UNIT 3

Space

Several hundred kilometres above Earth's surface, an orbiting satellite records images of the Nova Scotia coastline below. These images help researchers predict changes in weather, changes in temperature, and directions of ocean currents. Also orbiting Earth is the International Space Station, where astronauts from all over the world stay and study our planet and space for weeks at a time.

People have always searched for ways to explore the sky above us. Early scientists and explorers often wondered about the shape of Earth, the twinkling stars, and the bright Sun. What explanations did they come up with? Were they correct? Today we are still exploring space, and forming our own explanations of the world beyond Earth's atmosphere. We have made important discoveries about planets, meteors, comets, and stars. We have also learned how everything from the changing seasons, to the number of hours in a day, to the number of days in a year are all connected to what is happening in space!

In this unit, you will expand your exploration into space and learn how Canadian technologies have helped explore the universe beyond our home planet. As you learn more about space, you will also find out how it affects what happens here on Earth.

Unit Contents

Getting Ready...

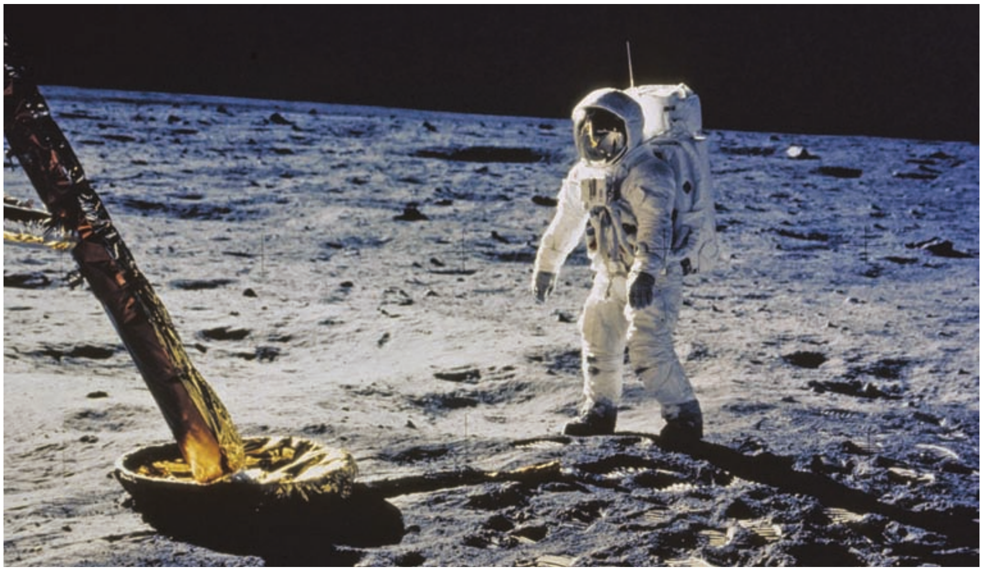
- What have people observed in space?
- How have Canadians contributed to technology that is used in space?
- How can events on Earth be explained by exploring the motions of Earth, the Moon, and the Sun?

CHAPTER 5

What is Out There?

Getting Ready...

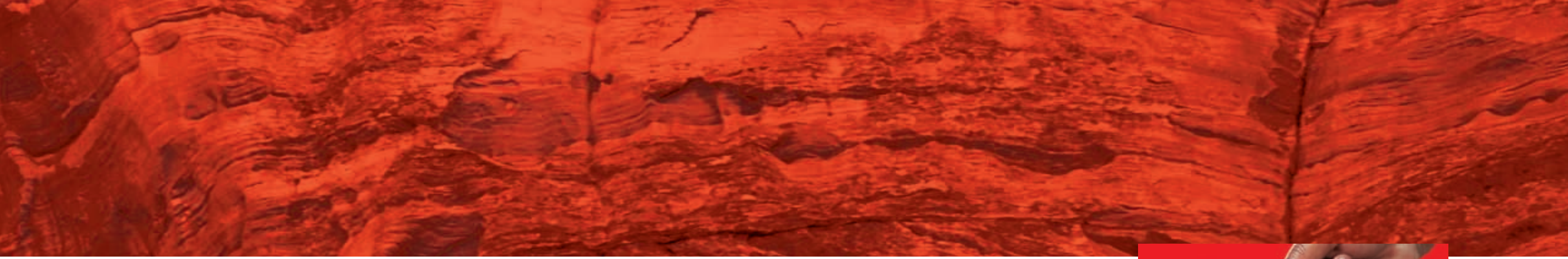
- What can we see in space?
- How have observations and knowledge about space changed over time?
- Why do you think it is important to study space?



The first humans stepped onto the Moon in July 1969. What knowledge and tools made their journey possible?

When Neil Armstrong first stepped onto the Moon in 1969, he said, "That's one small step for man, one giant leap for mankind." What do you think he meant by a "giant leap for mankind?" In order for the giant leap to happen, many questions needed to be answered. What materials would be suitable for the construction of a spacecraft? What fuel would provide enough energy to carry a spacecraft into space? What technology would be needed to allow people to survive outside Earth's atmosphere? How would space travellers communicate with people on Earth? How could the spacecraft return safely to Earth? Then scientists made that "giant leap" and began to develop the necessary tools and technologies to answer these questions.

While space shuttles, astronauts, and satellites may not seem new to us, imagine what people thought about space and what existed beyond Earth hundreds of years ago. In this chapter, you will learn what early people thought about the skies. You will find out how people learned about space and what they discovered. You will also learn about the tools needed to go to the Moon and to distant planets.



What You Will Learn

In this chapter, you will learn

- how ideas about Earth and space have changed over time
- how Canada contributes to space technology

Why It Is Important

- Technologies developed for exploring space can benefit people on Earth.
- Knowledge about what happens in space helps us explain what happens on Earth.

Skills You Will Use

In this chapter, you will

- observe movement in space
- model movement of Earth, the Sun, and the Moon
- simulate space technology

Why might you call spacecraft "the sailing ships of the twenty-first century"?

Starting Point ACTIVITY 5–A

Exploring Your Home Province

Exploring the province of Nova Scotia is not like exploring the Moon. Or is it? You may be surprised by how much technology you use every day.

What to Do

Group Work

1. In groups, make a list of the items you would need in each of the following situations. Hint: Think of what you need for safety, transportation, warmth, and food.
   (a) It is a cold, wet day. You are visiting a friend, but you must return to your home at the other side of town.
   (b) It is a hot summer night. You must get from Yarmouth to Halifax before morning.
   (c) You are driving along the Cabot Trail when a sudden snow storm closes the road. You must wait 48 h before the snow is cleared.

What Did You Find Out?

1. What were your three most important items for each situation? Explain why you chose each item.
2. Could you survive in each situation without these items? Explain.
3. Imagine that you are going to explore a large cave or perhaps a large desert about which you have no information. Draw and label a diagram listing the equipment that you would want to have with you on your exploration. How did the environment you chose affect your choices?

Section 5.1 Observing the Sky

Key Terms

- Earth-centred universe
- philosopher
- Sun-centred planetary system
- telescope
- binoculars
- observatory
- planet
- asteroid
- comet
- meteors
- meteorite

For most of human history, the only way that people could learn about Earth and the space around it was by simply observing the land and sky surrounding them. Until explorers began to chart distant places in the world in the 15th century, there were no maps or globes like the ones in your classroom. In fact, many Europeans had no idea that Earth was shaped like a globe at all. They believed the world was flat!

Thanks to the explorers and some ideas that came from philosophers more than 2000 years ago, knowledge about Earth's shape began to unfold. Inventions such as the telescope have also helped scientists begin to explain the skies around us. Telescopes make it possible to study objects in space in much more detail. Finally, in the last fifty years, space technology has allowed people to explore far beyond what our ancestors had even imagined.

READING Check

Hundreds of years ago, people believed Earth was flat. Explain why they thought this.

Ancient Ideas about Space

For thousands of years, people have been able to look to the skies to help them in their daily activities. The Sun would help them know the time of day; the cycle of the Moon would help them know the date; sailors would use the position of stars to guide them on their journeys. While all of this information helped, people still knew very little about Earth and the space around it.

Until a few hundred years ago, many people believed the world was flat. Now that may seem silly to you, but think about what early scientists and observers had to use for evidence. If you go to the ocean and look straight out as far as you can see, the line between the ocean and the sky looks straight. If you stand on a rooftop, the land before you seems to go on forever. So back then, people made the assumption that the earth was flat, and if you went far enough, you would eventually come to its edge.

Ancient ideas about the relationship between Earth and the Sun were also very different. Today we know that Earth orbits around the Sun. But for many people back then, they believed in an **Earth-centred universe**—meaning that everything, including the Sun, orbited around our world. It would take some courageous scientists to try and convince the world that these ideas were wrong.

THINK & LINK

INVESTIGATION 5-B

SKILLCHECK
- Inferring
- Predicting
- Communicating
- Interpreting Data

Sky Report

Have you ever looked up at the sky and wondered just what is out there? What have you seen when looking up on a clear night? Use your observation skills to take a closer look at the sky above us.

Think About It

What kinds of objects exist in space? How many can you name? What kinds of questions about space have you thought about while looking up at the stars?

What to Do

1. During the day or evening, gaze at the sky. What would you like to learn about space? Record your questions on a sheet of paper.
2. Choose one question from your list that you would like to try and answer.
3. Pretend you are a scientist in the 16th century, trying to find the answer to your question. This means that you will not have the benefit of the Internet to help you out!
4. Record what you think could be a possible answer, and explain your reasoning.
5. Then go to your library or the Internet to find information on your question.
6. Record the information you find.
7. In a report, compare your findings to what you had first answered on your own. Were you surprised by what you found out? Explain.

Analyze

1. After all your classmates have presented their reports, discuss how the answers helped you to better understand space.
2. What is the value for us to understand more about space and to keep asking questions?

Changing Ideas about Space

By the 15th century, our ideas about Earth and its position in the universe were changing. Scientists began to discuss the idea of a spherical Earth, or a globe-shaped Earth. Over 2000 years ago, ancient **philosophers**—people who try to understand the world and why things happen—had already suspected that Earth was a sphere. For example, the ancient philosopher Pythagoras knew that when he watched a ship sail away, the hull of the ship disappeared first, and the sails then dropped from view. Pythagoras believed that if Earth was actually flat, then a ship sailing away would get smaller and smaller but never disappear from view. Scientists and explorers in the 15th century began to use the information that these philosophers had found to help them prove that Earth was indeed spherical.

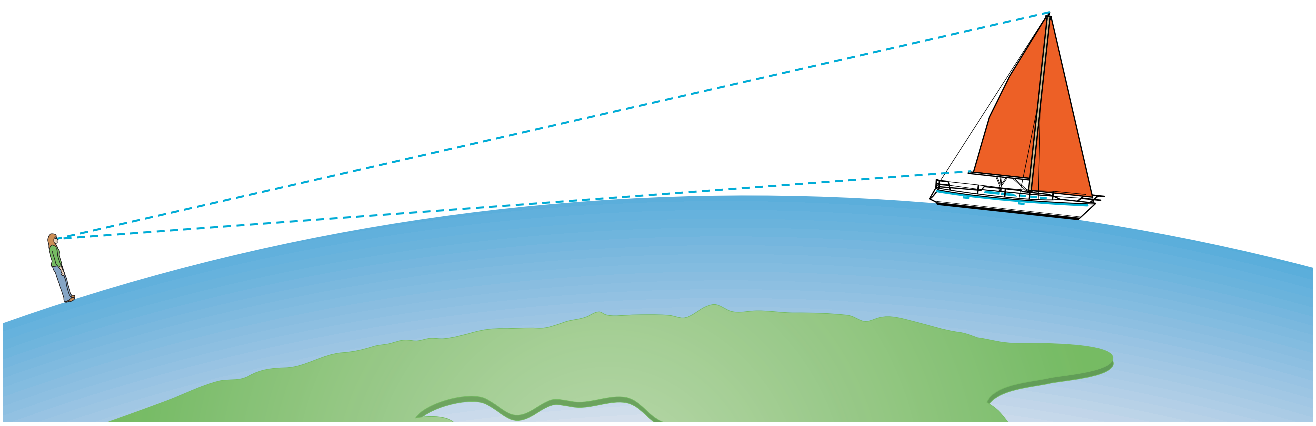


Figure 5.1 Over 2000 years ago, Greek philosopher Pythagoras suspected that Earth was a sphere because he noticed that a ship sailing into the horizon disappeared a piece at a time. He reasoned that if Earth was flat, the ship would never disappear from view.

As the ideas about Earth's shape were starting to change, so was the knowledge about Earth's position in the universe. In the early 1500s, the astronomer Nicholas Copernicus came up with the idea that it was the Sun, not Earth, that was the centre of Earth's planetary system. He believed that a spinning Earth orbited the Sun. The idea of a **Sun-centred planetary system** was not welcomed by many people, and it would take more scientists and some technological discoveries before people would finally agree that the Sun is the centre of our planetary system.

What You Can See from Earth

A **telescope** is an instrument that uses lenses and mirrors to collect light and small lenses in eyepieces to magnify distant objects. This allows the viewer to see objects more clearly. The telescope was developed by the Italian scientist Galileo Galilei in 1609. Using the telescope, Galileo (he was known by his first name) could see the craters on the Moon, Saturn's rings, and the four large moons of Jupiter. Today, bigger and better telescopes help people see much further than Galileo could. Scientists can also see much more detail, and these new telescopes have helped scientists discover many more objects in our universe.

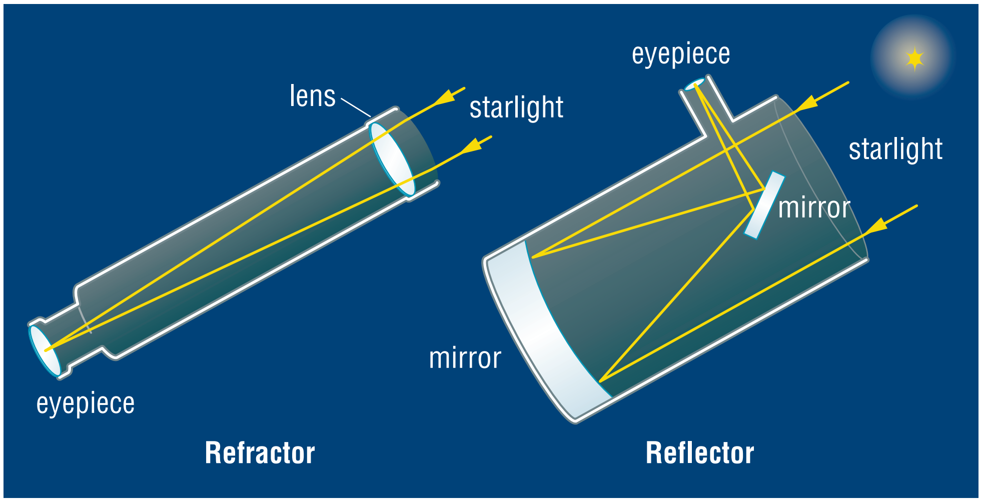


Figure 5.2 The job of a telescope is to gather as much light as possible into a small eyepiece or into a camera lens. There are two basic kinds of telescopes. Refractors use a large lens to collect light, and reflectors use a large curved mirror to collect light.

Another tool that was developed after the telescope was binoculars. **Binoculars** are really two telescopes that are hinged together and have an eyepiece that allows both eyes to view an object. The science behind binoculars is slightly different than telescopes, and the advantage of using binoculars is that it gives the viewer a better perception of distance.

Figure 5.3 Binoculars use prisms to shorten the optical path and lenses to collect the light from distant objects and enlarge the image for the viewer. Binoculars are usually less expensive than telescopes and can be used for viewing the Moon, comets, planets, and the Milky Way.

So, with better telescopes, how do present-day astronomers study the skies? Earth is surrounded by a dense atmosphere. That atmosphere can be filled with dust, clouds, smog, and haze that make the images dim and fuzzy. Especially near cities, tall buildings and light also make seeing the stars very difficult.

To get the best view of the sky, astronomers go to high mountain tops in remote areas, away from cities. These are the best places to build observatories. An **observatory** is a special type of building with a very large telescope. The roof of the observatory rotates and opens. Canadian astronomers share an observatory 4200 m above sea level on Mauna Kea in Hawaii. It is one of the world's best infrared observatories, which allows scientists to study the infrared light (radiant heat) coming from planets, stars, and galaxies. But even observatories on mountain tops do not always get the best pictures.

READING Check

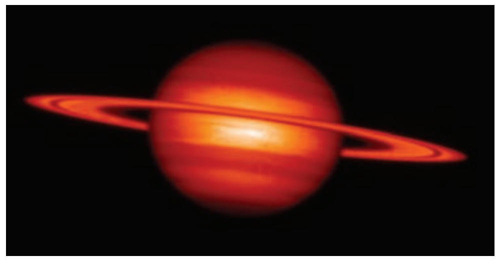
Explain why observatories are built away from cities.

Figure 5.4 The observatories at Mauna Kea in Hawaii sit on top of high mountains. Eleven countries share the various telescopes. Each telescope has a special function such as infrared or optical abilities.

To get the best quality astronomical images, telescopes that orbit above Earth's atmosphere are ideal. The most famous orbiting telescope is the Hubble Space Telescope, which was placed into low Earth orbit in 1990 with the help of Canadarm1 and the Space Shuttle *Discovery*.

Figure 5.5a The Hubble Space Telescope provides clearer images than Earth-based telescopes because it orbits outside of Earth's atmosphere.

Small backyard telescope



Canada-France-Hawaii Telescope

Hubble Space Telescope

Cassini-Huygens Spacecraft

Figure 5.5b View of the planet Saturn taken with various telescopes. How can you tell that the Cassini-Huygens photograph was taken by a spacecraft?

At Home **ACTIVITY 5–C**

The Moving Sky

Your view of the sky does not always stay the same. What you see will depend on your location and the time of day or year. In this activity, you will monitor changes in the night sky.

For this activity you will need to find a safe spot in your backyard, neighbourhood, park, or your schoolyard where you can observe stars in the nighttime sky. An east-facing window will do fine if it shows enough of the sky.

The task is to monitor the motion of the sky from hour to hour (for a few hours) and to monitor the motion of the Moon from night to night (for at least two nights in a row, but three or more are best).

What You Need

journal	clear view of the eastern sky
compass	clock

continued

What to Do

Part 1: Night One

1. Select a clear night when the Moon is near 1st quarter (that is when you can only see half of the Moon). Find a location and use your compass to find east. Your location should give you a clear view of the eastern sky, without trees or buildings in your way.

Select an observing location that will give you a clear view of the eastern horizon.

2. At your selected location, make a sketch showing the position of the Moon and one or two bright stars that are near the Moon. Record the exact time that you made your observation.

3. After exactly one hour, record the position of the Moon and the same bright stars on your sketch. If you are able to, repeat this step after exactly one more hour.

Part 2: Night Two

4. Repeat steps 1 to 3 exactly as you did the previous night.

5. If you are able to observe for extra nights, repeat steps 1 to 3 each night.

6. Prepare a report or poster that shows the changes in the Moon's position, and discuss your results with the class.

Analyze

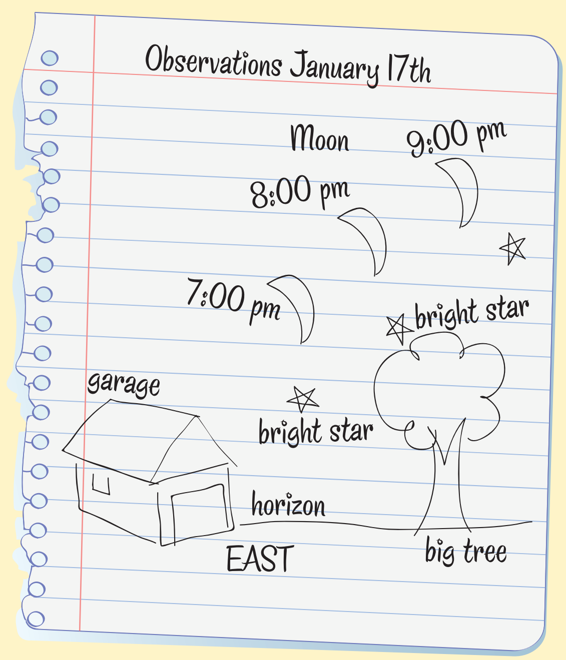
1. What happened to the Moon from the first time you observed it at night until the last time you observed at night?

2. How did the stars change during the same amount of time?

3. Did everyone in the class see the same thing?

4. Describe how you think the Moon and stars would change during several months or a year.

5. Observe the motion of the Moon and the stars over a period of several weeks or months.



A sample journal entry for one evening's observations showing the position of the stars and the Moon.

Watching the Skies

During the daytime, the cloudless sky is usually a brilliant blue colour. Because the day sky is so bright, you can usually only see the Sun and the Moon. (Yes, the Moon can often be seen in the daytime sky!) The Moon is the biggest object in the nighttime sky.

On a cloudless night, the sky in the countryside or seaside, away from smog and city lights, becomes deep black and is studded with thousands of twinkling stars. Early astronomers watching this sky noticed five unusual objects that looked almost like stars from Earth. Unlike stars, however, these five objects did not stay in the same place in relation to all the other stars in the sky. These moving objects are planets. A **planet** is a large body that orbits a star. Most of the planets have several moons in orbit around them, unlike Earth, which has just one moon. The word *planet* is derived from the Greek word *planētai* meaning "wanderer."

If modern astronomers watch the sky carefully for long enough, especially in the early evening or morning twilight, they will see some objects that look like stars moving across the sky. These are artificial satellites that orbit Earth high above the atmosphere.

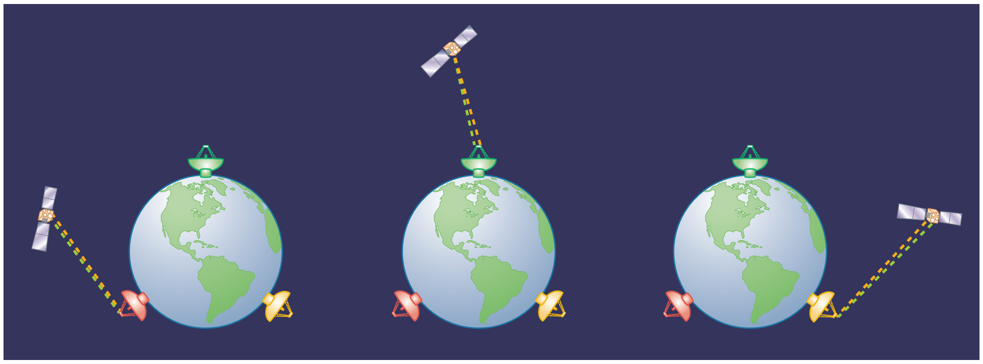


Figure 5.6 Satellites orbit Earth and transmit signals to receiving stations. These satellites can be used to send radio, television, and cellular phone signals.

Figure 5.7 This asteroid, named *Ida*, is so large that it has its own moon!

Asteroids, Comets, and Meteors

Along with planets, moons, satellites, and stars, there are many other objects in the solar system. Three of the most common objects are asteroids, comets, and meteoroids. An **asteroid** is an irregularly shaped rock orbiting the Sun. The larger ones are considered to be "minor planets" and can range in size from a few metres to hundreds of kilometres. The largest known asteroid is Ceres, which is almost 1000 km across! There are millions of asteroids in the solar system. A large number of them exist between Mars and Jupiter in what is called the "asteroid belt."

Occasionally comets appear in the sky. A **comet** is a mass of dust and ice that is surrounded by gases, water vapour, and rocky dust particles. Millions of comets orbit the Sun at large distances away from it. The orbits of comets, however, are very different in shape from the orbits of the planets. Comet orbits are long and narrow, and extend far out in space, even beyond our solar system. As the comet gets closer to the Sun, material begins to dissolve from the comet, forming tails that can be thousands of kilometres long. Two famous comets are Halley's Comet and Comet Hale-Bopp. These two comets are famous because their orbits are well-known, and scientists can predict when people will be able to see them.

Figure 5.8 Halley's Comet can be seen from Earth every 75–76 years. It appeared last in 1986. In what year will people be able to see it again?

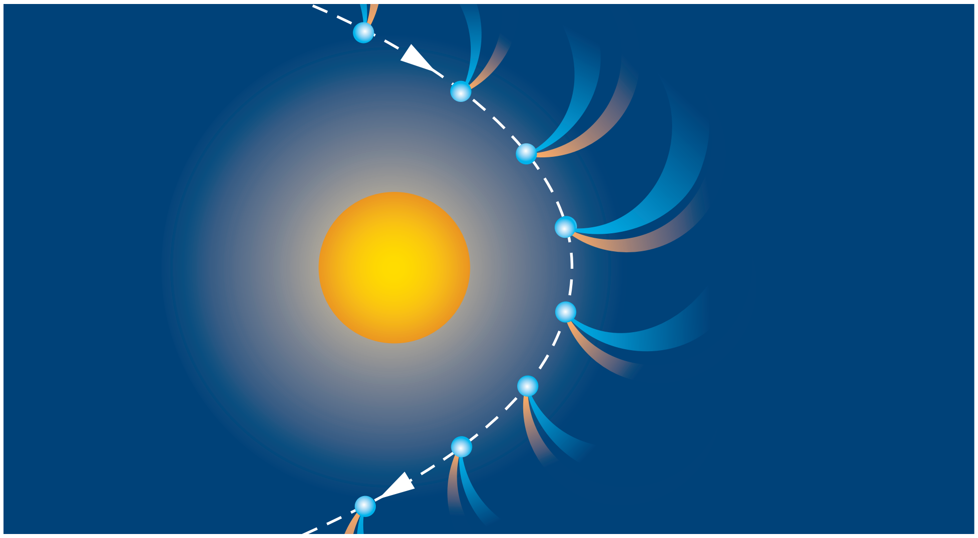


Figure 5.9 The dust tail and the gas tail of a comet always point away from the Sun. The dust tail usually is ahead of the gas tail.

Did You Know?

"Comet" comes from the Greek word for "hair." Early scientists thought comets looked like stars with hair flowing behind.

Every day, Earth's atmosphere is struck by thousands of rock fragments from space. We do not notice them because when they enter Earth's atmosphere, most of them burn up and nothing is left. If the fragment is large enough, it can create enough heat and light to make it visible in the sky. These are called **meteors**. Meteors are often called "shooting stars" because they look like a fast-moving star across the sky. If the fragment is very large, it can survive through the atmosphere and strike Earth's surface. These are called **meteorites**.

Figure 5.10 The Manicouagan Crater in Quebec was created 210 million years ago when a meteorite struck Earth's surface. The crater is about 70 km in diameter.

Off the Wall

The Moon has no atmosphere. This means it has no weather such as rain and wind. Because of this, footprints left by the first astronauts on the Moon in 1969 are expected to last for millions of years.

Moving on the Moon

After the first time astronauts walked on the Moon in 1969, a series of trips to the Moon soon followed to allow astronauts the chance to find out more about Earth's close companion. To help them get around on the Moon's surface, a vehicle called the Lunar Roving Vehicle (also called the LRV or the lunar buggy) was invented. The LRV allowed astronauts to leave their spaceship and travel on the surface of the Moon.

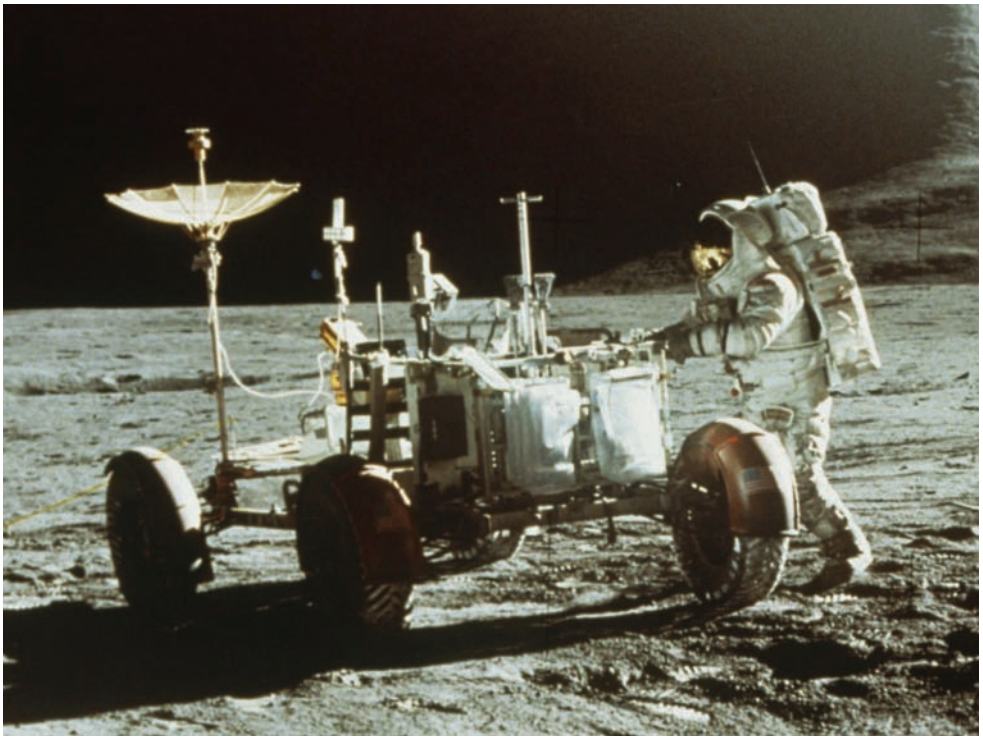


Figure 5.11 What types of information about the Moon do you think astronauts could gather when using the lunar buggy?

Did You Know?

The material for clear braces that orthodontists use is related to material created for space- and aircraft.

Surviving in Space

Did you know that many of the products that we use here on Earth were first developed for use in space? For example, smoke detectors were invented to help detect toxic vapours in an orbiting space station in 1973. And what about all those cordless tools such as cordless vacuum cleaners, drills, or screwdrivers? The first cordless tools were developed so astronauts could drill for samples on the Moon's surface. Where do you think the technology for the joystick that was used on early computer games came from? The joystick was first developed to help steer the Lunar Roving Vehicle!

INVESTIGATION 5-D

SKILLCHECK
- Observing
- Communicating
- Interpreting Data
- Making Inferences

Space Report

Think About It

What do you know about the extreme environment of space? For example, how far would you have to travel to explore the nearest planet? How would you get oxygen, food, and water? What hazards would you face during your space journey?

What to Do

1. As a class, brainstorm all the information you have learned about space so far. Record your ideas as single words or phrases on a large piece of paper.
2. In pairs or small groups, choose one topic that interests you. Your group will become class experts on that topic.

3. When you have made your choice, think about three or four questions related to the topic that you would like to answer. Record your questions in your notebook.
4. Use your library and the Internet to research the answers.
5. As you carry out your research, you may think of more questions or ideas. You may find out unexpected and interesting facts about your topic, including legends or stories about space from different cultures. Record any additional information that will fit with your final report
6. With your group, analyze all the data you have researched. Organize the data into different sections according to the question that it answers about your topic.
7. Prepare a group report of your findings for the class. Your report may be a model, display, poster, radio show, or other means approved by your teacher.

Analyze

1. After all the students have presented their reports, discuss what factors limit the exploration of space today. How might people overcome these limitations?
2. What is the value to people on Earth of exploring space?

Figure 5.12 How would science benefit from astronauts from different countries working together aboard the International Space Station?

Learning in Space

The year 2000 was the start of a new era in space exploration. People started living and working in a permanent base built in space. While we are here on Earth, astronauts are hundreds of kilometres above us conducting experiments and discovering new information.

The International Space Station (ISS) is an orbiting laboratory for long-term space research. Astronauts from all over the world spend weeks working together at the space station. They conduct experiments in biology, astronomy, and physics (the science that deals with matter, motion, energy, and force).

Even further away than the International Space Station, scientists are collecting information about planets such as Mars, and they are doing it without using astronauts. They do this by sending exploration vehicles on unmanned spacecraft. The exploration vehicles are remote-controlled, just like small racing cars or model airplanes. The movements of the exploration vehicles, called rovers, are directed by radio signals sent from Earth. In January 2004, two rovers like the one shown in Figure 5.13 began exploring Mars. Each rover arrived on the planet inside a lander that was launched from Earth many months earlier.

Off the Wall

The ISS circles Earth at a speed of almost 30 000 km/h. It sees 16 sunrises and sunsets within a day.

INTERNET CONNECT

www.mcgrawhill.ca/links/ns+science6

What do new scents for flowers, sandcastles, and thousands of tomato seeds have in common? They are all part of experiments in space. Go to the above web site and click on **Web Links** to find out where to go next.

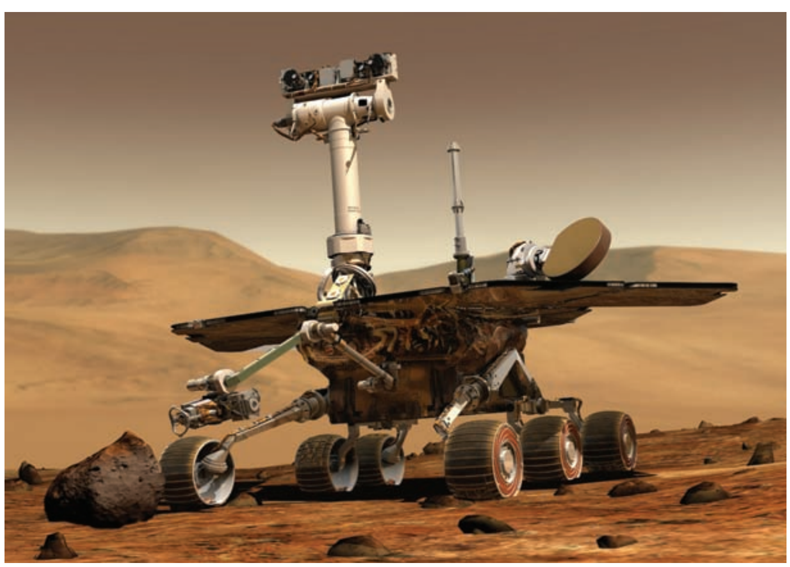


Figure 5.13 What are the advantages of a rover over a human explorer? What are the disadvantages?

A rover is equipped with some of the same tools a scientist would carry, such as a scraper to remove samples from the surface of rocks, and a camera to take and send pictures and other data to a team of scientists on Earth. The scientists look at the data they get and form a hypothesis about the information. Then they direct the rover to do tasks or take additional measurements and observations that test their hypothesis.

READING Check

What is a rover?

Canadian Technologies

Canadian scientists and engineers have been very active in contributing to the technology that is used to explore space. One of the most important contributions Canada has made is in the development of robotic arms for working in space.

Pause & Reflect

When we think of jobs in space, we often think of astronauts. How many other space jobs can you name? Which jobs are of interest to you? Record your ideas in a notebook.

Dextre

The robot in Figure 5.14 has a mass of nearly 1000 kg and has arms 3 m long. Despite its huge size, the robot can carry out tasks with a precise and gentle touch. This robot, named Dextre, is part of Canada's contribution to the International Space Station. Dextre was named after the term *dexterous*, which means being skillful in the use of your hands or body. Dextre is designed to carry out jobs normally done by astronauts during space walks, such as replacing small batteries, assembling parts, and manipulating scientific instruments. Having the robot do these jobs allows a lot of work to be done safely and efficiently without exposing astronauts to the hazards of working in space.

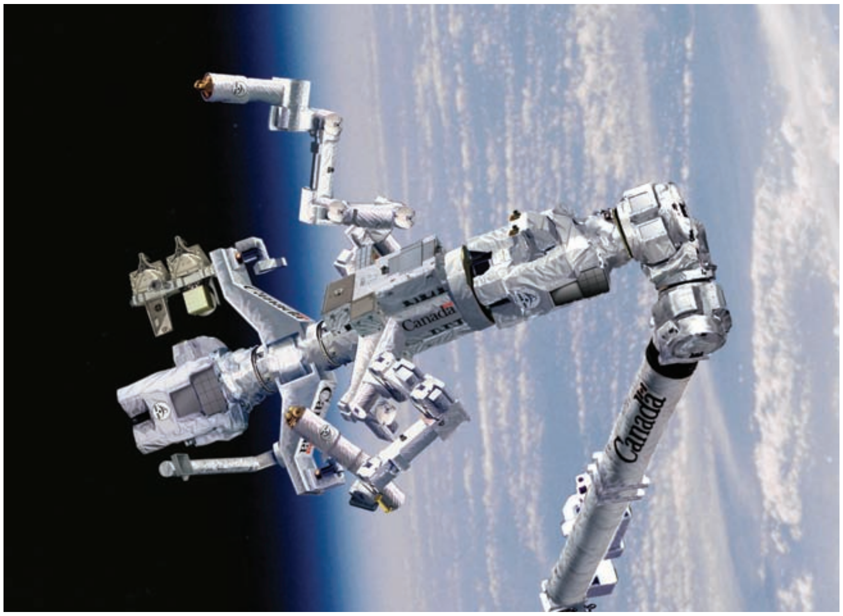


Figure 5.14 Dextre has arms that can turn, reach, and grip in fifteen different ways.

Canada to the Rescue

Dextre is a new technology that builds on Canadian experience with the Canadian remote manipulators Canadarm1 and Canadarm2. The Canadarm was first used on board the space shuttle *Columbia* on November 13, 1981. Since then it has been used on over 40 missions and has never failed.

One of Canadarm's tasks was to help capture and hold a five-tonne docking module, then turn the module 90° and lock it onto the space station. The Canadarm has also been used on missions to repair the Hubble Space Telescope and several communication satellites. Without the Canadarm, these satellites would have become unusable.

Figure 5.15 Look at the astronaut attached to the Canadarm. The astronaut is carrying an object toward the Hubble Space Telescope. The Canadarm also features the Canadian-developed and designed remote vision systems that allow the operators to see what they are doing.

Operating Canadarm

All Canadian astronauts are trained to operate Canadarm as well as to take space walks (work outside of the spacecraft or space station) and conduct scientific experiments. Canadian astronauts Chris Hadfield (Figure 5.16), Marc Garneau, Julie Payette, and Steve MacLean have all operated the Canadarm during missions into space.

Figure 5.16 Chris Hadfield was the first Canadian to operate the Canadarm, in 1995, on a mission to the Russian space station *Mir.*

READING Check

Who is Chris Hadfield?

Find Out **ACTIVITY 5–E**

Canadians and Space Exploration

Canadians have been important partners in the international exploration of space. Some Canadians have been astronauts, others have been engineers, astronomers, computer specialists, and vital support personnel. There are thousands of roles that need to be filled to safely and efficiently explore space.

What To Do

For one of the following Canadian contributions to space exploration and technology, perform an information search. Make a poster, write a report, or make a presentation explaining your finding to your class.

1. Research Canadarm1 and Canadarm2. Find out what is meant by the term "degrees of freedom."
2. Learn about Canada's development of robotic vision systems. What do they do and how are they important?
3. What are SciSat and RadarSat? For what purpose have they been built?
4. What is the Phoenix Lander? Where will it land? What Canadian instruments are on the Phoenix lander and what will they measure?
5. What is the CFHT? What do scientists do with the CFHT?
6. Take a tour of a university observatory or public observatory.

Canadian astronaut Chris Hadfield on a space walk.

7. Locate an amateur or professional astronomer in your area. Invite them to give a presentation to your class or conduct an interview. Report back to your class what you learned during the interview.
8. Write a biography of one of the Canadian astronauts such as Steve MacLean, Bjarni Tryggvason, Dave Williams, Chris Hadfield, Bob Thirsk, Julie Payette, Mark Garneau, or Roberta Bondar.

CONDUCT AN

INVESTIGATION 5-F

SKILLCHECK
- Observing
- Measuring
- Interpreting Data
- Modelling

Working in a Spacesuit

Take the challenge! Make yourself a spacesuit, then see how well you can work without the suit compared with wearing the suit.

Question

How well can you carry out different tasks while wearing a spacesuit?

Safety Precautions

- Take care using scissors.

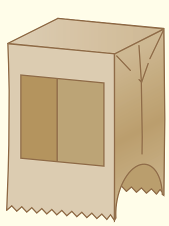
Materials

clock or stopwatch
scissors
pair of hockey gloves or oven mitts
school bag or backpack with zipper
CD or DVD in hard plastic case
jar with screw-top lid filled with dry macaroni
pen or pencil
wool socks
pull-on boots or shoes
6 clean empty 2 L milk or juice cartons
duct tape
3 sheets of $8\frac{1}{2} \times 11$ paper
resealable bag
brown paper grocery bag

Procedure

Making a Space Helmet

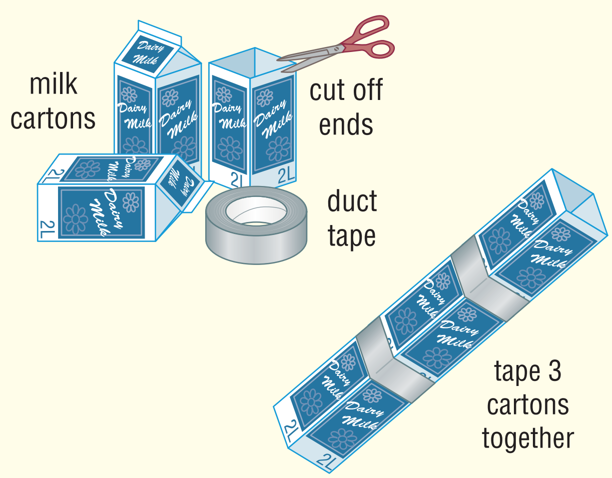
1. Cut an 18 cm × 10 cm rectangle out of the middle of one side of a brown paper bag.
2. Cut a semi-circular piece from opposite sides of the top of the bag so that the bag will fit around the shoulders when placed over the head.



paper bag helmet

Making Spacesuit Arms

3. Cut off both ends of the milk cartons.
4. Join three cartons together with duct tape for each arm. Put your arms and helmet in a safe place.



Preparing the Challenge

5. Place the jar of macaroni, resealable bag, sheets of paper, pen or pencil, socks, boots, and CD or DVD in the school bag and close the zipper.

6. Prepare a data table to record the results of the five tasks described below.

Taking the Challenge

7. Working with a partner, carry out all five tasks (see below). Record the time it takes to complete all the activities.

Task 1	Remove all the contents of the school bag.
Task 2	Remove the CD or DVD from its case and exchange it with your partner's. Place your partner's CD or DVD in your case.
Task 3	Pour the macaroni from the jar into the resealable bag. Seal the bag. If any macaroni spills, you must pick it up and place it in the bag.
Task 4	Write your name on one sheet of paper. Fold the paper in half.
Task 5	Put on the socks and boots.

8. Repeat step 5.

9. Put on the space helmet, spacesuit arms, and space gloves (the hockey gloves or oven mitts).

10. Repeat all five tasks. Record the time it takes.

Analyze

1. How long did it take you to complete the challenge during each trial?
2. Which tasks were most difficult to carry out when you were wearing a spacesuit?
3. How did having a partner help you or make tasks more difficult?

Conclude and Apply

4. What recommendations would you make to help an astronaut carry out tasks more efficiently?
5. How do you think astronauts hold and grip tools?

Extend Your Skills

6. Design a spacesuit and include features that would make it easier for an astronaut to collect rock samples. Label your design.

Off the Wall

Robot technology that was originally developed for space is now at work in movie studios. Dinosaurs and monsters move with better motion, thanks to robot technology.

Other Canadian Technologies in Space

Canadian astronaut Bjarni Tryggvason (Figure 5.17) invented the Microgravity Vibration Isolation Mount or "MIM," (Figure 5.18). MIM uses magnets to make a vibration-free floating platform for conducting experiments. Canadian researchers hope to use this platform on the ISS to melt and mix various materials to make new metals, computer parts, and other products for Canadian industry.

Figure 5.17 Canadian astronaut Bjarni Tryggvason is about to perform an experiment in space.

Figure 5.18 This is a Microgravity Vibration Isolation Mount.

Section 5.1 Summary

In this section, you learned that:

- Beliefs in a flat Earth changed to an understanding that we live on a spherically shaped Earth.
- Beliefs in an Earth-centred universe changed to an understanding of a Sun-centered planetary system.
- Asteroids, comets, and meteoroids also orbit the Sun.
- Technology has played an important part in helping people gain knowledge about Earth and space.
- Many products developed for space also benefit us on Earth.
- Canadians have made many important contributions to space exploration.

Check Your Understanding

1. What did ancient philosopher Pythagoras see that made him suspect that Earth was a sphere?
2. Why was the telescope such an important invention for helping scientists explore the skies?
3. List two ways technology has helped people explore space.
4. Explain two ways Canadians have contributed to exploring space.
5. You hear a news program that suggests they may decide to stop exploring space. Prepare a short response you would give if they interviewed you on television.
6. Should countries continue to work together on projects like the International Space Station? What are the advantages? What are the disadvantages?

Key Terms

- Earth-centred universe
- philosopher
- Sun-centred planetary system
- telescope
- binoculars
- observatory
- planet
- asteroid
- comet
- meteors
- meteorite

Section 5.2 Events on Earth and Events in the Sky

Key Terms

- axis
- orbit
- lunar phases
- solar eclipse
- lunar eclipse
- tides

Many parts of our daily routines are influenced by the universe in which our planet exists. Earth's rotation and path around the Sun gives us night and day. It is also the reason why we have seasons, and why there are 365 days in the year. Learning how Earth, the Moon, and Sun exist together is an important step to explaining daily changes here on Earth.

Day and Night

Each morning, the Sun appears to rise in the east and set in the west in the evening. At night, the Moon and stars seem to rise in the east and set in the west in the morning. What causes this constant movement above us? Stand in one spot and point your left arm to the east. Now, turn your arm and body until your arm is pointing west. How would you get back to pointing east without moving backward? That is right. You would continue to spin in the same direction as you started. Now spin again and watch what you see. Do you see the same things over again? Just as you see the same things because you are spinning, Earth sees the same Sun, Moon, and stars because it is spinning, too. Earth rotates in a counterclockwise direction as seen looking down from the North Pole. When Earth rotates your side of the globe toward the Sun, you experience daytime. As Earth continues to spin, the Sun disappears from view and you experience nighttime as you face away from the Sun. We define the length of one day to be exactly 24 hours. Twenty-four hours is the average amount of time it takes for the Sun to cross an observer's meridian (an imaginary line in the sky) each day.

READING Check

How long does it take Earth to make one complete rotation?

CONDUCT AN

INVESTIGATION 5-G

SKILLCHECK
- Observing
- Interpreting Observations
- Interpreting Data
- Modelling

Model Earth's Rotation

Although it looks as if the Sun is moving around us on Earth, in fact, the Earth is rotating on its axis. Can you explain how this causes night and day to occur? You will find out when you build this model of Earth and Sun.

Question

What causes us to have day and night?

Safety Precautions

Be careful never to shine a flashlight in someone's eyes.

Materials

globe(s)
toothpick(s)
modelling clay
compass(es)
high-powered flashlight

Procedure

Part 1

1. As class, take a globe outside into an area where there are no other shadows from other objects.
2. Using a compass, point the North Pole on the globe to the North. This means that the equator will be facing up.
3. Rotate the globe so that the area where you live is now on top.
4. Put the toothpick in a small piece of modelling clay, and use it to mark where you live on the globe.
5. As a class, discuss the shadow produced by the toothpick on the globe compared to those on the ground.
6. Look at the rest of the globe. Which areas are receiving light? Which areas are in darkness?
7. Now rotate the globe to the East and observe what you see about Earth.

Part 2

1. Moving inside, five students hold hands and form a circle.
2. Standing outside the circle, a sixth student shines a flashlight toward the centre of the circle.
3. Dim the lights in the room.
4. The five students forming the circle will follow each other and walk in a circle without holding hands. This will represent Earth rotating.
5. The part of the circle that is in the light represents daytime while the part that is in the darkness represents the night.

Analyze

1. How does the rotation of Earth produce day and night?

Conclude and Apply

2. What would happen if Earth stopped rotating?

Extend Your Skills

3. Design a small and simple model that you could use to explain to a fellow student how day and night occur on Earth.

The Four Seasons

It usually surprises most people to learn that Nova Scotia and the rest of Canada are closer to the Sun in the wintertime than in the summertime. Why do you think we are further away from the Sun during the hottest time of the year? The answer can be explained by the fact that seasons are not caused by our distance from the Sun. Seasons happen because of the tilt of Earth.

Earth's Axis

Imagine you are holding a globe in front of you. The North Pole is pointing to the ceiling, and the South Pole is pointing to the ground. Now, tilt the globe slightly to the right. Earth rotates in this position. If you could draw a straight line from the North Pole to the South Pole, the line would be tilted as well. Although in real life there is no line drawn from pole to pole, the tilted imaginary line that it forms is called Earth's **axis**. Earth's axis is tilted at an angle of 23.5°.

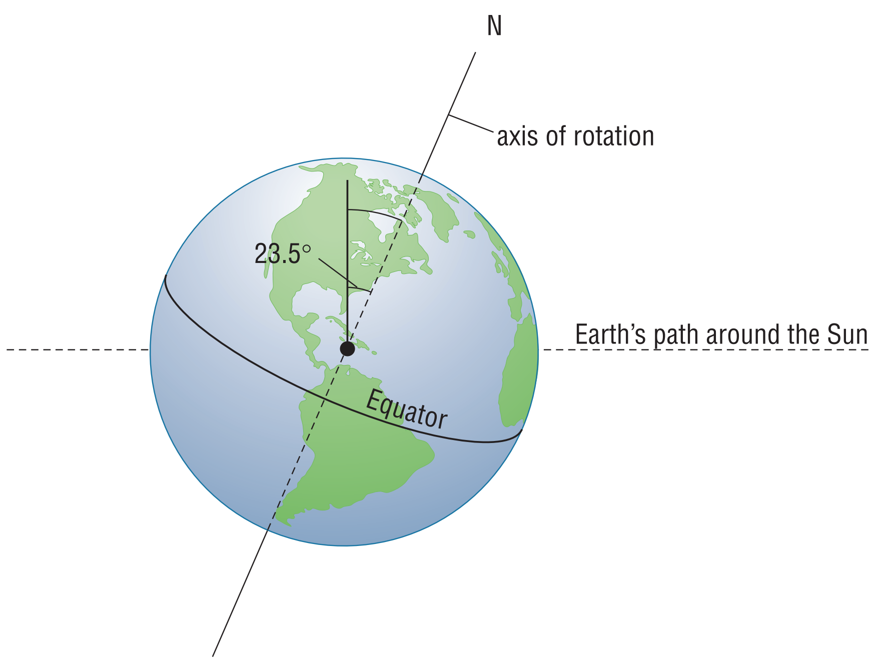


Figure 5.19 What do scientists mean when they say, "Earth spins on its axis"?

Find Out ACTIVITY 5–H

Seeing the Reasons for the Seasons

How does the tilt of Earth's axis of rotation and its orbit around the Sun affect the seasons on Earth?

Safety Precautions

Be careful never to shine a flashlight in someone's eyes.

Materials

flashlight(s)	coloured tape
globe(s)	sheet of paper
toothpick(s)	lamp(s)
modelling clay	pens, 2 different colours

4 large place cards, labelled with the seasons

What to Do

Part 1

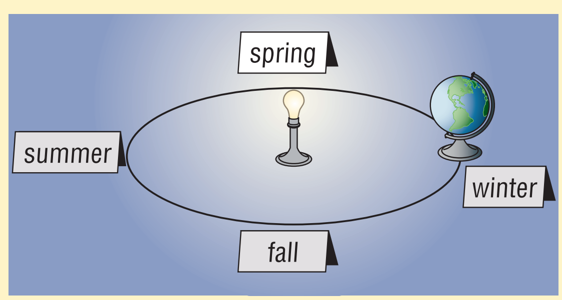
1. Place the sheet of paper on a desk.
2. In a dimly lit classroom, hold the flashlight about 30 cm away from the surface of the desk, and shine the light on the paper at a 90-degree angle. Draw a circle around the pool of light on the paper.
3. Change the angle of the flashlight to 60 degrees, and outline the light on the paper using a different colour pen.
4. Compare the two areas. Is the shape and size of the second circle the same as the first one? Discuss how this different size of circle could affect the concentration of the light (brightness and heat) shining on the object.
5. At what angle do you think the Sun's rays come to your part of Earth in summer? At what angle in winter?

Part 2

1. On the floor of the classroom, draw or tape an oval that represents Earth's orbit. Put the "season" place cards around the oval, as shown.
2. Use a piece of modelling clay to mount the toothpick where you live on the globe.
3. Place a lamp in the centre of the oval to represent the Sun.
4. Now place the globe at the spring season position, with the toothpick facing the Sun. Discuss how much light is on different parts of the globe.
5. Move the globe to the summer season. Keep the same side of the globe facing the Sun. Keep the axis pointing the same way. How is the area of light changing for different parts of the globe?
6. Complete step 5 for the fall and winter seasons.

What Did You Find Out?

1. What is the difference in the concentration or amount of the Sun's light between winter and summer where you live?
2. How do you think these different concentrations of sunlight relate to the different seasons on Earth?



READING Check

Use the word *orbit* correctly in a sentence.

The Season Reason

As Earth rotates on its axis, it also travels in an oval-shaped path around the Sun. This path is called an **orbit**. Earth takes 365 days, or one year, to complete one full orbit of the Sun. While Earth moves around the orbit, the position, or tilt, of the axis never changes. This means that during the summer months in Canada, the axis is pointed toward the Sun, but during the winter months, the axis is pointed away from the Sun. In the winter, sunlight is spread out over a larger area. In the summer, sunlight is concentrated in a smaller area, meaning it will be hotter.

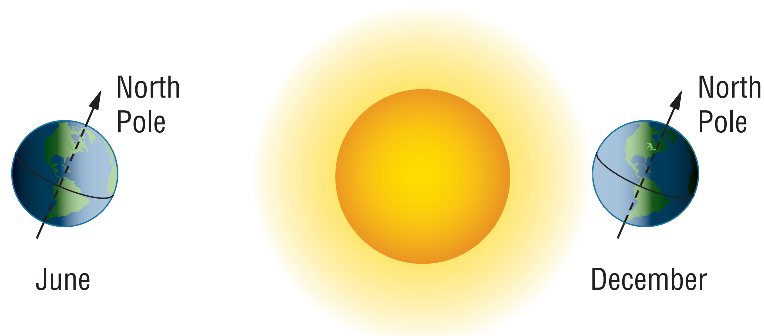


Figure 5.20 The angle of the axis never changes during Earth's orbit of the Sun. However, the concentration of sunlight reaching the hemispheres does change. These changing levels of sunlight create what we call the seasons of winter, spring, summer, and fall. (These diagrams are not to scale.)

Phases of the Moon

Have you ever noticed that the Moon looks different from night to night? Sometimes it is big and round, and other times it looks like a tiny crescent. Why do you think it changes? The answer has to do with the positions of the Moon and the Sun and how they look from our view on Earth.

Just as Earth travels in an orbit around the Sun, the Moon travels in an orbit around Earth. The Moon orbits in the same counterclockwise direction as Earth. It takes about 29 days (almost one month) for the Moon to make one complete orbit of Earth. As the Moon travels around its orbit, the amount of surface we see that reflects sunlight changes. That is the reason why sometimes the Moon appears large, and other times it appears small. As the Moon completes its orbit once a month, these changes in its appearance are called **lunar** (moon) **phases**.

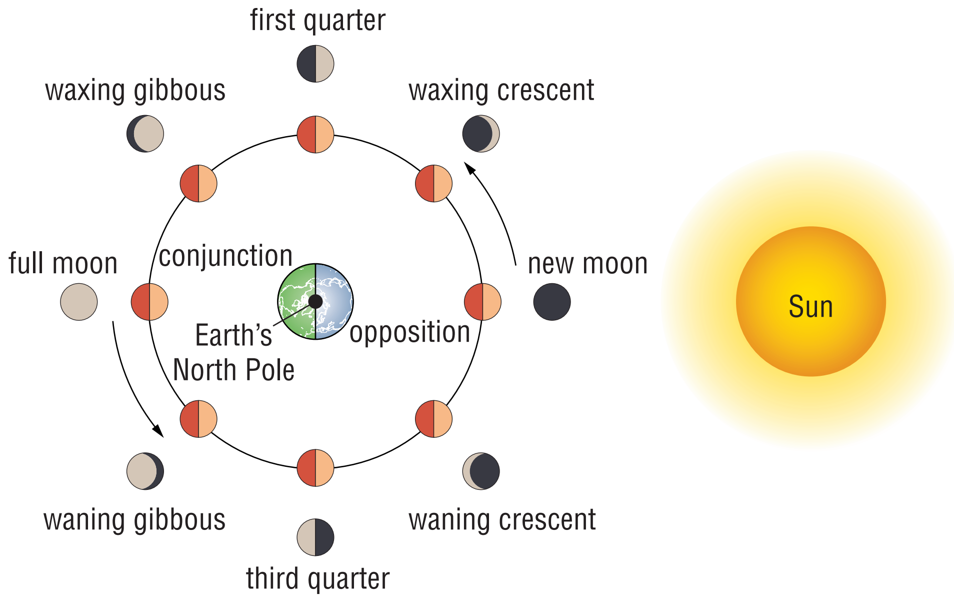


Figure 5.21 The position of Earth and the Moon showing the lunar phases. The outside drawings of the Moon are how it appears to us from Earth. (This diagram is not to scale.)

Figure 5.22 A time sequence that shows the phases of the Moon.

Eclipses

Many times in ancient history, people believed something terrible was happening as they looked up into the sky. Right before their eyes, the Sun, high in the sky, would be slowly blocked from their view, and daylight would turn to darkness. As quickly as it was blocked, it would suddenly start to shine again, but people were convinced that it was a sign of bad events to come.

INTERNET CONNECT

www.mcgrawhill.ca/links/ns+science6

What do lunar and solar eclipses look like from Earth? Go to the above web site and click on **Web Links** to find out where to go next.

CONDUCT AN

INVESTIGATION 5-1

SKILLCHECK
- Inferring
- Predicting
- Communicating
- Interpreting Data

Modelling Moon Movement

Questions

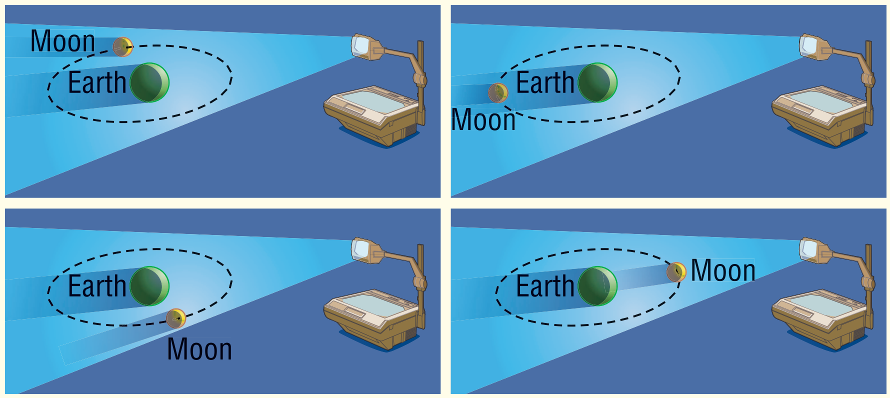
What causes the various phases of the Moon? What causes eclipses?

Safety Precautions

Do not look directly into the projector light.

Materials

projector
volleyball
baseball
black marker (water soluble)
sheet of white chart paper



This simple set up shows how the Moon revolves around Earth. The size and position of the shadowed part of the Moon changes as the Moon changes position around Earth. You can model this set up yourself using a volleyball and a baseball to represent Earth and the Moon. (These diagrams are not to scale.)

Procedure

1. Lay the white paper out on a large flat surface (four student desks pushed together works well).
2. Using a piece of string to help you, draw a large oval on the paper. This will represent the orbit of the Moon.
3. Place the volleyball in the centre of the oval. This will represent Earth.
4. Place the projector at a height so the light is at the same level as the table and about 3 metres away. The projector will act as the Sun.
5. Place the baseball on the circle so it lies exactly between the volleyball and the projector. This baseball represents the New Moon phase of the Moon in this position.
6. Assuming that the North Pole of Earth is at the top of the volley ball, move the baseball around the circle at 45 degree intervals in a counterclockwise direction. At each interval, write the lunar phase that the position of the baseball represents.

Analyze

1. During which lunar phase are eclipses of the Moon possible?
2. During which lunar phase are solar eclipses possible?

Conclude and Apply

1. The model that you have used to demonstrate the phases of the Moon would indicate there should be eclipses every lunar month. In reality there are usually only two lunar eclipses and two solar eclipses each year. Can you explain why that is?
2. Create an acronym or song to help you remember the names of the lunar phases.

Today we know that these people were watching an event that occurs because of the orbital paths of Earth and the Moon. Sometimes in their paths, the Moon and Earth move into a straight line with the Sun. When this happens, either the Moon or the Sun can become blocked from our view for a brief time. This event is called an eclipse. There are two types of eclipses: a **lunar eclipse**, and a **solar eclipse**.

During a lunar eclipse, Earth moves between the Moon and Sun, and blocks the Sun's light from reaching the Moon (the Moon is in Earth's shadow) (Figure 5.23). A solar eclipse happens when the Moon travels between Earth and the Sun, and prevents most of the Sun's light from reaching Earth (the Moon casts a shadow on Earth) (Figure 5.24). If the Moon and Sun are in a perfect line, it is called a total eclipse, but these do not happen very often. Most eclipses are partial eclipses because the Moon and Sun are not in a perfect line.

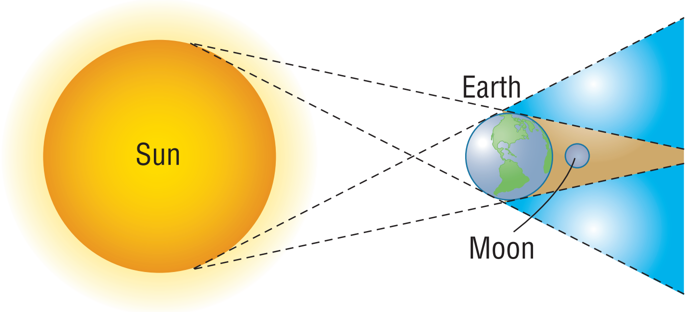


Figure 5.23 During a lunar eclipse, Earth is between the Moon and Sun, and casts a shadow over the Moon.

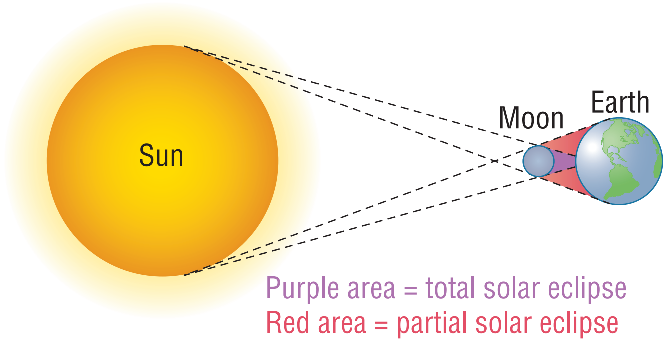


Figure 5.24 During a solar eclipse, the Moon passes in between Earth and the Sun and casts a shadow on Earth.

Tides

Because they live next to the Atlantic Ocean, people in Nova Scotia are very familiar with the daily rising and falling of the ocean, called **tides**. But did you know that tides happen because of the closeness of the Moon to Earth? All objects in space exert a force, called gravity, on other objects. Gravity is a force that pulls together any two objects that have mass. The ocean tides are caused by the gravitational force of the Moon pulling on Earth.

The Moon's pull on the side of Earth facing the Moon is much greater than the pull on the side away from the Moon. This difference in the strength of the Moon's gravitational pull causes a distortion in the shape of the oceans. As shown in Figure 5.25, the water level of the oceans is higher on the sides facing the Moon and farthest from the Moon, than on the other parts of Earth.

READING Check

What causes ocean tides?

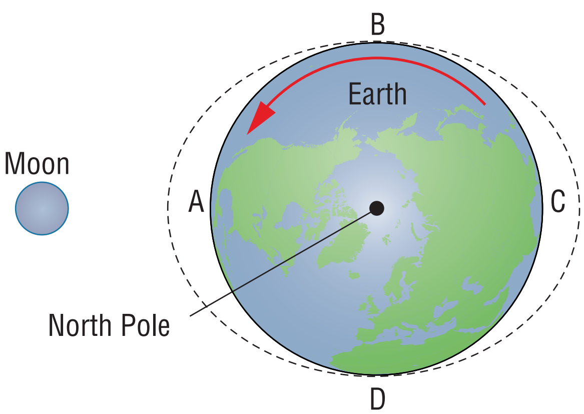


Figure 5.25 If you could look down on Earth's North Pole, you would see that the level of the water in the ocean facing the Moon and in the ocean farthest from the Moon is higher than the water level on the other sides of Earth.

Look at Figure 5.25 and imagine that Nova Scotia was at location B. The water level is lowest and therefore is at low tide. As Earth rotates on its axis, Nova Scotia moves toward location A. The water level becomes higher and moves up on the shore line. When Nova Scotia reaches location A, the water level is at its highest point and it is therefore at high tide. As Earth continues to spin, Nova Scotia reaches location D and experiences another low tide. As you can see, when Earth makes one complete rotation, which is one full day, Nova Scotia has experienced two high tides and two low tides.

DidYouKnow?

The highest tides on Earth occur in the Bay of Fundy.

THINK & LINK

INVESTIGATION 5-J

SKILLCHECK
- Inferring
- Predicting
- Communicating
- Interpreting Data

Tide's In, Tide's Out

Think About It

Living near the ocean means being aware of the tides. Everyone needs to be careful not to get caught walking far out onto the shore during low tide, only to discover that the high tide is coming in. Most coastal areas now offer timetables to help you calculate high and low tide times. But did you know that the tide times and heights can be different for other places? Even a community that is down the coast might have different tide times and heights. Let's see if we can explain why.

Figure 5.27 The Bay of Fundy is known throughout the world for its high tides. Look how far these boats rise during high tide.

Procedure

1. Check your local newspaper or an Internet site for tide times and heights in your area. (When using the Internet, use search key words "tide table".)

2. For one week, keep track of high and low tide times and the tide heights. Create a chart each day in your notebook that looks like this:

Tide Times: Week 1

Date: Monday	
Time	**Height**
High:	
Low:	
High:	
Low:	

3. After one week, locate a tide table for the same week in a community in another Atlantic province.

Analyze

1. Compare the tide times from your findings to those of the other community. What differences can you find? Record your findings in your notebook.

2. As a class, discuss the differences that you found between the two sets of tide times and heights.

3. Brainstorm explanations for the reasons why different areas would have different tide times and tide heights.

Section 5.2 Summary

In this section you learned that:

- Day and night occur because of Earth's rotation.
- The tilt of Earth's axis stays the same as it orbits the Sun, and this explains why Earth experiences changing seasons.
- Solar and lunar eclipses happen when the Moon and Earth are in a straight line with the Sun and cast a shadow on each other.
- The Moon goes through a lunar cycle each month as it orbits Earth.
- Tides are caused by the difference in the Moon's gravitational pull between opposite sides of Earth.

Key Terms

axis
orbit
lunar phases
solar eclipse
lunar eclipse
tides

Check Your Understanding

1. Explain how Earth experiences day and night.
2. What is the connection between the tilt of Earth and the seasons?
3. During one month, why does the Moon look different each night?
4. How do solar and lunar eclipses occur?
5. Show how you could model a solar eclipse to a fellow student.
6. Explain why you only observe tides in oceans and not in lakes or ponds.

Pause & Reflect

Would you like to ride a space elevator to the Moon? Engineers are designing a paper-thin, super-strong ribbon of carbon between Earth and a space station in geostationary orbit. An elevator attached to the 100 000 km-long ribbon could haul equipment—and even people—up into space.

Draw a picture of what this elevator might look like. Record your ideas about the view you would have from the elevator. What kinds of problems do you think engineers would encounter trying to build this elevator?

Prepare Your Own Chapter Summary

Summarize this chapter by doing one of the following:

- Create a graphic organizer such as a concept map.
- Produce a poster.
- Write a summary to include the key chapter ideas.

Here are a few ideas to use as a guide:

- Write a pamphlet for visitors to Earth to help guide them on the different things they might see in the night sky.
- Create a news program or documentary to show how Canadians are involved in space exploration.
- Draw a poster showing the different technologies we use to get around in space.