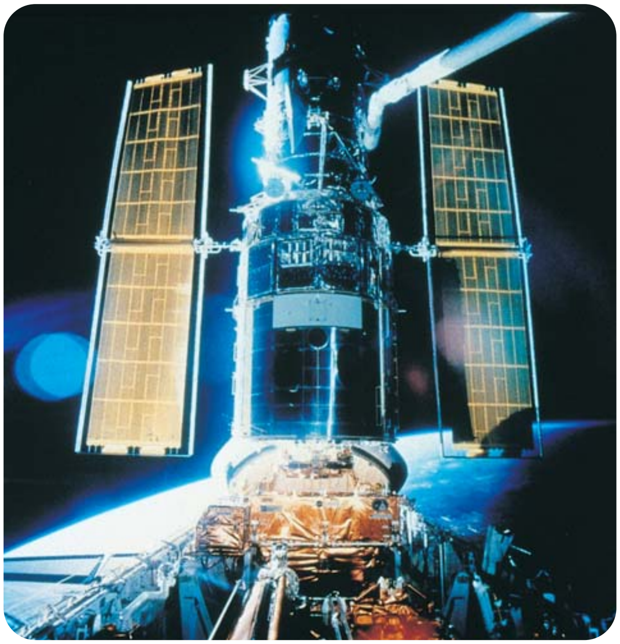


Figure 8
The Hubble Space Telescope takes computerized pictures of space and sends them to astronomers on Earth.

The Canadarm was also used to install the second robotic arm, the Canadarm 2, on the International Space Station in 2001. While helping to install the new robotic arm, Canadian astronaut Chris Hadfield became the first Canadian to walk in space. Hadfield also manipulated the Canadarm from inside the space shuttle to take a piece of equipment from the Canadarm 2 into the space station—a handshake between two Canadian robotic arms!

CHECK YOUR UNDERSTANDING

1. How is thrust created during a rocket launch?
2. Compare an artificial satellite with the Moon. How are they the same? How are they different?
3. What is RADARSAT? What is it used for?
4. Canada has made an important contribution to space exploration through the development of satellites. List two or more things that satellites do for us.
5. What important contribution have Canadian scientists made in robotic space technology? What is this technology used for?

Awesome SCIENCE

Robots can explore where people can't!

NOMAD, THE DESERT EXPLORER

Deserts can be hot, difficult areas to explore, but not for Nomad! Nomad is a four-wheel-drive roving robot, created by scientists at National Aeronautics and Space Administration (NASA). During the 45 days it spent exploring the rugged Atacama Desert in Chile, Nomad travelled 214 km over rough territory—19 km totally on its own. Nomad even picked up an undiscovered rock from the Jurassic Period.

DANTE II, THE VOLCANO EXPLORER

Dante II is a robot that was built by NASA to explore Mount Spurr, an active volcano in Alaska. Dante II was actually the second robot built to explore volcanoes. The first robot, Dante I, was sent into Mount Erebus in Antarctica. It had only covered a few metres before its cable broke and it fell into the inferno below. Unfortunately, Dante II was also damaged as it explored Mount Spurr. Dante II now tours the United States promoting robotic research.

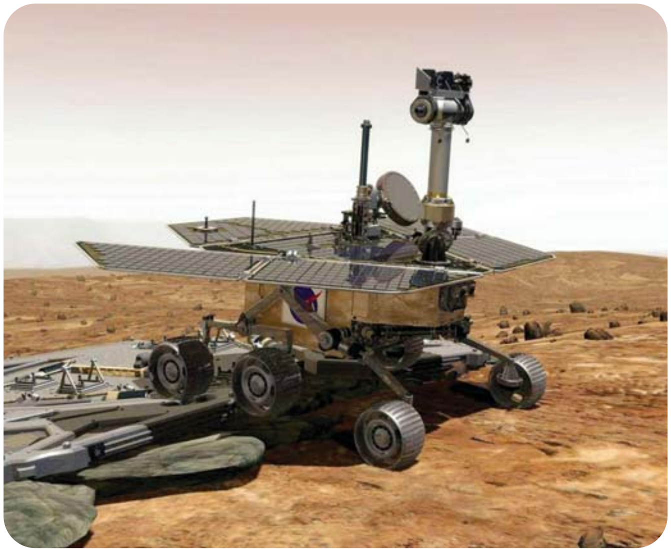
ROPOS AND THE UNDERWATER VOLCANOES

Have you ever wondered what an underwater volcano looks like? ROPOS, which stands for **R**emotely **O**perated **P**latform for **O**cean **S**cience, is a robotic submersible that was developed in Canada. It is used to study submarine volcano systems. It is also used to collect samples and take scientific readings.

ROPOS is placed inside a cage and lowered 5000 m. It is attached to a tether cable and is moved out of the cage to complete the dive. ROPOS uses different tools, such as giant steel jaws, cutters, hooks, and drills, to break off samples from the ocean floor. It uses suction samplers, strainers, and scoops to collect the samples. It has cameras and video and computer recorders to log its underwater explorations. Four people work from the surface ship to direct ROPOS. A scientist directs the dive, a pilot operates the machine, a sample collector operates the tools for collecting the samples, and an event recorder keeps a log of what ROPOS does.

SPIRIT AND OPPORTUNITY ON MARS

In January 2004, two robot geologists—Spirit and Opportunity—landed on the surface of Mars and began to explore their surroundings. Guided from Earth by a team of engineers (in charge of navigating the area) and a team of scientists (in charge of learning about the Martian environment), the rovers travelled across Mars. Spirit took microscopic pictures of an intriguing rock known as Pot-of-Gold. Opportunity moved down into a crater known as Endurance Crater, making observations and using a rock abrasion tool to dig into rocks. Scientists used the computer systems on the two rovers and the computer systems in the laboratory on Earth to analyze soil and rock samples for signs of past life and water on Mars.



11.4 Conduct an Investigation

SKILLS MENU

○ Questioning	● Observing
○ Predicting	● Measuring
○ Hypothesizing	○ Classifying
○ Designing Experiments	● Inferring
● Controlling Variables	● Interpreting Data
○ Creating Models	● Communicating


apron


goggles


film canisters and lids


paper

antacid tablets


tape

beakers of cold and warm water

beaker of water at room temperature


shoebox lid


tape measure


stopwatch

Rocket Blasters

Young scientists, here is your chance to discover how to achieve the greatest thrust for a canister rocket. You will work as part of a three-member team. Your teacher will assign your team one of the Questions to investigate.

To make sure that your tests are fair and accurate, pay close attention to the procedure and change only one variable at a time. Do at least three trials, and conduct your tests the same way in each trial. Using the results for each variable, you will collaborate with your team to design a new procedure to create a rocket blaster!

Questions

a) Can I create the greatest thrust with my canister rocket using cold water or warm water?

b) Can I create the greatest thrust with my canister rocket using half of an antacid tablet or a whole tablet?

Materials

- apron
- safety goggles
- 2 film canisters, with lids that fit inside the rims
- paper
- tape
- 6 antacid tablets
- beaker of cold water and beaker of warm water (for Question (a))
- beaker of water at room temperature (for Question (b))
- shoebox lid
- tape measure
- stopwatch

Conduct this experiment outside or in a large indoor space. Wear goggles, and make sure that the canister is placed upside down (inverted) during the tests. Everyone should stand well back from the canisters because the rockets can travel up to 7 m.

Procedure

1 Make a paper rocket (**Figure 1**). Wrap a piece of paper around the film canister and tape it in place. The lid of the canister should face down. Remember to leave room at the bottom of the canister so you can put the lid back on. Cut a piece of paper into a cone and tape it to the top of the rocket. Draw and cut out four fins for your rocket, and tape them in place.

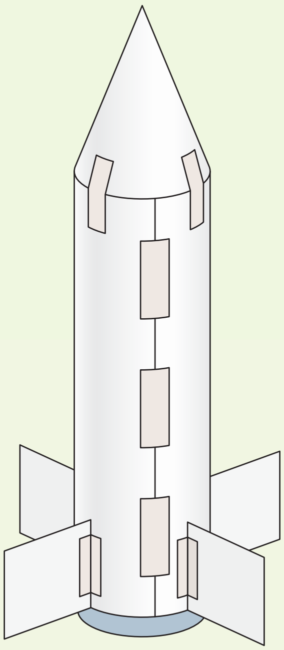


Figure 1

2 Put on your apron and safety goggles. Get six antacid tablets from your teacher. If you are investigating Question (a), you will need a beaker of warm water and a beaker of cold water. If you are investigating Question (b), you will need a beaker of water at room temperature. You will also need to break two antacid tablets in half.

3 Build a launch pad using the shoebox lid. Prop up the lid on an angle. The canister rockets will blast sideways instead of straight up when launched at this angle.

Question (a)

4 Make a table like the one below.

Observations for Question (a)

	Time to blast off (s)			Distance travelled (cm)		
Water	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
hot						
cold						

5 Fill one canister one-third full of warm water. Drop in one tablet, and quickly put the lid on the canister. Place your rocket on the launch pad as shown in **Figure 2**, and stand back. Measure the time the rocket takes to blast off. Record this time in your table. After the rocket lands, measure the distance it travelled. Record your measurements in your table.

Figure 2

6 Repeat step 5, but this time use cold water. Record your measurements in your table.

7 Repeat steps 5 and 6 two more times, for a total of three trials.

Question (b)

8 Make a table like the one below.

Observations for Question (b)

Amount of tablet	Time to blast off (s)			Distance travelled (cm)		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
one tablet						
half of a tablet						

9 Fill both canisters one-third full of water. Put one tablet in one of the canisters. Quickly put the lid on the canister. Place your rocket on the launch pad, and stand back. Measure the time the rocket takes to blast off. After your rocket has launched, measure the distance your rocket travelled. Record your measurements in your table.

10 Repeat step 9 using half a tablet. Record your measurements in your table.

11 Repeat steps 9 and 10 two more times, for a total of three trials.

LEARNING TIP

For help preparing your graph, read "Graphing Data" in the Skills Handbook.

Analyze and Evaluate

1. Find the average time and distance for the three tests.
2. Create a graph to illustrate the results of your test.
3. What conditions created the greatest thrust for your canister rocket?

Apply and Extend

4. As a whole class, discuss the results for Questions (a) and (b). Which conditions do you think will produce the greatest thrust for the canister rockets?
5. What did you do in your investigation to ensure that your results were as accurate as possible?
6. Can you think of other ways to measure the range of your rocket? Are there other variables that you would like to test?

CHECK YOUR UNDERSTANDING

1. Why is it important to follow the procedure the same way in each trial? Why is it important to repeat a test?
2. What variable did you change in your investigation?
3. What made your test a fair test?

The International Space Station

11.5

Space stations are important for space exploration. Before humans can live on places like the Moon or Mars, scientists need to understand how space affects the human body. Scientists research the effects of space in space stations that orbit Earth. The International Space Station, or ISS, is the biggest technological project in space (**Figure 1**). The ISS is so important that space agencies from 16 countries around the world are involved in the project. When it is finished, it will be over 100 m long and will orbit about 320 km above Earth.

Figure 1
The International Space Station (ISS) orbits high above Earth.

The ISS is a laboratory in space. Science experiments on the ISS can last for months. The ISS has a microgravity environment, in which the effects of gravity are very small. Everything appears to be almost weightless. Scientists on the ISS are studying the effects of microgravity on animals and plants.

Scientists on the ISS are also studying the effects of space on human bones. As well, they are studying Earth's climate, learning about the solar system, and developing new technologies that may be used for further space exploration. Canadian scientists are conducting experiments that may lead to the development of new medicines and ways to keep astronauts healthy when they are living and working in space.

Once the ISS is complete, scientists hope that it can also be used as a refuelling station for longer missions. If you look up at night, you may see the ISS passing overhead.

CHECK YOUR UNDERSTANDING

1. Describe some uses of the ISS.
2. Why is it important to research the effects of space on humans and on the growth of plants?

11.6 Living and Working in Space

LEARNING TIP

Set a purpose for your reading of this section. First, read the headings and look at the illustrations in the section. Then make a list of questions that you have about how astronauts live and work in space.

In the International Space Station, the phrase "floating off to sleep" has a totally different meaning. Since the ISS has so little gravity, astronauts must attach their sleeping bags to a wall or seat to prevent them from floating around the cabin as they sleep (**Figure 1**). What other things do you think would be difficult to do in space?

Figure 1
An astronaut zips up for a cozy sleep in space.

Living and working in space is very difficult for astronauts. There are many challenges, such as lack of air in space, extremely low temperatures, and low gravity. Even growing food and getting water are difficult in space.

Breathing in Space

There is no air in space. On the ISS, however, astronauts can breathe easily. This is because of the **life-support systems** on the ISS. The life-support systems provide oxygen for the astronauts to breathe and absorb the carbon dioxide that the astronauts exhale.

Wearing Space Suits for Protection

Space suits are like mini spacecraft, designed to protect astronauts from exposure to space. For example, the normal human body temperature is about 37 °C. When you are hot, your body sweats to cool off. When you are cold, your body warms up by shivering. The temperature of an object in space can drop to −157 °C in the darkness and soar to 121 °C in the sunlight. Astronauts need to wear space suits to protect themselves from these extreme temperatures.

On board the ISS, astronauts wear a T-shirt and shorts as they work and exercise. During a launch or re-entry, however, they wear a partially pressurized suit called a Launch and Entry Space Suit, or LES. An LES can provide enough air pressure to return to Earth during an emergency landing, when cabin pressure in the space shuttle may decrease (**Figure 2**).

Figure 2
The Launch and Entry Space Suit (LES) has batteries for power and radio devices for communication. The LES is also insulated and has an emergency oxygen system, a parachute harness and parachute pack, 2 L of drinking water, and floatation devices.

Figure 3
An astronaut wearing an EMU carries the life-support system in a backpack.

To work in space, an astronaut wears an Extravehicular Mobility Unit, or EMU (**Figure 3**). An EMU has many layers to protect the astronaut from the vacuum of space, extreme temperatures, and the Sun's harmful radiation. A gold visor on the helmet protects the astronaut's eyes from the blinding sunlight. Oxygen tanks provide oxygen for about seven or eight hours. Gloves have heaters to prevent the astronaut's hands from freezing when the astronaut is working in space at night in the cold temperatures. The EMU also contains a small thermostat that can be adjusted if the astronaut becomes too warm while working in space during the day. Tubes coil through special underwear to keep the astronaut at a comfortable temperature. Not surprisingly, the EMU is very heavy. It is made with ball bearings at the joints, which allow the astronaut to bend and twist.

The Manned Maneuvering Unit, or MMU, is a nitrogen-propelled backpack that latches to the EMU and allows the astronaut to move when outside of the spacecraft. An astronaut wearing an MMU can move forward, backward, turn, and even do flips in space.

Falling in Space

If you drop an apple on Earth, it falls to the ground. What happens if an astronaut on the ISS drops an apple? Even though the apple may look like it is floating, just like Chris Hadfield appears to be floating in **Figure 4**, it is actually falling. In fact, the apple, the astronaut, and the ISS are all falling together around Earth. Since they are all falling at the same rate, the apple and the astronaut appear to be weightless inside the ISS. The microgravity condition in the ISS makes them appear to float.

Figure 4
It looks like Canadian astronaut Chris Hadfield is floating. He is actually falling.

TRY THIS: MODEL WEIGHTLESSNESS

Skills Focus: creating models, observing, inferring

The reason that objects feel weightless in space is because they are falling toward Earth's surface. You can make a model to show weightlessness (**Figure 5**). Start by cutting a rubber band. Put one end so that it hangs down into a plastic bottle, while the other end lies across the mouth of the bottle. Screw on the lid to keep the rubber band in place. Note your observations about the rubber band. Unscrew the lid, and put some modelling clay on one end of the rubber band. Put the end with the modelling clay in the bottle. The other end should drape across the mouth of the bottle. Screw the lid on the bottle. Notice the effect of the modelling clay on the rubber band. Hold the bottle about 1 m in the air, and drop it.

1. What do you observe?
2. How do your observations relate to what happens on the ISS?

Figure 5

Because of microgravity, there is a lack of force against the muscles in an astronaut's body. When astronauts are living on the ISS, their muscles become smaller and their bones lose calcium and become weak. The spine and other joints spread apart. This causes the astronauts to stretch up to 5 cm taller. To combat the effects of microgravity on their bodies, astronauts exercise daily on special exercise machines (**Figure 6**). They even race from one end of the ISS to the other to keep in shape!

Figure 6
This astronaut is exercising while on the space shuttle.

Food, Water, and Waste in Space

Survival in space depends on having enough food and water, and on finding ways to dispose of waste. Astronauts get three meals a day. The food must be nutritious and easy to eat in a floating environment (**Figure 7**). The astronauts have more than 100 foods to choose from, including fruits, nuts, peanut butter, chicken, beef, seafood, and candy. Drinks include coffee, tea, orange juice, fruit punch, and lemonade. Drinking straws have clamps that stop the liquid from coming out after the astronaut stops sucking. Some foods are dehydrated [dee-HI-dray-ted], so the astronauts just need to add water. Most foods are precooked, so the astronauts just reheat them in an oven. There are no refrigerators on the ISS.

Figure 7
Astronauts have to be careful that pieces of food do not escape and get into the sensitive instruments.

Did you know that when you exhale, or breathe out, your breath contains water? On the ISS, all water—including water from the astronauts' breath—is recycled and purified so that it can be used again. There is a lot of water on the ISS in containers that were transported from Earth. Since bringing water from Earth is expensive, scientists have developed technology to collect humidity from the air. In the future, every drop of water, from waste water to water used for hygiene, may be recycled and purified on the ISS. On Earth, when we **recycle,** we reuse something instead of discarding it. On the ISS, it is very important to find ways to recycle all materials and to reduce waste as much as possible.

Designing materials so they can be reused is important. Most garbage is packed up and returned to Earth, but sometimes it is deposited into space, where it burns up. Staying clean on the space station is a must. Micro-organisms (bacteria) grow easily in a closed system. Astronauts do not get very dirty in space. To stay clean, they use a moist cloth to wipe themselves clean.

What about personal wastes? To use a toilet on the ISS, astronauts first strap themselves in so they will not float away (**Figure 8**). They then sit on a rubber ring to create a seal around the toilet as their solid waste is vacuumed into a waste receptacle. There is a hose to collect urine. All liquids, including urine, are processed to remove pure water, which can be reused.

Figure 8
The toilet on the ISS is quite a bit different from the toilets on Earth.

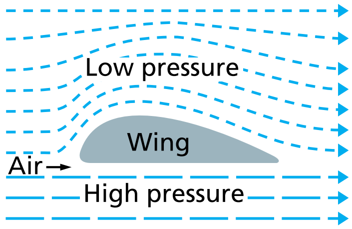
CHECK YOUR UNDERSTANDING

1. How are astronauts able to breathe on the ISS?
2. What are some functions of a space suit?
3. Water is a valuable resource on Earth and on the ISS. Compare how you use water to how an astronaut uses water.
4. Why is it important for astronauts to exercise in space?
5. Compare the needs of an astronaut on a space flight for a few days with the needs of an astronaut living in space for a few months.

11 Chapter Review

Technology allows us to explore the extreme environment of space.

Key Idea: **Flight technology allows us to explore the skies.**



Curved wings give an airplane lift so it can fly.

Vocabulary

lift p. 204

Key Idea: **Rocket technology allows us to travel through Earth's atmosphere and into space.**

The space shuttle

Vocabulary

thrust p. 210

Key Idea: **Canadian scientists make important contributions to space exploration.**

The Canadarm and RADARSAT are Canadian contributions to space exploration.

Vocabulary

Canadarm p. 212

Key Idea: **Living and working in space requires protection from extreme temperatures, a lack of air pressure, and low gravity.**

The International Space Station is a laboratory in space.

Vocabulary

life-support systems p. 220

recycle p. 224

Review Key Ideas and Vocabulary

When answering the questions, remember to use the chapter vocabulary.

1. How did an understanding of lift help people develop the technology of flight?
2. Give an example of a flying machine, such as a helicopter, that humans have invented. What things or creatures from nature may have inspired the design?
3. How does thrust cause a rocket to launch into space?
4. What are the three main obstacles to human survival in space? For each obstacle, discuss a technology that has made it possible for humans to survive in space.
5. Describe two important Canadian contributions to space exploration.

Use What You've Learned

6. What happens if one member of a scientific team does not complete his or her job properly? For example, in Investigation 11.4, there were three members on each team. Write a paragraph about the importance of completing a job properly. Infer how your experiences in this investigation could relate to space exploration.
7. Research the countries that are involved in the International Space Station.

   www.science.nelson.com GO

8. Research Canada's contributions to the ISS.

   www.science.nelson.com GO

9. Research a Canadian astronaut. When did this astronaut go into space? What did he or she do on the mission?

   www.science.nelson.com GO

10. On October 5, 2004, *SpaceShipOne* became the first privately built manned rocket ship to fly into space (**Figure 1**). In the future, people may be able to fly into space on board rocket ships like *SpaceShipOne*. What do you think about the possibility of riding in a rocket ship? What could this mean for the future of space exploration?

Figure 1
SpaceShipOne and its launch ship

Think Critically

11. What lessons about recycling on Earth can be implemented to reduce waste in space?
12. What do you think would be the most difficult part of living in space? Why?

Reflect on Your Learning

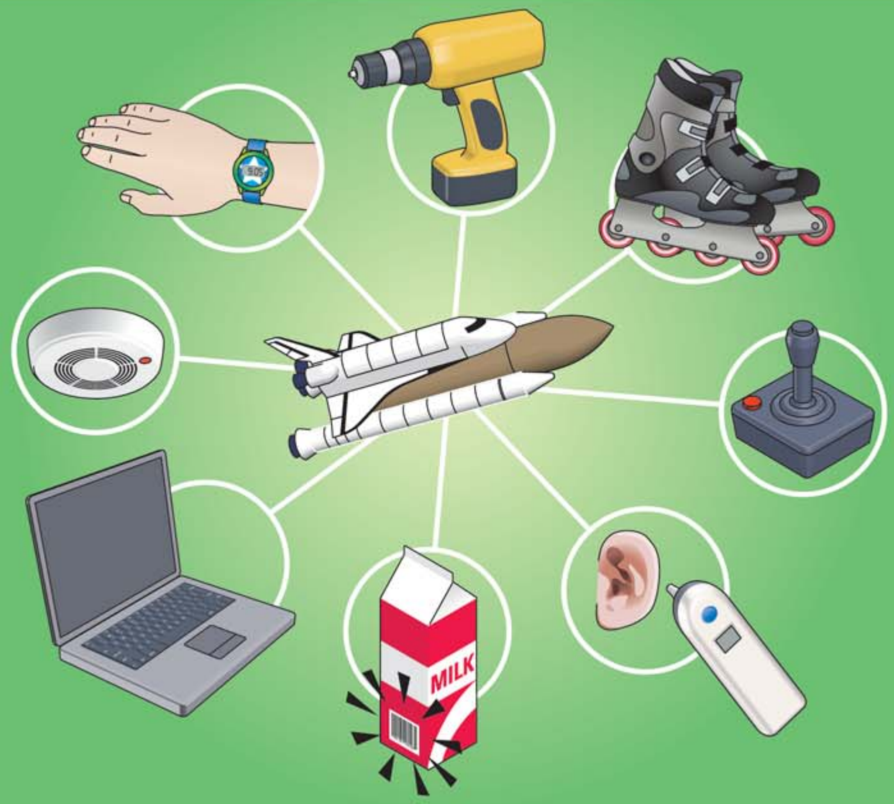
13. Which activity best helped you understand the concepts presented in this chapter? How do you learn best?
14. In this chapter, you have learned about the exploration of space, the most extreme environment. What aspect of space exploration interested you the most? What questions do you have about future space explorations?

CHAPTER 12

Exploring extreme environments has both benefits and costs.

KEY IDEAS

- The exploration of extreme environments produces spinoffs and other benefits.
- The exploration of extreme environments has drawbacks and costs.



Did you know that the joystick you use to play video games is modelled on the controls that astronauts use to practise shuttle landings? Exploration technology is all around you. Many inventions created for exploring extreme environments find their way into everyday life.

Exploration provides knowledge about the world you live in. New species of plants and animals discovered deep in the oceans may lead to new medicines. Satellites in space are used to predict the weather on Earth. Information sent from sensors on the ocean floor may help predict earthquakes.

But there are costs to exploring extreme environments, too. Deciding whether the benefits of exploration outweigh the costs is an important issue, not just for scientists, but for everyone.

Exploration Spinoffs

12.1

What do the bar codes you see on many products have in common with space technology? National Aeronautics and Space Agency (NASA) developed bar code technology to keep track of millions of spacecraft parts. Today, grocery stores and department stores use bar codes to keep track of their products (**Figure 1**). Bar code technology is an example of a **spinoff**—an everyday use of a technology that was first developed for exploration.

Figure 1
Scanning bar codes is just one example of space technology.

Space exploration, in particular, has given us many spinoffs. Smoke detectors, like the ones used in your home, were originally developed to detect deadly gases on *Skylab*, the first space station. Cordless tools were originally developed for astronauts to use on the Moon to collect rock samples. Even portable laptop computers were first used on space shuttle missions. Other examples of spinoffs are shown in **Figure 2**.

Figure 2
A type of fetal heart monitor (left) and industrial robots that put cars together (right) are two spinoffs from space technology.

LEARNING TIP

Before you read a table, look at its title. The title will help you focus on what the table shows. Then read the column headings to see how the information is organized.

Spinoffs from space and ocean exploration are listed in **Table 1**.

Table 1 Spinoffs from Space and Ocean Exploration

Exploration technology	Examples
microelectronics	digital watches, computers, heart pacemakers, calculators, cordless tools
new materials	waterproof materials, flame-resistant materials, nonstick coating
ceramic materials	dental braces
plastics	safety helmets, in-line skates
space food	freeze-dried foods
robotics	building cars, mining, oil exploration
medicine	motion sickness patches, scanning equipment, fetal heart monitor, heart pump, kidney dialysis, insulin pumps, temperature pill, surgical probe

TRY THIS: *RESEARCH A SPINOFF*

Skills Focus: questioning, inferring

Look at the spinoff technologies listed in **Table 1**. Choose one technology and research how it was developed. For example, you could research the development of in-line skates or safety helmets (**Figure 3**). Make a time line for the technology. How is this technology used in daily life?

Figure 3
Helmets and in-line skates are spinoffs of exploration technology.

CHECK YOUR UNDERSTANDING

1. What is a spinoff? Why are spinoffs important?
2. What exploration spinoff do you think has the most impact on your life? Explain your choice.

Exploration and Your Health

12.2

The technology developed for space exploration has produced many medical spinoffs. For example, heart pacemakers, laser surgery, and medical imaging systems are three important spinoffs from space exploration.

We also benefit from medical experiments done in space. In space, substances mix together more easily, and crystals grow differently because of the microgravity environment. These conditions allow scientists to develop new medicines. Space medicines have been used to treat people on Earth who have diabetes, burns, and blood diseases. Research is also being done on producing medicines that are made with "space-grown" crystals.

Three Canadian astronauts—Dr. Roberta Bondar (**Figure 1**), Dr. Robert Thirsk, and Dr. Dave Williams (**Figure 2**)—are medical doctors who specialize in space medicine. They study the impact of working and living in space. As well, they experiment to find ways to apply what they have learned to help people on Earth. For example, astronauts are given medication to stop them from feeling dizzy during landing. This medication is now being used to treat heart patients on Earth.

Figure 1
Roberta Bondar flew on the space shuttle *Discovery* in 1992. The crew looked at how microgravity affects shrimp eggs, lentil seedlings, and bacteria. Dr. Bondar also investigated how humans adapt to weightlessness.

Figure 2
Dave Williams flew on the space shuttle *Columbia* in 1998. During the 17-day mission, the crew studied the effects of weightlessness on the nervous system. They also looked at how the inner ear, cardiovascular system, and muscles cope without gravity.

CHECK YOUR UNDERSTANDING

1. Give two reasons why scientists do medical experiments in space.
2. Why is it important to study the effects that living in space has on astronauts?

12.3 The Drawbacks of Exploration

The discovery of new species, spinoffs, knowledge about the world and the universe, and new energy sources are just some of the benefits of exploring extreme environments. However, there are also drawbacks to explorations.

Figure 1
The space shuttle *Columbia*

Space exploration, for example, is costly and dangerous. Since space exploration began, 18 astronauts have been killed on missions. The most recent space disaster occurred on February 2003, when the space shuttle *Columbia* (**Figure 1**) disintegrated upon re-entry to Earth's atmosphere. All seven of the astronauts on board were killed. Even training for space missions can be deadly. Ten astronauts have been killed in training accidents on the ground.

What orbits Earth, is found on the surfaces of the Moon, Venus, and Mars, and is greatly feared by space explorers? Space junk! Space junk includes broken satellites, discarded pieces of rockets, and even nuts and bolts from spacecraft. All human-made objects that remain in orbit and serve no useful purpose are called space junk. Space scientists estimate that there are millions of pieces of space junk floating around Earth (**Figure 2**).

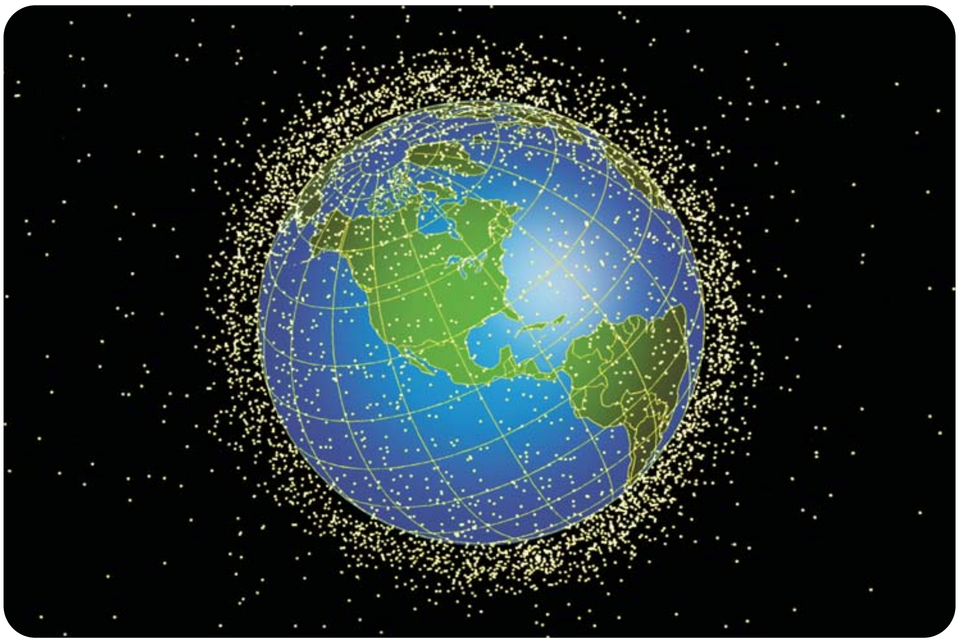


Figure 2
Space junk orbits Earth and poses a hazard to the International Space Station and to spacecraft.

Space junk comes in different sizes and shapes. Some pieces are as large as trucks. Others are smaller than a flake of paint. There's even a glove that floated away from the crew of *Gemini 4* during the first spacewalk and a camera lost by an astronaut during the *Gemini 10* mission. All this space junk zooms around Earth at speeds of up to 36 000 km/h.

Space junk poses a danger to working satellites and spacecraft because it travels at great speeds. Even small pieces can damage a spacecraft in a collision (**Figure 3**).

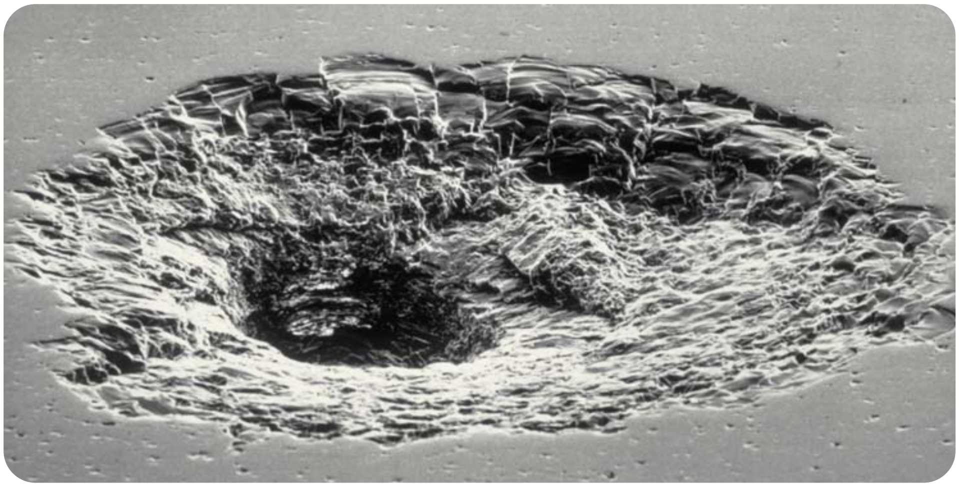


Figure 3
This tiny crater in the window of the space shuttle *Challenger* may have been caused by a flake of paint.

Ground stations track large pieces of space junk so that collisions with working satellites, spacecraft, and the International Space Station can be avoided. Different countries are also working on plans to stop the creation of space junk and to clean up what is already there. Perhaps a future job may be space junk collector!

Another drawback to exploration is cost. Billions of dollars are spent designing and testing vehicles for space and ocean exploration. This money could, perhaps, be better spent elsewhere. Or could it? In the next section, you will look at whether exploration is worth the cost.

CHECK YOUR UNDERSTANDING

1. What are some of the drawbacks of space exploration?
2. What is space junk? Where does space junk come from?
3. What drawbacks do you think are associated with exploring volcanoes or oceans?

12.4 Explore an Issue

> **LEARNING TIP**
>
> Before you begin this activity, read the section "Exploring an Issue" in the Skills Handbook.

Is Exploration Worth the Cost?

Exploration benefits us in many ways, from the spinoff technologies that we use in daily life to the discovery of new resources. However, the exploration of extreme environments is costly, and scientists don't always know whether an exploration will prove worthwhile.

The Issue

Some people believe that exploration, especially space exploration, costs too much. They would prefer to see the money used to deal with problems that are closer to home, such as social problems and pollution (**Figure 1**).

Figure 1
Some people believe that the money spent on exploring space should be spent on cleaning up polluted rivers and lakes.

Background to the Issue

Designing and developing the technology needed to explore extreme environments is very costly. For example, Canada's space program receives about $300 million from the federal government. Even though this is only a small amount of Canada's national budget, it represents a lot of money. People who support space and ocean exploration believe that the spinoffs and benefits outweigh the cost. What do you think? Is the exploration of extreme environments worth the cost?

Identify Perspectives

To decide whether the exploration of extreme environments is worth the cost, you must look at the issue from different perspectives. This means that you have to look at both the positive aspects and the negative aspects of exploration.

Working in groups of three, choose one of the extreme environments that you have learned about in this unit: polar regions, deserts, oceans, volcanoes, or space.

Use the Internet and the library to research your topic. Start by looking for information on recent expeditions to study the extreme environment that you have chosen. Make sure that you look at both the benefits and drawbacks of your topic. Use questions, such as the following, to help identify the information you need:

- What were the goals of the expeditions?
- What benefits could the expeditions provide?
- What technology did the exploration require?
- What were the problems, dangers, and costs of the exploration?

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How do you feel about about your topic after assessing the information that you found? Can you conclude whether this type of exploration is worth the cost?

Communicate Your Ideas

Share what you have learned with your class. You can make a presentation, design a poster, act out a scene, give a speech about your topic, or use a graphic organizer to present what you have learned.

CHECK YOUR UNDERSTANDING

1. Why is it important to consider both the benefits and costs of exploration?
2. What difficulties did you encounter in trying to weigh the benefits and the costs of exploration?

LEARNING TIP

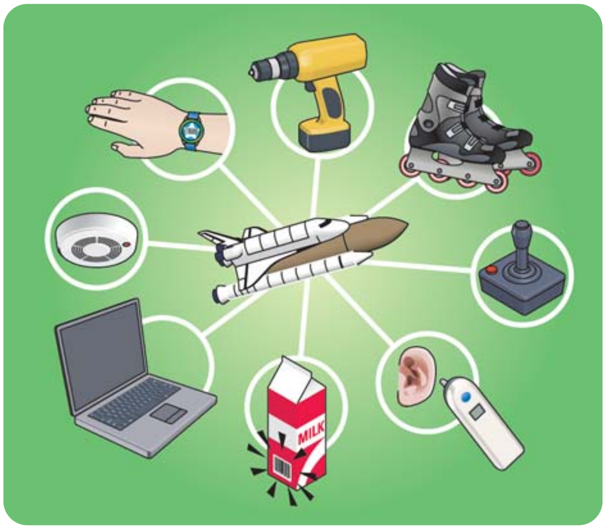
When you look at the benefits and drawbacks of something, you are looking at the pros and cons. What other topics have you learned about that were organized into pros and cons?

12

Chapter Review

Exploring extreme environments has both benefits and costs.

Key Idea: **The exploration of extreme environments produces spinoffs and other benefits.**

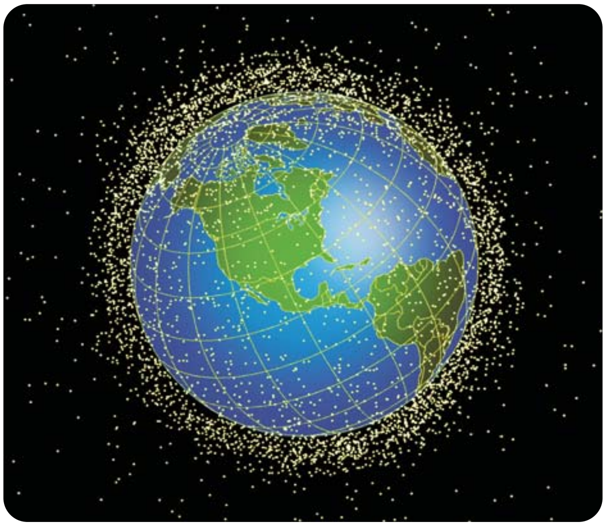


Many things that were created for exploring space are used in everyday life.

Vocabulary

spinoff **p. 229**

Key Idea: **The exploration of extreme environments has drawbacks and costs.**



There are millions of pieces of space junk floating around Earth.

Review Key Ideas and Vocabulary

When answering the questions, remember to use the chapter vocabulary.

1. What are some of the benefits of exploring extreme environments?
2. How are spinoffs related to space exploration? Give an example of a spinoff.
3. What are some of the drawbacks of exploring extreme environments?

Use What You've Learned

4. Think about different careers that are related to a spinoff of science exploration. Which career most interests you?
5. Look at **Figure 1**. What space missions are taking place right now? Do an Internet search to find out. Select one mission, and write a short description of its purpose.

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Figure 1
The Cassini-Huygens mission to Saturn began on October 15, 1997. It reached Saturn's rings on June 30, 2004.

6. Name three Canadian astronauts who have conducted health experiments on space shuttle missions. Research one of these astronauts.

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7. New medicines are being created in space. Research and write a paragraph about the work of Canadian astronauts in space health sciences.

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Think Critically

8. Dogs and chimpanzees were launched into space before humans. Many of the experiments done in the International Space Station involve fish, birds, snakes, frogs, rats, jellyfish, and insects. Why are animals sent into space? Does the benefit to humans outweigh the risk to animals? Discuss your answers in a small group.

Reflect on Your Learning

9. What spinoffs of exploration technology most surprised you? Why?
10. It is hard to believe that 50 years ago, video games did not exist and no one imagined working as a video-game programmer. Invent a career that you think will exist as a result of exploration technology when you are an adult.

UNIT C

Making Connections

Design an Exploration Vehicle

Looking Back

In this unit, you learned about extreme environments and the obstacles they present for human survival. You learned that technology allows people to travel to and survive in extreme conditions, like those found in space and in the oceans (**Figure 1**).

For this project, you will work with a partner to design and build a 3-D model of an exploration vehicle to travel to and investigate an extreme environment.

Demonstrate Your Learning

Part 1: Research an extreme environment

Which extreme environment would you like to explore? Choose one of the environments discussed in this chapter: polar regions, deserts, oceans, volcanoes, or space. Research the challenges that this environment would pose for an exploration vehicle. Also research the scientific principles that need to be incorporated into your design to overcome these challenges. For example, a submersible

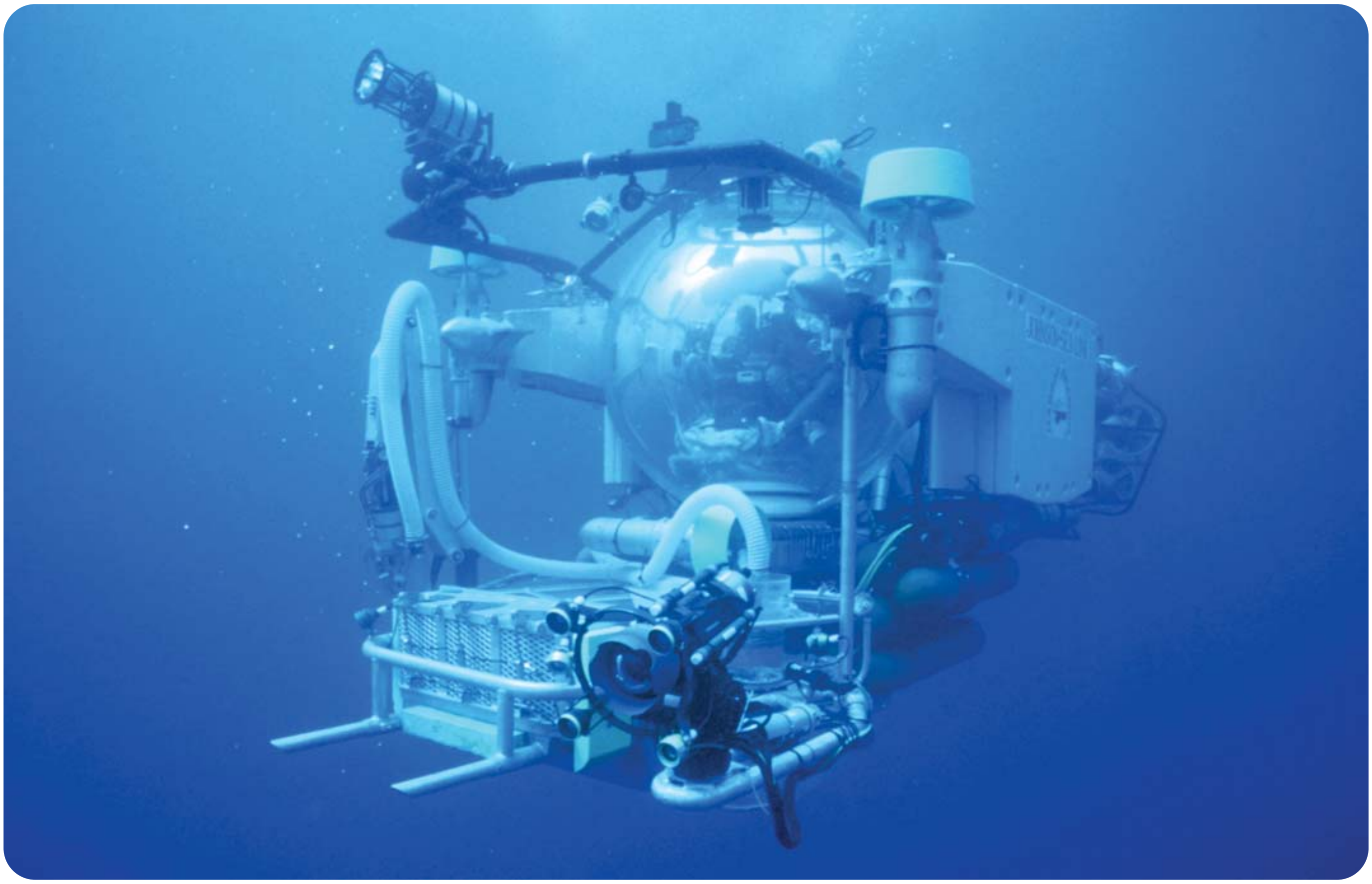


Figure 1
The *Johnson Sea-Link* is a submersible used to study life in deep water, perform search and recovery tasks, and conduct underwater archeological missions.

would need to have a pressurized hull to withstand the immense water pressure. A vehicle that is travelling over rough terrain would need large wheels (**Figure 2**).

Figure 2
NASA is developing Big Wheels, an inflatable robot rover, for future missions to Mars. Its large wheels will allow it to travel over rocky terrain.

Part 2: Brainstorm the design of an exploration vehicle

Brainstorm different ideas for the design of your exploration vehicle. Consider the following questions:

- What information do you want to collect about the extreme environment you are exploring?
- How will your vehicle gather this information? (For example, how will it take pictures or collect samples?) What devices and accessories will you need to collect scientific data?
- How is your vehicle controlled and guided? (For example, does it need a driver or is it remote controlled?)
- How will your vehicle move?

Draw a diagram of the model you want to build. Discuss the materials you will need to build your model.

Part 3: Build a model of your exploration vehicle

Build a model of your exploration vehicle. Use your diagram as a guide. Make any adjustments to your design as necessary.

Part 4: Communicate

Prepare a report about your exploration vehicle. Describe the environment in which your vehicle would be used. Also describe the function and purpose of your vehicle.

ASSESSMENT

MODEL

Check to make sure that your model of an exploration vehicle provides evidence that you are able to

- apply appropriate technology
- design a model that meets the conditions of an extreme environment
- work cooperatively with a partner

REPORT

Check to make sure that your report provides evidence that you are able to

- identify the information needed
- find appropriate sources of information
- identify and describe the conditions in an extreme environment
- use appropriate scientific language
- communicate clearly

THINKING AS A SCIENTIST

You may not think you're a scientist, but you are! You investigate the world around you, just like scientists do. When you investigate, you are looking for answers. Imagine that you are planning to buy a mountain bike. You want to find out which model is the best buy. First, you write a list of questions. Then you visit stores, check print and Internet sources, and talk to your friends to find the answers. You are conducting an investigation.

Scientists conduct investigations for different purposes:

- *Scientists investigate the natural world in order to describe it.* For example, oceanographers explore the deep ocean to study the habitats of deep-sea creatures and to look for new organisms.

- *Scientists investigate how objects and organisms can be classified.* For example, biologists examine organisms to see if they have one cell or many cells. By classifying organisms on the basis of their similarities and differences, scientists are able to organize their observations and learn about the relationships among living things.

- *Scientists investigate to test their ideas about the natural world.* Scientists ask cause-and-effect questions about what they observe. They propose hypotheses to answer their questions. Then they design experiments to test their hypotheses.

CONDUCTING AN INVESTIGATION

When you conduct an investigation or design an experiment, you will use a variety of skills. Refer to this section when you have questions about how to use any of the following investigation skills and processes.

- Questioning
- Predicting
- Hypothesizing
- Controlling Variables
- Observing
- Measuring
- Classifying
- Inferring
- Interpreting Data
- Communicating
- Creating Models

Questioning

Scientific investigations start with good questions. To write a good question, you must first decide what you want to know.

You must think carefully about what you want to know in order to develop a good question. The question should include the information you want to find out.

Sometimes an investigation starts with a special type of question, called a cause-and-effect question. A cause-and-effect question asks whether something is causing something else. It might start in one of the following ways:
What causes ...?
How does ... affect ...?
What would happen if ...?

When an investigation starts with a cause-and-effect question, it also has a hypothesis. Read "Hypothesizing" on page 244 to find out more about hypotheses.

PRACTICE

Think of some everyday examples of cause and effect, and write statements about them. Here's one example: "When I stay up too late, I'm tired the next day." Then turn your statements into cause-and-effect questions: for example, "What happens if I stay up late?"

Predicting

A prediction states what is likely to happen based on what is already known. Scientists base their predictions on their observations. They look for patterns in the data they gather to help them see what might happen next or in a similar situation. This is how meteorologists come up with weather forecasts.

Remember that predictions are not guesses. They are based on solid evidence and careful observations. You must be able to give reasons for your predictions. You must also be able to test them by doing experiments.

Hypothesizing

To test your questions and predictions scientifically, you need to conduct an investigation. Use a question or prediction to create a cause-and-effect statement that can be tested. This kind of statement is called a **hypothesis**.

An easy way to make sure that your hypothesis is a cause-and-effect statement is to use the form "If … then …" (**Figure 1**). For example, "If the number of times a balloon is rubbed against hair (the cause) is increased, then the length of time it sticks to a wall (the effect) increases."

When you conduct an investigation, you do not always prove that your hypothesis is correct. Sometimes you prove that your hypothesis is incorrect. An investigation that proves your hypothesis to be incorrect is not a bad investigation or a waste of time. It has contributed to your scientific knowledge. You can re-evaluate your hypothesis and design a new experiment.

PRACTICE

Write hypotheses for questions or predictions about rubbing a balloon on your hair and sticking it to a wall. Start with the questions above, and then write your own questions. For example, if your question is "Does the balloon stick better if you rub it more times?", then your hypothesis might be "If the number of times you rub the balloon on your hair is increased, then the length of time it sticks to the wall is increased."

Figure 1
This student is conducting an investigation to test this hypothesis: if the number of times the balloon is rubbed against hair increases, then the length of time it will stick to the wall will increase.

Controlling Variables

When you are planning an investigation, you need to make sure that your results will be reliable by conducting a fair test. To make sure that an investigation is a fair test, scientists identify all the variables that might affect their results. Then they make sure that they change only one variable at a time. This way they know that their results are caused by the variable they changed and not by any other variables (**Figure 2**).

- The variable that is changed in an investigation is called the **independent variable**.
- The variable that is affected by a change is called the **dependent variable**. This is the variable you measure to see how it was affected by the independent variable.
- All the other conditions that remain unchanged in an experiment, so that you know they did not have any effect on the outcome, are called **controlled variables**.

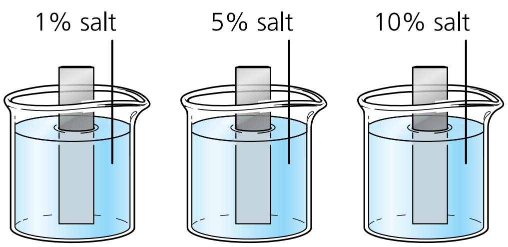


Figure 2

This investigation was designed to find out if the amount of salt in a solution has an effect on the rusting of metal.

- The amount of salt in each solution is the independent variable.
- The amount of rust on the pieces of metal is the dependent variable.
- The amount of water in each beaker and the amount of time the metal strip stays in the water are two of the controlled variables.

PRACTICE

Suppose that you have noticed mould growing on an orange. You want to know what is causing the mould. What variables will you have to consider in order to design a fair test? Which variable will you try changing in your test? What is this variable called? What will your dependent variable be? What will your controlled variables be?

Observing

When you observe something, you use your senses to learn about the world around you. You can also use tools, such as a balance, metre stick, and microscope.

Some observations are measurable. They can be expressed in numbers. Observations of time, temperature, volume, and distance can all be measured. These types of observations are called **quantitative observations**.

Other observations describe qualities that cannot be measured. The smell of a fungus, the shape of a flower petal, or the texture of soil are all examples of qualities that cannot be put in numbers. These types of observations are called **qualitative observations**. Qualitative observations also include colour, taste, clarity, and state of matter.

The colour and shape of this box are qualitative observations. The measurements of its height, depth, and width are quantitative observations.

PRACTICE

Make a table with two columns, one for quantitative observations and the other for qualitative observations. Find a rock that you think is interesting. See if you can make 10 observations about the rock. Record your observations in your table.

Measuring

Measuring is an important part of observation. When you measure an object, you can describe it precisely and keep track of any changes. To learn about using measuring tools, turn to "Measurement and Measuring Tools" on page 259.

Measuring accurately requires care.

Classifying

You classify things when you sort them into groups based on their similarities and differences. When you sort clothes, sporting equipment, or books, you are using a classification system. To be helpful to other people, a classification system must make sense to them. If, for example, your local supermarket sorted all the products in alphabetical order, so that soap, soup, and soy sauce were all on the same shelf, no one would be able to find anything!

Classification is an important skill in science. Scientists try to group objects, organisms, and events in order to understand the nature of life (**Figure 3**).

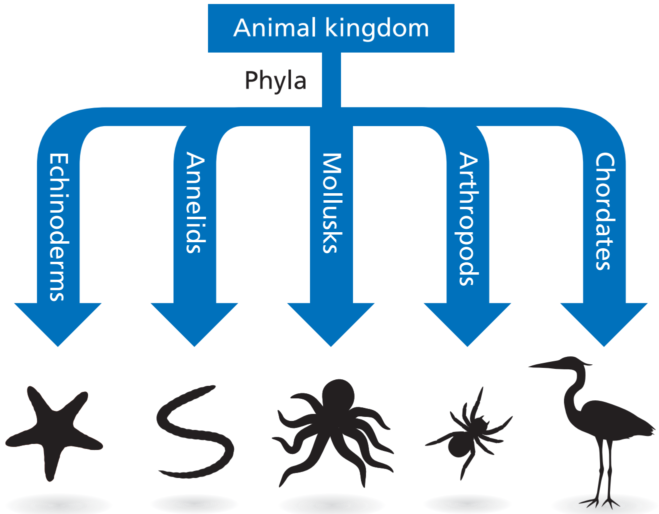


Figure 3

To help classify animals, scientists divide the animal kingdom into five smaller groups called *phyla* (singular *phylum*).

PRACTICE

Gather photos of 15 to 20 different types of insects, seashells, or flowers. Try to include as much variety as possible. How are all your samples alike? How are they different? How could you classify them?

Inferring

An inference is a possible explanation of something you observe. It is an educated guess based on your experience, knowledge, and observations. You can test your inferences by doing experiments.

It is important to remember that an inference is only an educated guess. There is always some uncertainty. For example, if you hear a dog barking but do not see the dog, you may infer that it is your neighbour's dog. It may, however, be some other dog that sounds the same. An observation, on the other hand, is based on what you discover with your senses and measuring tools. If you say that you heard a dog barking, you are making an observation.

PRACTICE

Decide whether each of these statements is an observation or an inference.

a) You see a bottle filled with clear liquid. You conclude that the liquid is water.

b) You notice that your head is stuffed up and you feel hot. You decide that you must have a cold.

c) You tell a friend that three new houses are being built in your neighbourhood.

d) You see a wasp crawling on the ground instead of flying. You conclude that it must be sick.

e) You notice that you are thirsty after playing sports.

Interpreting Data

When you interpret data from an investigation, you make sense of it. You examine and compare the measurements you have made. You look for patterns and relationships that will help you explain your results and give you new information about the question you are investigating. Once you have interpreted your data, you can tell whether your predictions or hypotheses are correct. You may even come up with a new hypothesis that can be tested in a new experiment.

Often, making tables or graphs of your data will help you see patterns and relationships more easily (**Figure 4**). Turn to "Communicating in Science" on page 271 to learn more about creating data tables and graphing your results.

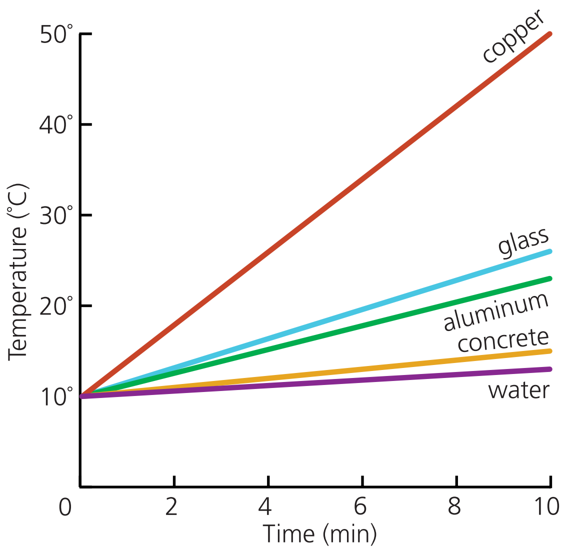


Figure 4
This graph shows data from an investigation about the heating rates of different materials. What patterns and relationships can you see from this data?

Communicating

Scientists learn from one another by sharing their observations and conclusions. They present their data in charts, tables, or graphs and in written reports. In this student text, each investigation or activity tells you how to prepare and present your results. To learn more about communicating in a written report, turn to "Writing a Lab Report" on page 274.

Creating Models

Have you ever seen a model of the solar system? Many teachers use a small model of the solar system when teaching about space because it shows how the nine planets orbit the Sun.

A scientific model is an idea, illustration, or object that represents something in the natural world (**Figure 5**). Models allow you to examine and investigate things that are very large, very small, very complicated, very dangerous, or hidden from view. They also allow you to investigate processes that happen too slowly to be observed directly. You can model, in a few minutes, processes that take months or even millions of years to occur.

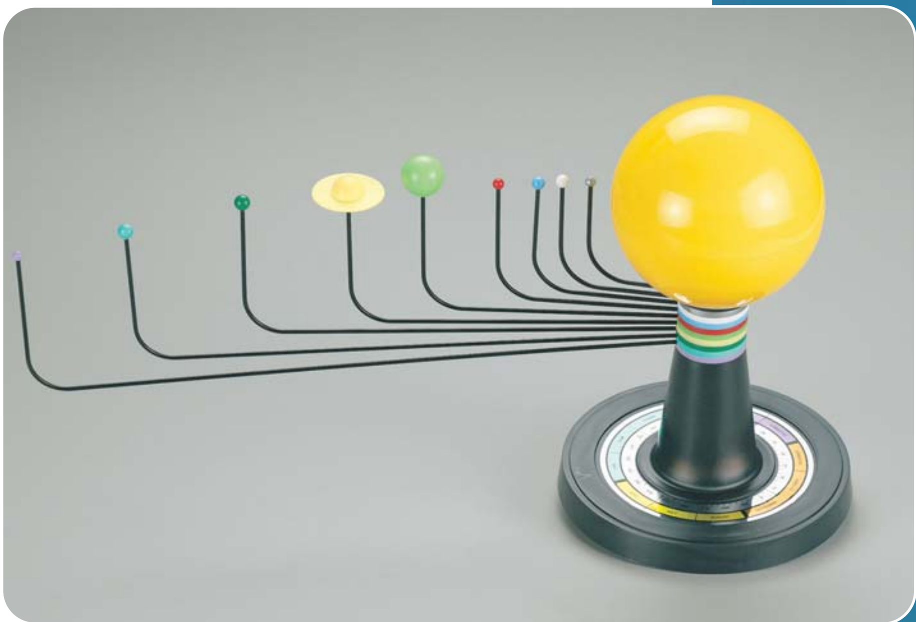
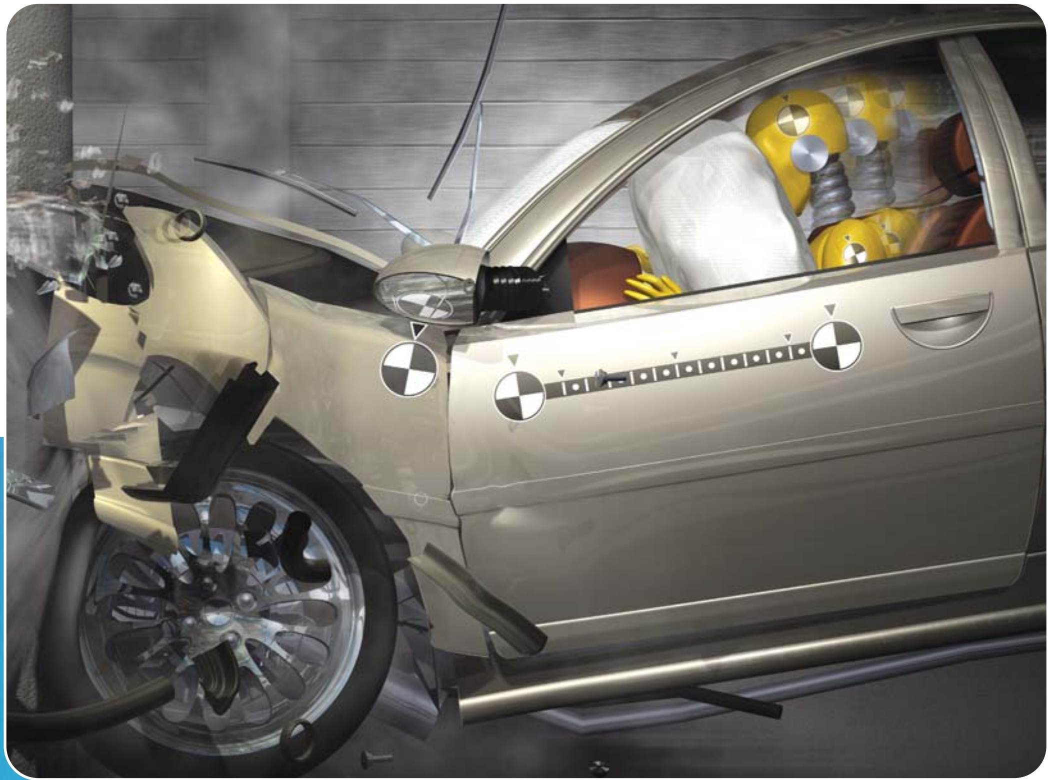
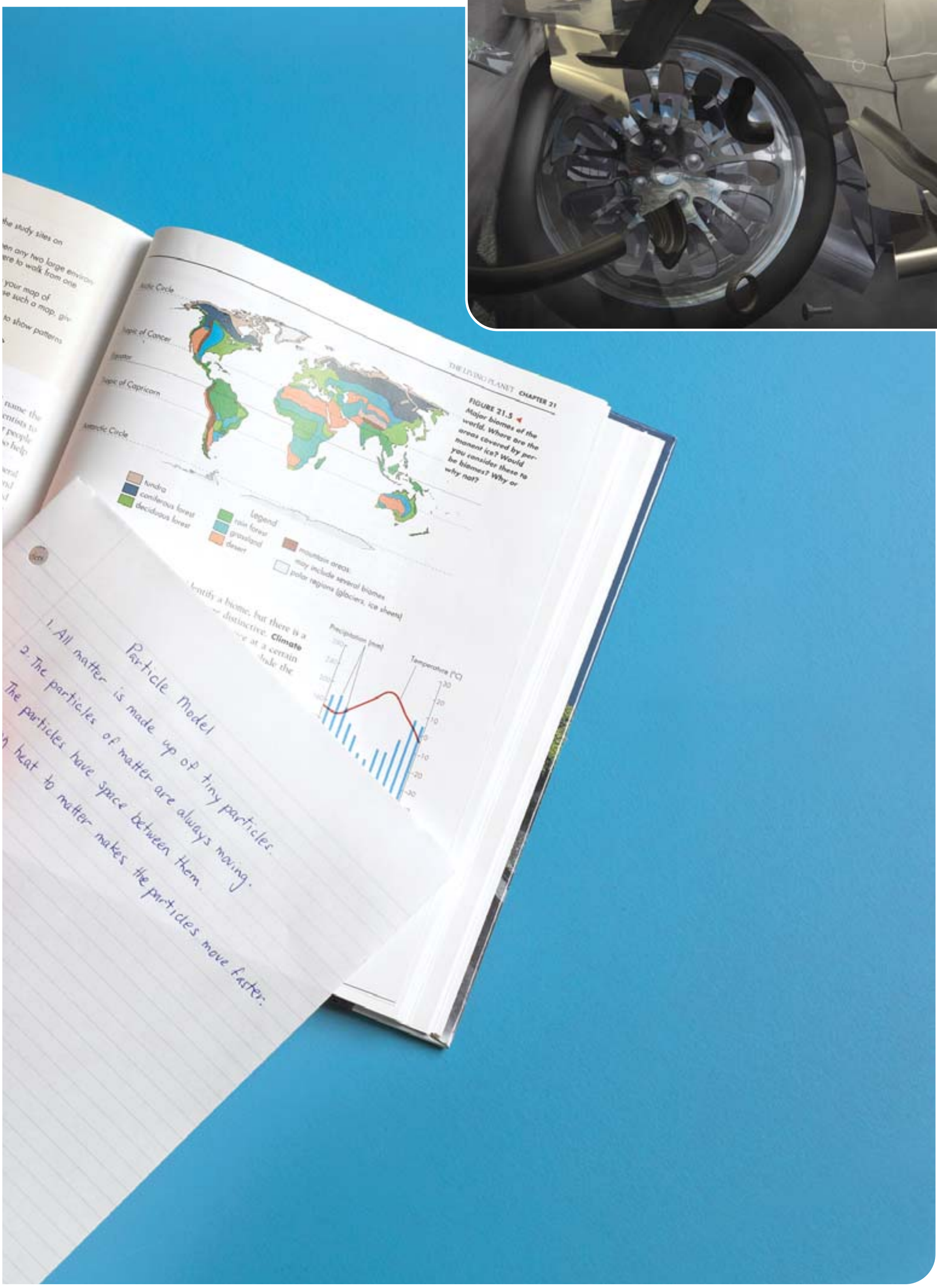


Figure 5
A model of the solar system (far left) is an example of a physical model. A paper airplane is also a physical model. When you throw a paper airplane, you test a model of a real airplane. Illustrations, such as maps, are also models. Models can also be created from stories and words. Models can be used to demonstrate dangerous situations, such as car crashes (far right). Can you think of any other models?

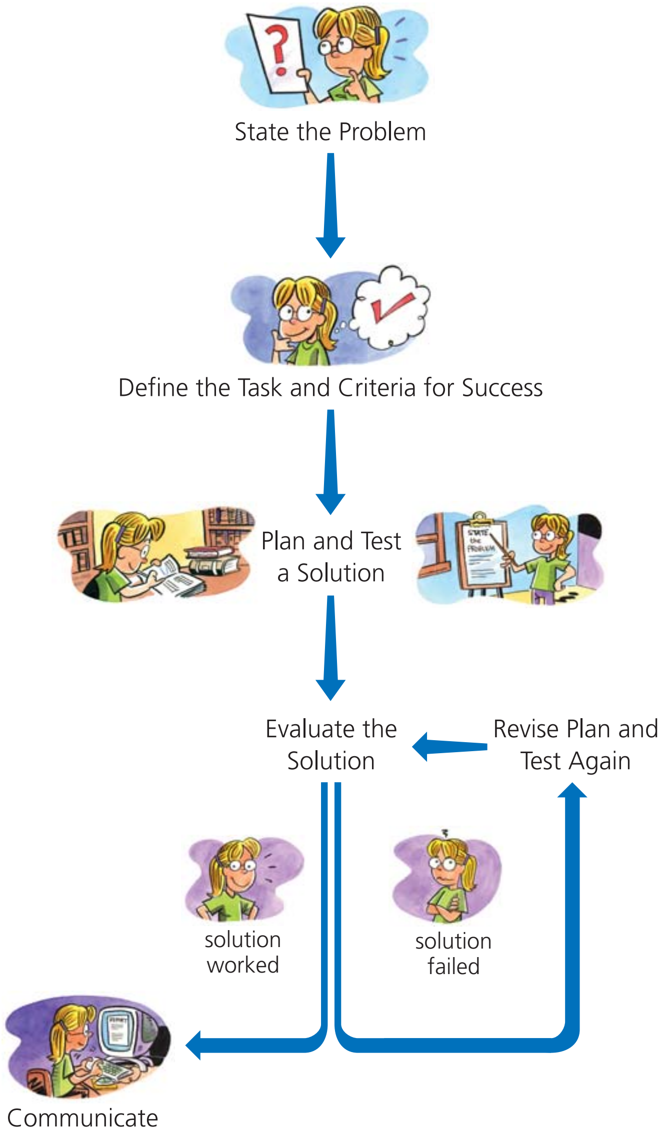




Particle Model
1. All matter is made up of tiny particles.
2. The particles of matter are always moving.
The particles have space between them.
heat to matter makes the particles move faster.

SOLVING A PROBLEM

Refer to this section when you are doing a "Solve a Problem" activity.



State the Problem

The first step in solving a problem is to state what the problem is. Imagine, for example, that you are part of a group that is investigating how to reduce the risk of people getting the West Nile Virus. People can become very sick from this virus.

When you are trying to understand a problem, ask yourself these questions:

- What is the problem? How can I state it as a problem?
- What do I already know about the problem?
- What do I need to know to solve the problem?

Define the Task and the Criteria for Success

Once you understand the problem, you can define the task. The task is what you need to do to find a solution. For the West Nile Virus problem, you may need to find a way to reduce the number of mosquitoes in your community because they could be carrying the West Nile Virus.

Before you start to consider possible solutions, you need to know what you want your solution to achieve. One of the criteria for success is fewer mosquitoes. Not every solution that would help you achieve success will be acceptable, however. For example, some chemical solutions may kill other, valuable insects or may be poisonous to birds and pets. The solution should not be worse than the problem it is meant to solve. As well, there are limits on your choices. These limits may include the cost of the solution, the availability of materials, and safety.

Use the following questions to help you define your task and your criteria for success:

- What do I want my solution to achieve?
- What criteria should my solution meet?
- What are the limits on my solution?

Plan and Test a Solution

The planning stage is when you look at possible solutions and decide which solution is most likely to work. This stage usually starts with brainstorming possible solutions. When you are looking for solutions, let your imagination go. Keep a record of your ideas. Include sketches, word webs, and other graphic organizers to help you.

As you examine the possible solutions, you may find new questions that need to be researched. You may want to do library and Internet research, interview experts, and talk to people in your community about the problem.

Choose one solution to try. For the West Nile Virus problem, you may decide to inspect your community for wet areas where mosquitoes breed, and try to eliminate as many of these wet areas as possible. You have discovered, through your research, that this solution is highly effective for reducing mosquito populations. It also has the advantage of not involving chemicals and costing very little.

Now make a list of the materials and equipment you will need. Develop your plan on paper so that other people can examine it and add suggestions. Make your plan as thorough as possible so that you have a blueprint for how you are going to carry out your solution. Show your plan to your teacher for approval.

Once your teacher has approved your plan, you need to test it. Testing allows you to see how well your plan works and to decide whether it meets your criteria for success. Testing also tells you what you might need to do to improve your solution.

Evaluate the Solution

The evaluating stage is when you consider how well your solution worked. Use these questions to help you evaluate your solution:

- What worked well? What did not work well?
- What would I do differently next time?
- What did I learn that I can apply to other problems?

If your solution did not work, go back to your plan and revise it. Then test again.

Communicate

At the end of your problem-solving activity, you should have a recommendation to share with others. To communicate your recommendation, you need to write a report. Think about what information you should include in your report. For example, you may want to include visuals, such as diagrams and tables, to help others understand your results and recommendation.

DESIGNING YOUR OWN EXPERIMENT

Refer to this section when you are designing your own experiment.

After observing the difference between his lunch and Dal's, Simon wondered why his food was not as fresh as Dal's.

Scientists design experiments to test their ideas about the things they observe. They follow the same steps you will follow when you design an experiment.

Ask a Testable Question

The first thing you need is a testable question. A testable question is a question that you can answer by conducting a test. A good, precise question will help you design your experiment. What question do you think Simon, in the picture above, would ask?

A testable question is often a cause-and-effect question. Turn to "Questioning" on page 243 to learn how to formulate a cause-and-effect question.

Develop a Hypothesis

Next, use your past experiences and observations to formulate a hypothesis. Your hypothesis should provide an answer to your question and briefly explain why you think the answer is correct. It should be testable through an experiment. What do you think Simon's hypothesis would be? Turn to "Hypothesizing" on page 244 to learn how to formulate a hypothesis.

Plan the Experiment

Now you need to plan how you will conduct your experiment. Remember that your experiment must be a fair test. Also remember that you must only change one independent variable at a time. You need to know what your dependent variable will be and what variables you will control. What do you think Simon's independent variable would be? What do you think his dependent variable would be? What variables would he need to control? Turn to "Controlling Variables" on page 244 to learn about fair tests and variables.

List the Materials

Make a list of all the materials you will need to conduct your experiment. Your list must include specific quantities and sizes, where needed. As well, you should draw a diagram to show how you will set up the equipment. What materials would Simon need to complete his experiment?

Write a Procedure

The procedure is a step-by-step description of how you will perform your experiment. It must be clear enough for someone else to follow exactly. It must explain how you will deal with each of the variables in your experiment. As well, it must include any safety precautions. Your teacher must approve your procedure and list of materials. What steps and safety precautions should Simon include?

Record Data and Observations

You need to make careful observations, so that you can be sure about the effects of the independent variable. Record your observations, both qualitative and quantitative, in a data table, tally chart, or graph. How would Simon record his observations?

Turn to "Observing" on page 245 to read about qualitative and quantitative observations. Turn to "Creating Data Tables" on page 271 to read about creating data tables.

Analyze Data

If your experiment is a fair test, you can use your observations to determine the effects of the independent variable. You can analyze your observations to find out how the independent and dependent variables are related. Scientists often conduct the same test several times to make sure that their observations are accurate.

Make a Conclusion

When you have analyzed your observations, you can use the results to answer your question and determine if your hypothesis was correct. You can feel confident about your conclusion if your experiment was a fair test and there was little room for error. If you proved that your hypothesis was incorrect, you can revise your hypothesis and perform the experiment again.

Apply Findings

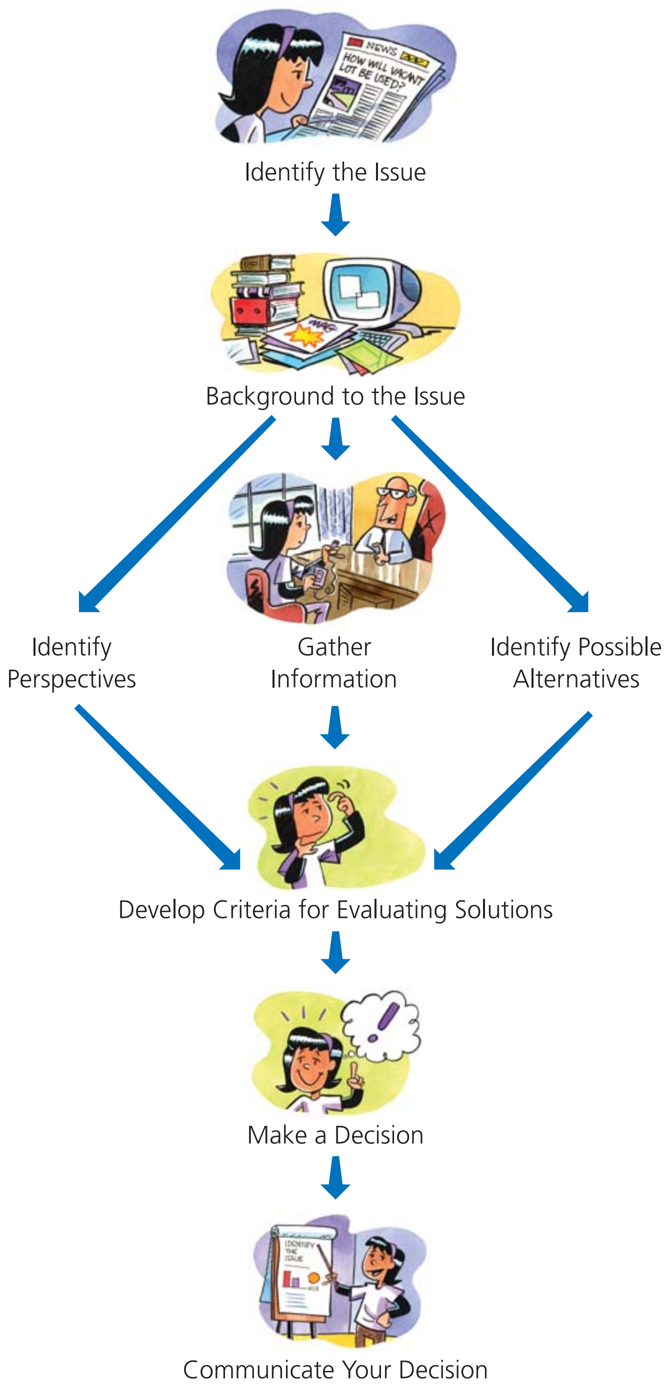
The results of scientific experiments add to our knowledge about the world. For example, the results may be applied to develop new technologies and medicines, which help to improve our lives. How do you think Simon could use what he discovered?

PRACTICE

You are a tennis player. You observe that your tennis ball bounces differently when the court is wet. Design a fair test to investigate your observation. Use the headings in this section.

EXPLORING AN ISSUE

Use this section when you are doing an "Explore an Issue" activity.



You make decisions everyday that can affect yourself, others, and the environment. What might seem like the right decision to you can look quite different to someone else. For example, you might think that bicycles are the only means of transportation that people need. But many other people rely on their cars and could not replace them with bicycles.

People hold different viewpoints about a lot of issues that affect other people and the environment. An issue is a situation in which several points of view need to be considered in order to make a decision. Often what different people think is the best decision is based on what they think is important or on what they value. Often, it is difficult to come to a decision that everyone agrees with.

When a decision has an impact on many people or on the environment, it is important to explore the issue carefully. This means thinking about all the possible solutions and trying to understand all the different points of view—not just your own point of view. It also means researching and investigating your ideas, and talking to and listening to others.

Identify the Issue

The first step in exploring an issue is to identify what the issue is. An issue has more than one solution, and there are different points of view about which solution is the best. Try stating the issue as a question: "What should ...?"

Background to the Issue

The background to the issue is all the information that needs to be gathered and considered before a decision can be made.

- *Identify perspectives.* There are always different points of view on an issue. That's what makes it an issue. For example, suppose that your municipal council is trying to decide how to use some vacant land next to your school. You and other students have asked the council to zone the land as a nature park. Another group is proposing that the land be used to build a seniors' home because there is a shortage of this kind of housing. Some school administrators would like to use the land to build a track for runners and sporting events.
- *Gather information.* The decision you reach must be based on a good understanding of the issue. You must be in a position to choose the most appropriate solution. To do this, you need to gather factual information that represents all the different points of view. Watch out for biased information, presenting only one side of the issue. Develop good questions and a plan for your research. Your research may include talking to people, reading about the issue, and doing Internet research. For the land-use issue, you may also want to visit the site to make observations.
- *Identify possible alternatives.* After identifying points of view and gathering information, you can now generate a list of possible solutions. You might, for example, come up with the following solutions for the land-use issue:
  - Turn the land into a nature park for the community and the school.
  - Use the land as a playing field and track for the community and the school.
  - Create a combination park and playing field.
  - Use the land to build a seniors' home, with a "nature" garden.

Develop Criteria for Evaluating Solutions

Develop criteria to evaluate each possible solution. For example, should the solution be the one that has the most community support? Should it be the one that protects the environment? You need to decide which criteria you will use to evaluate the solutions so that you can decide which solution is the best.

Make a Decision

This is the stage where everyone gets a chance to share his or her ideas and the information he or she gathered about the issue. Then the group needs to evaluate all the possible solutions and decide on one solution based on the list of criteria.

Communicate Your Decision

Choose a method to communicate your decision. For example, you could choose one of the following methods:

- Write a report.
- Give an oral presentation.
- Design a poster.
- Prepare a slide show.
- Create a video.
- Organize a panel presentation.
- Write a newspaper article.
- Hold a formal debate.

WORKING AS A SCIENTIST

GETTING OFF TO A SAFE START

Science activities and investigations can be a lot of fun. You have the chance to work with new equipment and substances. These can be dangerous, however, so you have to pay attention! You also have to know and follow special rules. Here are the most important rules to remember.

1 Follow your teacher's directions.

- Listen to your teacher's directions, and follow them carefully.
- Ask your teacher for directions if you are not sure what to do.
- Never change anything, or start an activity on your own, without your teacher's approval.
- Get your teacher's approval before you start an experiment that you have designed yourself.

2 Act responsibly.

- Pay attention to your own safety and the safety of others.
- Tell your teacher immediately if you see a safety hazard, such as broken glass or a spill. Also tell your teacher if you see another student doing something that you think is dangerous.
- Tell your teacher about any allergies or medical problems you have, or about anything else your teacher should know.
- Do not wear contact lenses while doing experiments.
- Read all written instructions carefully before you start an activity.
- Clean up and put away any equipment after you are finished.

3 Be science-ready.

- Come prepared with your student text, notebook, pencil, worksheets, and anything else you need for an activity or investigation.
- Keep yourself and your work area tidy and clean.
- Wash your hands carefully with soap and water at the end of each activity or investigation.
- Never eat, drink, or chew gum in the science classroom.
- Wear safety goggles or other safety equipment when instructed by your teacher.
- Keep your clothing and hair out of the way. Roll up your sleeves, tuck in loose clothing, and tie back loose hair. Remove any loose jewellery.

SAFE SCIENCE

Follow these instructions to use chemicals and equipment safely in the science classroom.

HEAT, FIRE, AND ELECTRICITY

- Never heat anything without your teacher's permission.
- Always wear safety goggles when you are working with fire.
- Keep yourself, and anything else that can burn, away from heat or flames.
- Never reach across a flame.
- Before you heat a test tube or another container, point it away from yourself and others. Liquid inside can splash or boil over when heated.
- Never heat a liquid in a closed container.
- Use tongs or heat-resistant gloves to pick up a hot object.
- Test an object that has been heated before you touch it. Slowly bring the back of your hand toward the object to make sure that it is not hot.
- Know where the fire extinguisher and fire blanket are kept in your classroom.
- Never touch an electrical appliance or outlet with wet hands.
- Keep water away from electrical equipment.

CHEMICALS

- If you spill a chemical (or anything else), tell your teacher immediately.
- Never taste, smell, touch, or mix chemicals without your teacher's permission.
- Never put your nose directly over a chemical to smell it. Gently wave your hand over the chemical until you can smell the fumes.
- Keep the lids on chemicals you are not using tightly closed.
- Wash your hands well with soap after handling chemicals.
- Never pour anything into a sink without your teacher's permission.
- If any part of your body comes in contact with a chemical, wash the area immediately and thoroughly with water. If your eyes are affected, do not touch them but wash them immediately and continuously with cool water for at least 15 min. Inform your teacher.

HANDLE WITH CARE

GLASS AND SHARP OBJECTS

- Handle glassware, knives, and other sharp instruments with extra care.
- If you break glassware or cut yourself, tell your teacher immediately.
- Never work with cracked or chipped glassware. Give it to your teacher.
- Use knives and other cutting instruments carefully. Never point a knife or sharp object at another person.
- When cutting, make sure that you cut away from yourself and others.

LIVING THINGS

- Treat all living things with care and respect.
- Never treat an animal in a way that would cause it pain or injury.
- Touch animals only when necessary. Follow your teacher's directions.
- Always wash your hands with soap after working with animals or touching their cages or containers.

Caution Symbols

The activities and investigations in *B.C. Science Probe 6* are safe to perform, but accidents can happen. This is why potential safety hazards are identified with caution symbols and red type (**Figure 1**). Make sure you read the cautions carefully and understand what they mean. Check with your teacher if you are unsure.

Wash your hands with soap and water after each time you work with the plants.

Figure 1
Potential safety hazards are identified with caution symbols and red type.

Safety Symbols

The following safety symbols are used throughout Canada to identify products that can be hazardous (**Figure 2**). Make sure that you know what each symbol means. Always use extra care when you see any of these symbols in your classroom or anywhere else.

PRACTICE

In a group, create a safety poster for your classroom. For example, you could create a map of the route your class should follow when a fire alarm sounds, a map of where safety materials (such as a fire extinguisher and a first-aid kit) are located in your classroom, information about the safe use of a specific tool, or a list of safety rules.

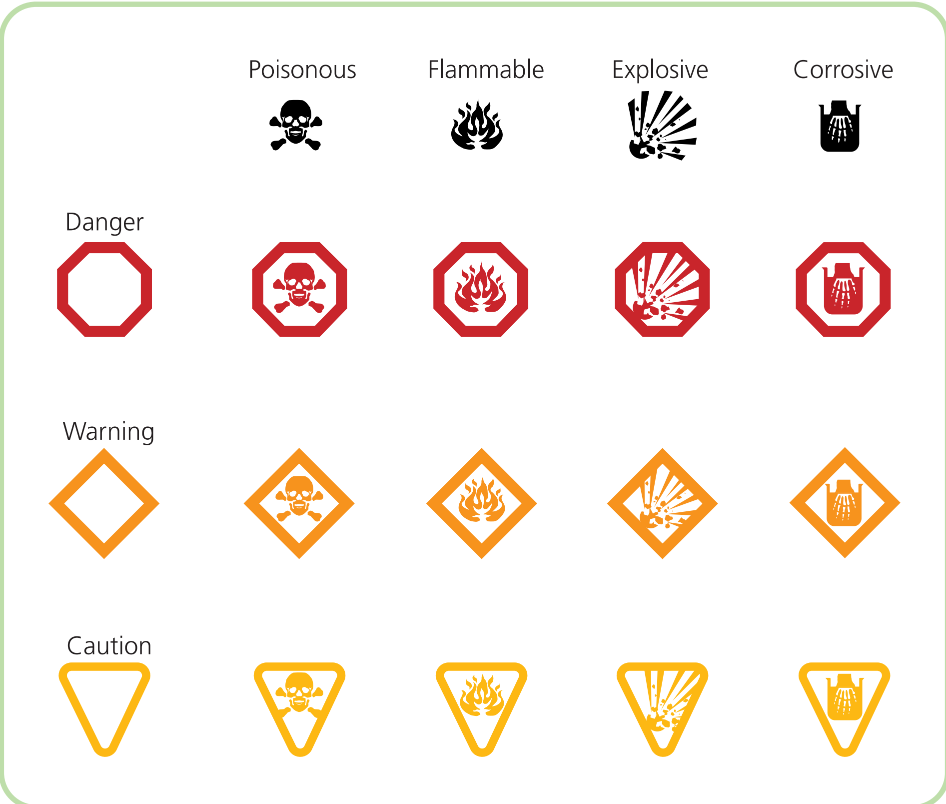


Figure 2
Hazardous Household Product Symbols (HHPS) appear on many products that are used in the home. Different shapes show the level of danger.

MEASUREMENT AND MEASURING TOOLS

Refer to this section when you need help with taking measurements.

Measuring is an important part of doing science. Measurements allow you to give exact information when you are describing something.

These are the most commonly used measurements:

- Length
- Mass
- Volume
- Temperature

The science community and most countries in the world, including Canada, use the SI system. The SI system is commonly called the metric system.

The metric system is based on multiples of 10. Larger and smaller units are created by multiplying or dividing the value of the base units by multiples of 10. For example, the prefix *kilo-* means "multiplied by 1000." Therefore, one kilometre is equal to one thousand metres. The prefix *milli-* means "divided by 1000," so one millimetre is equal to $\frac{1}{1000}$ of a metre. Some common SI prefixes are listed in **Table 1**.

Table 1 Common SI Prefixes

Prefix	Symbol	Factor by which unit is multiplied	Example
kilo	k	1000	1 km = 1000 m
hecto	h	100	1 hm = 100 m
deca	da	10	1 dam = 10 m
		1	
deci	d	0.1	1 dm = 0.1 m
centi	c	0.01	1 cm = 0.01 m
milli	m	0.001	1 mm = 0.001 m

Measuring Length

Length is the distance between two points. Four units can be used to measure length: kilometres (km), metres (m), centimetres (cm), and millimetres (mm).

10 mm = 1 cm
1000 mm = 1 m
100 cm = 1 m
1000 m = 1 km

You measure length when you want to find out how long something is. You also measure length when you want to know how deep, how tall, how far, or how wide something is. The metre is the basic unit of length (**Figure 3**).

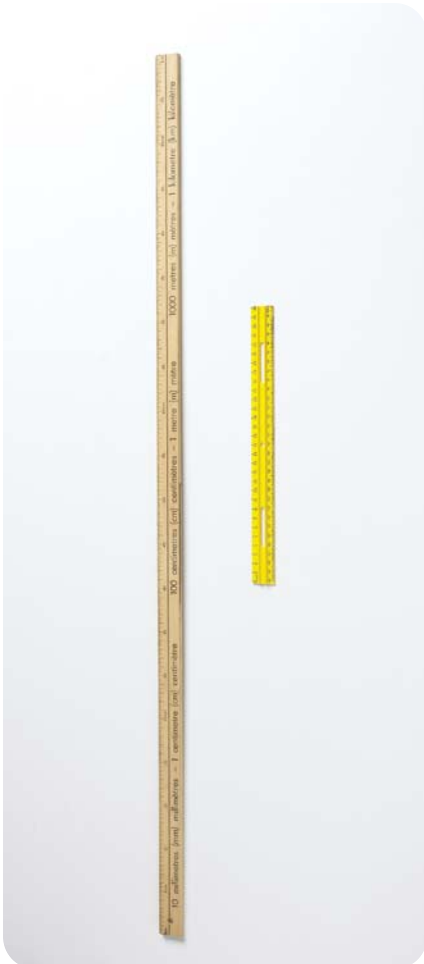


Figure 3
Metre sticks can be used to measure long lengths, up to 100 cm. Metric rulers are used to measure shorter lengths in millimetres and centimetres, up to 30 cm.

PRACTICE

Which unit—millimetres, centimetres, metres, or kilometres—would you use to measure each quantity?

a) the width of a scar or mole on your body
b) the length that your toenails grow in one month
c) your height
d) the length that your hair grows in one month
e) the distance between your home and Calgary
f) the distance between two planets

Tips for Measuring Length

- Always start measuring from the zero mark on a ruler, not from the edge of the ruler.
- Look directly at the lines on the ruler. If you try to read the ruler at an angle, you will get an incorrect measurement.
- To measure something that is not in a straight line, use a piece of string (**Figure 4**). Cut or mark the string. Then use a ruler to measure the length of the string. You could also use a tape measure made from fabric.

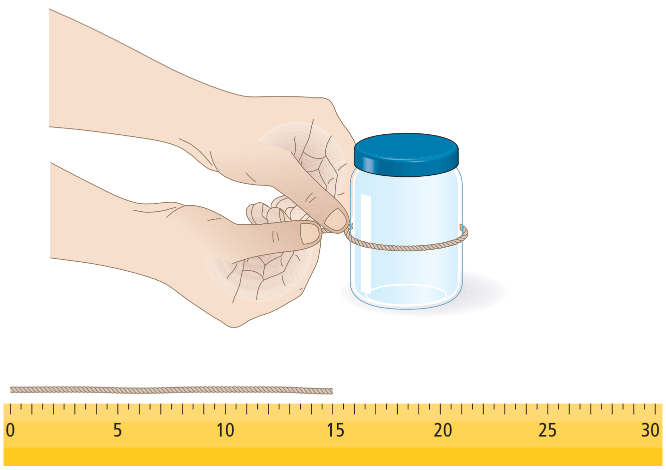


Figure 4

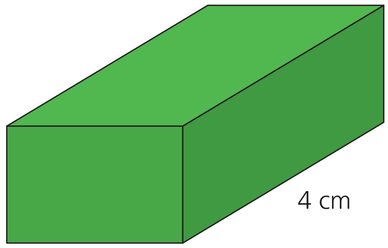
Measuring Volume

Volume is the amount of space that something takes up. The volume of a solid is usually measured in cubic metres (m^3) or cubic centimetres (cm^3). The volume of a liquid is usually measured in litres (L) or millilitres (mL).

1000 mL = 1 L	1 L = 1000 cm^3
1 cm^3 = 1 mL	1000 L = 1 m^3

The volume of a rectangular solid is calculated by measuring the length, width, and height of the solid and then by using the formula

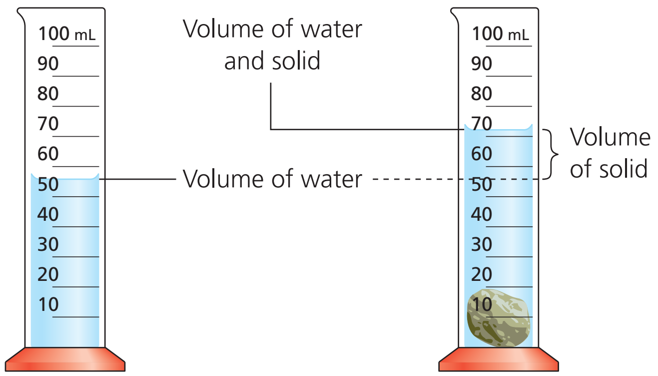
$$\text{volume} = \text{length} \times \text{width} \times \text{height}$$



Volume is also used to measure the amount of liquid in a container. Scientists use special containers, such as beakers and graduated cylinders, to get precise measurements of volume.

You can also use liquid to help measure the volume of irregularly shaped solids, such as rocks. To measure the volume of an irregularly shaped solid, choose a container (such as a graduated cylinder) that the irregular solid will fit inside. Pour water into the empty container until it is about half full. Record the volume of water in the container, and then carefully add the solid. Make sure that the solid is completely submerged in the water. Record the volume of the water plus the solid. Calculate the volume of the solid using the following formula:

volume of solid = (volume of water + solid) − volume of water



PRACTICE

What volume of liquids do you drink in an average day? Use the illustrations of volume measurements to help you answer this question.

Measuring cup
500 mL

Milk carton
1 L

Tablespoon
15 mL

Pop bottle
2 L

Tips for Measuring Volume

- Use a beaker that is big enough to hold twice as much liquid as you need. You want a lot of space so that you can get an accurate reading.
- To measure liquid in a graduated cylinder (or a beaker or a measuring cup), make sure that your eyes are at the same level as the top of the liquid. You will see that the surface of the liquid curves downward. This downward curve is called the **meniscus**. You need to measure the volume from the bottom of the meniscus (**Figure 5**).

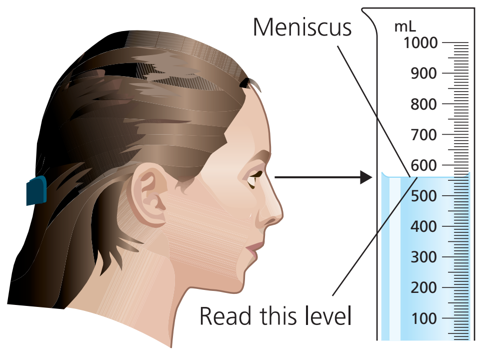


Figure 5
Reading the measurement of a liquid correctly

- Use a graduated cylinder to get the most accurate measurement of volume.

Measuring Mass

Mass is the amount of matter in an object. In everyday life, weight is often confused with mass. For example, you probably state your weight in kilograms. In fact, what you are really stating is your mass. The units that are used to measure mass are grams (g), milligrams (mg), kilograms (kg), and metric tonnes (t).

1000 g = 1 kg   1000 kg = 1 t
1000 mg = 1 g

Scientists use balances to measure mass. Two types of balances are the triple-beam balance (**Figure 6**) and the platform, or equal-arm, balance (**Figure 7**).

Figure 6
A triple-beam balance: Place the object you are measuring on the pan. Adjust the weights on each beam (starting with the largest) until the pointer on the right side is level with the zero mark. Then add the values of each beam to find the measurement.

Figure 7
A platform balance: Place the object you are measuring on one pan. Add weights to the other pan until the two pans are level. Then add the values of the weights you added. The total will be equal to the mass of the object you are measuring.

Tips for Measuring Mass

- To measure the mass of a liquid, first measure the mass of a suitable container. Then measure the mass of the liquid in the container. Subtract the mass of the container from the mass of the liquid and the container.
- To measure the mass of a powder or crystals, first determine the mass of a sheet of paper. Then place the sample on the sheet of paper, and measure the mass of both. Subtract the mass of the paper from the mass of the sample and the sheet of paper.

Measuring Temperature

Temperature is the degree of hotness or coldness of an object. In science, temperature is measured in degrees Celsius.

0 °C = freezing point of water
20 °C = room temperature
37.6 °C = normal body temperature
65 °C = water hot to touch
100 °C = boiling point of water

Measuring the temperature of water

Each mark on a Celsius thermometer is equal to one degree Celsius. The glass contains a coloured liquid—usually mercury or alcohol. When you place the thermometer in a substance, the liquid in the thermometer moves to indicate the temperature.

Tips for Measuring Temperature

- Make sure that the coloured liquid has stopped moving before you take your reading.
- Hold the thermometer at eye level to be sure that your reading is accurate.

COMMUNICATING IN SCIENCE

CREATING DATA TABLES

Data tables are an effective way to record both qualitative and quantitative observations. Making a data table should be one of your first steps when conducting an investigation. You may decide that a data table is enough to communicate your data, or you may decide to use your data to draw a graph. A graph will help you analyze your data. (See "Graphing Data," on page 272, for more information about graphs.)

Sometimes you may use a data table to record your observations in words, as shown below in the classification key set up as a table.

Observations from Investigation 7.2

Plant	Number of leaves on stem	Position of leaf on stem	Shape of leaf	Vein pattern of leaf	Size of leaf	Colour of leaf	Texture of leaf

Sometimes you may use a data table to record the values of the independent variable (the cause) and the dependent variables (the effects), as shown to the left. (Remember that there can be more than one dependent variable in an investigation.)

Average Monthly Temperatures in Cities A and B

Month	Temperature (°C) in City A	Temperature (°C) in City B
January	-7	-6
February	-6	-6
March	-1	-2
April	6	4
May	12	9
June	17	15

Follow these guidelines to make a data table:

- Use a ruler to make your table.
- Write a title that describes your data as precisely as you can.
- Include the units of measurements for each variable, when appropriate.
- List the values of the independent variable in the left-hand column of your table.
- List the values of the dependent variable(s) in the column(s) to the right of the independent variable.

GRAPHING DATA

When you conduct an investigation or do research, you often collect a lot of data. Sometimes the patterns or relationships in the data are difficult to see. For example, look at the data in **Table 1**.

Table 1 Average Rainfall in Campbell River

Month	Rainfall (mm)
January	142
February	125
March	128
April	73
May	59
June	50
July	40
August	43
September	62
October	154
November	210
December	197

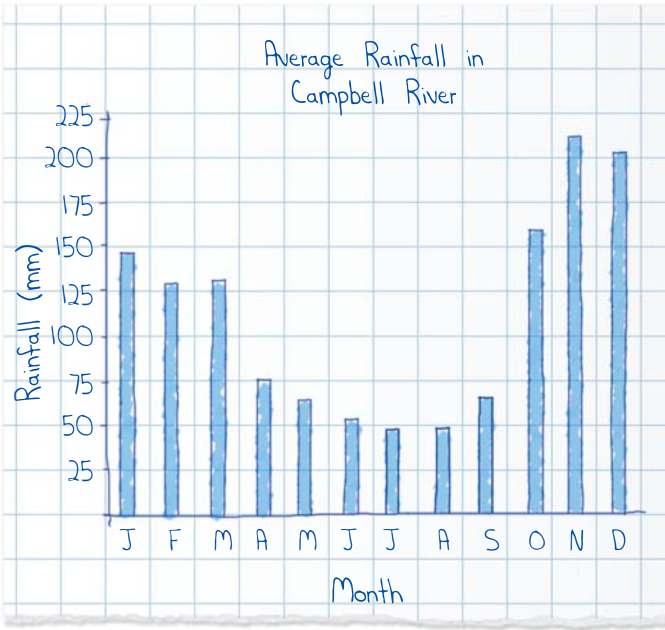
One way to arrange your data so that it is easy to read and understand is to draw a graph. A graph shows numerical data in the form of a diagram. There are three kinds of graphs that are commonly used:

- bar graphs
- line graphs
- circle (pie) graphs

Each kind of graph has its own special uses. You need to identify which type of graph is best for the data you have collected.

Bar Graphs

A **bar graph** helps you make comparisons and see relationships when one of two variables is in numbers and the other is not. The following bar graph was created from the data in **Table 1**. It clearly shows the rainfall in different months of the year and makes comparison easy.

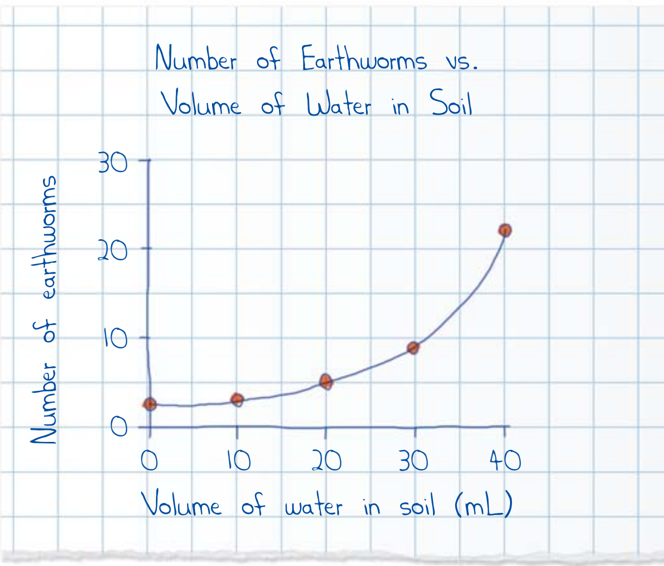


Line Graphs

A **line graph** is useful when you have two variables in numbers. It shows changes in measurement. It helps you decide whether there is a relationship between two sets of numbers: for example, "if this happens, then that happens." **Table 2** gives the number of earthworms found in specific volumes of water in soil. The line graph for these data helps you see that the number of earthworms increases as the volume of water in soil increases.

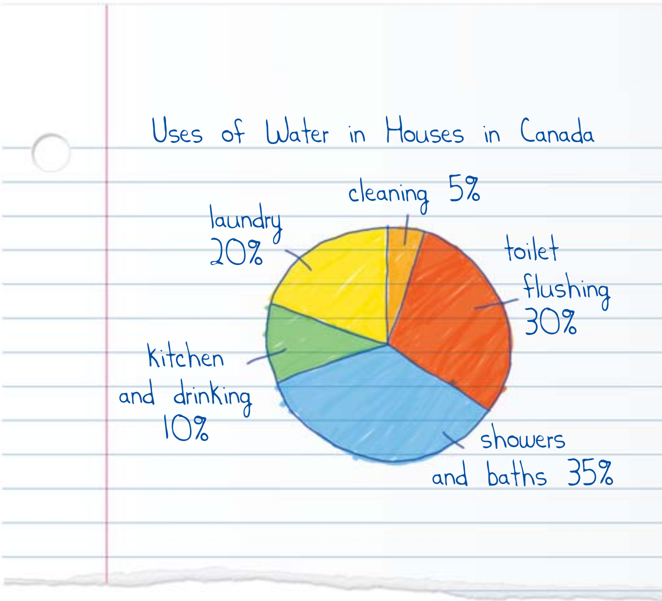
Table 2 Number of Earthworms per Volume of Water in Soil

Volume of water in soil (mL)	Number of earthworms
0	3
10	4
20	5
30	9
40	22



Circle Graphs

A **circle graph** (or pie graph) shows the whole of something divided into all its parts. A circle graph is round and shows how large a share of the circle belongs to different things. You can use circle graphs to see how the different things compare in size or quantity. It is a good way to graph data that are percentages or can be changed to percentages.



WRITING A LAB REPORT

When you design and conduct your own experiment, it is important to report your findings. Other people may want to repeat your experiment, or they may want to use or apply your findings to another situation. Your write-up, or report, should reflect the process of scientific inquiry that you used in your experiment.

> Write the title of your experiment at the top of the page.

Conductivity of Water

> List the question(s) you were trying to answer. This section should be written in sentences.

Question

Which type of water – pure water, water with dissolved sugar, or water with dissolved salt – conducts electricity the best?

> Write your hypothesis. It should be a sentence in the form "If … then …."

Hypothesis

If water is very pure, like distilled water with no solutes, then it will conduct electricity better than water with sugar or salt dissolved in it.

> Write the materials in a list. Your list should include equipment that will be reused and things that will be used up in the investigation. Give the amount or size, if this is important.

Materials

- 3 clean glass jars
- distilled water
- sugar
- salt
- 3 short strips of masking tape
- pen
- 2 D-cell batteries
- battery holder
- 1 piece of wire, 25 cm long
- 2 pieces of wire, each 10 cm long
- wire strippers
- light-bulb holder
- small light bulb (such as a flashlight bulb)

> Describe the procedure using numbered steps. Each step should start on a new line and, if possible, it should start with a verb. Make sure that your steps are clear so that someone else could repeat your experiment and get the same results. Include any safety precautions.
>
> Draw a large diagram with labels to show how you will set up the equipment. Use a ruler for straight lines.

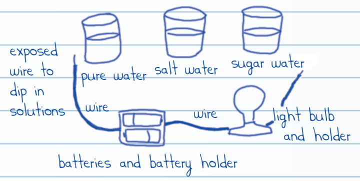
Procedure

1. Put 250 mL of distilled water in each clean jar. Do not add anything to the first jar. Add 30 mL of salt to the second jar, and mix. Add 30 mL of sugar to the third jar, and mix. Label the jars "pure water," "salt water," and "sugar water."
2. Put the batteries in the holder.
3. Strip the plastic coating off the last centimetre at the ends of all three wires, using the wire strippers.

CAUTION: Always pull the wire strippers away from your body.

4. Attach one end of the 25-cm wire to the knobby end of the battery by tucking it in the battery holder. The other end of the wire should hang free for now.
5. Attach one end of a 10-cm wire to the flat part of the battery. Attach the other end to the clip in the light-bulb holder.

6. Place the light bulb in the holder.
7. Attach one end of the other 10-cm wire to the clip in the light-bulb holder. Let the other end hang free for now.
8. Dip the loose wire ends into the distilled water. Observe whether the light bulb goes on. Record "yes" or "no."
9. Repeat step 8 for the other two types of water.



Data and Observations

Type of water	Does the light bulb go on?
distilled water	no
water with salt	yes
water with sugar	no

Present your observations in a form that is easily understood. The data should be recorded in one or more tables, with units included. Qualitative observations can be recorded in words or drawings. Observations in words can be in point form.

Analysis

The salt water was the only type of water that turned on the light bulb. Something in the salt must help to conduct electricity. Since the distilled water did not turn on the light bulb, this must mean that it cannot conduct electricity. Something is missing from the distilled water. The sugar water did not conduct electricity either, so it must also be missing the ingredient that helps to conduct electricity.

Interpret and analyze your results. If you have made graphs, include and explain them here. Answer any questions from the student text here. Your answers should include the questions.

Conclusion

Pure (distilled) water does not conduct electricity. The hypothesis is not supported by the data, so it is incorrect. Salt water conducts electricity.

A conclusion is a statement that explains the results of an experiment. Your conclusion should refer back to your hypothesis. Was your hypothesis correct, partly correct, or incorrect? Explain how you arrived at your conclusion. This section should be written in sentences.

Applications

Knowing that salt water conducts electricity might help scientists recover materials from seawater by running electricity through it. Also, I think the water in the human body has salt and other things dissolved in it. It would conduct electricity well, so people should be careful about electricity.

Describe how the new information you gained from doing your experiment relates to real-life situations. How can this information be used?

GLOSSARY

A

amphibian a class of vertebrates that is born in water, but develops legs and can walk on land; examples include frogs, toads, and salamanders

Animalia part of the scientific system of classification; one of the five kingdoms; examples include insects, birds, fish, and mammals

atom the tiny building block that makes up everything around you; the air you breathe and the clothes you wear are made up of atoms

B

battery an energy source that uses a chemical reaction to create an electric current; is actually two or more electric cells connected together; term is commonly used to refer to one cell

behaviour the way an organism responds to its environment

biomass any type of plant or animal tissue, such as wood, straw, and crop waste; biomass can be burned to heat water and create steam to turn turbines and generate electricity

bird a class of vertebrates with feathers, wings, and a beak; examples include eagles, parrots, and cardinals

buoyancy the ability to float in water

C

camouflage the colouring of an animal that allows it to blend into its environment

Canadarm a robotic manipulator arm developed by the Canadian Space Agency that is controlled by astronauts inside the space shuttle

cell a microscopic structure that is the basic unit of all living things; organisms can be made of as little as one cell (some types of bacteria) or as many as several trillion cells (human beings)

cell membrane a thin covering around an entire cell that acts as a gatekeeper by controlling which materials move into and out of the cell

chlorophyll a green pigment found in chloroplasts that gives plants and some protists their green colour

chloroplast the cell structure containing chlorophyll; found in plant cells and some protists

circuit made of a source of electricity, a pathway, and an electrical device to operate; electric current flows around a complete circuit

classification system the organization of living or non-living things according to their similarities and differences

closed circuit a circuit that is complete; allows the current to flow along the pathway

coal a hard fossil fuel made of ancient plants such as trees and ferns

colouration an adaptation of an organism's colour to help it survive in its environment; mimicry and camouflage are examples of colouration

conductor a material that lets electricity flow through it easily; for example, metals are good conductors

conservation the careful and responsible use of energy resources; for example, turning out the light when you leave a room

consumption the amount of electricity used by a household; determined by meters placed on the transmission line that comes into your home

cover slip a small, thin piece of glass used to cover an object or specimen on a microscope slide

current electricity electricity produced by a flow of electrons through a conductor, such as a wire

D

direct current current that flows in one direction; a battery produces electric current

E

electric current the continuous flow of electrons from one place to another along a pathway

electrocute death caused by electric current

electromagnetism magnetic forces produced by electricity

electron a negatively charged particle that makes up an atom

environment your surroundings; other living organisms, non-living objects, and weather all make up your environment

exploration voyage into unknown territory to investigate new frontiers and to search for new discoveries

extreme harsh; beyond normal limits; to the greatest degree

extreme environment a place where the conditions are so harsh that human survival is difficult or impossible; for example, deserts, volcanoes, and space are extreme environments for humans

F

fish a class of vertebrates with gills and fins that lives in water; examples include salmon, whale sharks, and rays

fossil fuels the most common non-renewable energy sources used to produce electricity; made from the remains of dead organisms that lived millions of years ago; coal, natural gas, and oil are the three types of fossil fuels

Fungi part of the scientific system of classification; one of the five kingdoms; examples include yeast and mushrooms

G

geothermal energy energy from deep inside Earth that heats water and produces steam, which can then be used to turn turbines and produce electricity

H

hibernation a method of coping with winter where an animal's body temperature drops, and its heartbeat and breathing slow down; chipmunks and ground squirrels are animals that hibernate

hydro refers to hydroelectric energy, which is the electricity generated by the conversion of energy from moving water; accounts for approximately 85% of all electricity generated in British Columbia

hydroelectric dam a barrier that stops the flow of water on a river; an electricity generating station that converts the energy of moving water into electricity

I

indigenous knowledge understandings, values, and beliefs about the natural world that are unique to a particular group or culture who have lived for a very long time in a particular area; this specialized knowledge is passed from generation to generation in the form of stories told, experiences shared, or songs sung by Elders or other people

insulator a material that resists the flow of electricity (such as wood) and prevents heat from escaping (such as a winter jacket)

invertebrate an animal that does not have a backbone, or spinal column; examples of invertebrates include insects, worms, and crabs

K

kingdom the most basic grouping of all living things in the scientific system of classification (taxonomy); this text uses the five-kingdom system of classification—Plantae, Fungi, Animalia, Protista, and Monera

L

life-support system a system that helps astronauts to survive in space; for example, life-support systems allow astronauts to breathe easily in space where there is a lack of air

lift the movement of air around an airplane's wing creating an area of low pressure under the wing and an area of high pressure over the wing; the high pressure under the wing pushes the wing up and forces the airplane upward

light bulb electrical device that changes electricity into light and heat

M

magnetism the property of attracting or repelling iron

magnify to make objects appear larger, as with a lens

mammal a class of vertebrates that breathe oxygen from the air and are warm blooded; examples include bats, mice, and humans

micro-organism a very small living thing that can only be seen with a microscope

microscope a device used for viewing very small objects or specimens

migration the seasonal movement of animals to a less harsh environment; for example, the elk moves from the mountains to spend the winter in the lowlands

mimicry an adaptation where an organism looks like another organism

Monera part of the scientific system of classification; one of the five kingdoms; example includes bacteria

multicellular made of more than one cell; humans, for example, are multicellular

N

natural gas a fossil fuel that comes from plankton (tiny plants and animals) that lived in ancient seas and lakes; usually found with oil, often in deep wells

negative the kind of electric charge carried by electrons

non-renewable something that once used up cannot be replaced; coal is an example of a non-renewable resource

nuclear energy energy that uses uranium as a fuel to heat water and produce steam, which turns a turbine and produces electricity

nucleus the cell structure that acts as the control centre by directing all of the cell's activities, such as movement and growth

O

open circuit a circuit that is incomplete, current cannot flow along the pathway

organism a living thing, such as a plant or an animal

P

parallel circuit a type of circuit in which current can travel through more than one pathway

Plantae part of the scientific system of classification; one of the five kingdoms; examples include mosses, trees, and flowers

positive the kind of electric charge carried by protons

Protista part of the scientific system of classification; one of the five kingdoms; examples include algae and paramecia

R

radar an acronym for RAdio Detection And Ranging; a device that sends out radio waves and picks up any echoes that are bounced back off objects to tell the distance, speed, direction of motion, and shape of the object; boats and ships searching for land, ice, and other ships use radar

recycle to reuse something rather than discarding it; for example, water on the International Space Station is recycled

renewable something that is constantly being replaced and is always there to use; water is an example of a renewable resource

reptile a class of vertebrates that breathe through lungs and has a body temperature that depends on the external temperature; examples include crocodiles, alligators, and snakes

S

satellite an object in space that revolves around Earth or any other planet

scuba an acronym for Self-Contained Underwater Breathing Apparatus; allows divers to carry their air supply on their backs

series circuit a type of circuit in which current has only one pathway to travel through

slide a piece of glass that an object, or specimen, is placed on to be viewed under a microscope

solar energy energy from the Sun; can be used to produce electricity by using mirrors to focus sunlight on water tanks and heat the water, producing steam which turns the turbines to generate electricity

sonar an acronym for SOund NAvigation and Ranging; a device that ships use to chart the depth of oceans using the echoes of sound waves

species organisms that are capable of breeding together and having fertile offspring

spinoff an everyday use of a technology that was first developed for another purpose; for example, bar codes used in grocery stores were first developed by NASA for space exploration

static electricity electricity where the electric charges are at rest, or not moving; caused by negative charges transferring from one object to another through rubbing; for example, electric charges built up in the clothes dryer or rubbing a balloon against your pet's fur

switch a device used to control the flow of electric current

T

technology tools that make it possible to survive in challenging environments

tidal energy energy created by filling a reservoir with ocean water at high tide, and later releasing the water through hydroelectric turbines as the tide goes back out in order to produce electricity

thrust an upward force

U

unicellular made of only one cell; a characteristic of organisms in the Kingdom Monera and most organisms in the Kingdom Protista

V

vertebrate animal with a backbone, or spinal column; birds, fish, and mammals are examples of vertebrates

voltage the force or push that moves electrons in a circuit

W

water pressure the application of force by water that increases with depth

wind power energy created by wind pushing against the blades of a wind turbine and turning it, which then turns a magnet that generates electricity

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