Chapter 12

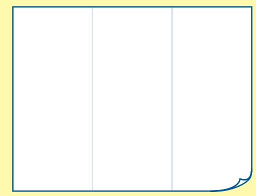
Human understanding of Earth and the universe continues to increase through observation and exploration.

Space technology is progressing at an amazing rate, enabling us and our instruments to travel farther and farther from Earth. In 1961, the first human went out into space, followed since then by more than 400 others. In your parents' lifetime alone, a space-based laboratory has been established and robotic probes have landed on the Moon, Venus, Mars, an asteroid, and a moon of Saturn. Sophisticated telescopes have enabled us to see close-up images of every planet, and the Hubble Space Telescope has beamed back images that reveal the most distant regions of the universe.

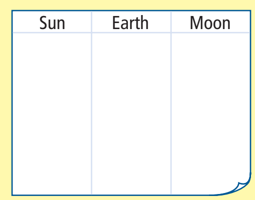
FOLDABLES™
Reading & Study Skills

Make the following Foldable and use it to take notes on what you learn in Chapter 12.

STEP 1 **Fold** a sheet of paper into thirds along the long axis to form three columns.



STEP 2 **Make** a 2 cm fold along one of the long sides and use sections to **sketch** and **label** the Sun, Earth, and Moon.



STEP 3 **Record** information on the Sun-Earth-Moon system in the appropriate columns.

STEP 4 On the back, **label** the columns as shown and **record** what you learn about A Traditional Perspective of Nature, Instruments and Tools, and Ethical Issues Associated with Space Trave.

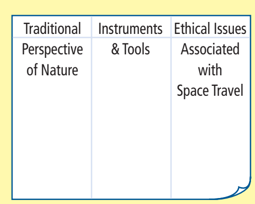


Diagram and Label Diagram the Sun-Earth-Moon system along the top of the folded chart. Include other diagrams within the columns of your chart. For example, in the Sun column, diagram geocentric and heliocentric models of celestial motion.

What You Will Learn

In this chapter, you will
- **explain** the motion and interrelationships of the Sun-Earth-Moon system
- **describe** traditional perspectives of a range of Aboriginal peoples in British Columbia on the nature of bodies in the solar system
- **identify** a range of instruments and tools used in astronomy
- **analyze** implications and ethical issues associated with space travel and exploration

Why It Is Important

Human understanding of space has come from a need to learn and a desire to explore. Improvements in technology increase our ability to observe and our ability to journey farther into space. Human society has also benefited immensely from technologies developed originally for exploring space.

Skills You Will Use

In this chapter, you will
- **model** star positions in a constellation
- **explain** how the Sun-Earth system creates seasons
- **control** variables in modelling the Moon's movement
- **show** respect for Aboriginal perspectives on the relationship between Earth and other celestial bodies
- **develop** an understanding of ethical issues related to space exploration

12.1 Earth, Moon, and Sun Interactions

Human understanding of Earth and its place in the universe has evolved as technology has enabled us to see farther into space. Astronomers believe that the Moon formed shortly after the solar system did, from rocky material orbiting the young Earth. Earth completes a full rotation roughly every 24 hours, and its axis tilt is responsible for seasons changing in the northern and southern hemispheres. The orbits of Earth and the Moon sometimes cause them to block the light of the Sun briefly, in events called eclipses.

Words to Know

axis tilt
constellations
Copernicus
Galileo
Kepler
lunar eclipse
Ptolemy
solar eclipse

Compared with most people today, early people were much more aware of daily and seasonal changes in their everyday lives. Fishermen and other mariners, for example, knew the fixed pattern of stars in the sky and used them to navigate by. Hunters, gatherers, and farmers watched the changing phases of the Moon through a month and the changing path of the Sun through the year. They used that information to prepare for changing seasons, animal migrations, flooding rivers, and other natural phenomena. Several highly sophisticated structures were designed and built around the world with the express purpose of observing and tracking celestial movements. Several of these structures are shown in Figure 12.1.

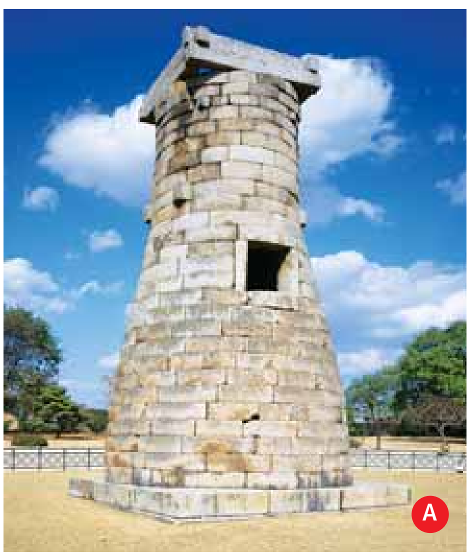


Figure 12.1 Many astronomical observatories built in ancient times remain today. Shown here are Cheomseongdae in Korea (A); Chichén Itzá in Mexico's Yucatán (B); Stonehenge in England (C); the pyramids of Giza in Egypt (D); and the Bighorn Medicine Wheel in Wyoming, U.S.A. (E).

Still, it was only when better technology allowed people to see more than they could with their naked eye that they began to gain a clearer understanding of celestial movements.

People originally thought that Earth was the centre of the universe. They believed that everything else in "the heavens" revolved around it: the Sun, the Moon, the other planets, and all the stars. This was called the **geocentric model** of celestial motion ("geo" is from the Greek word for Earth). It was based largely on the work of **Ptolemy**, a Greek astronomer in the second century C.E., and remained the main model for almost 1500 years. Not until Polish astronomer Nicolaus **Copernicus** presented new observations did a **heliocentric model** begin to take hold. This model stated that Earth and all the planets revolved around the Sun. It created much controversy. When Italian physicist and astronomer **Galileo** Galilei confirmed Copernicus's model half a century later, he was eventually put on trial for suggesting Earth was not the centre of everything.

Gradually, however, the heliocentric model was adopted as more evidence showed it could not be proven wrong. The discovery by German mathematician and astronomer Johannes **Kepler** that the planets orbited in elliptical paths, not circles, meant that accurate predictions about planetary orbits were possible. This further strengthened the model's validity.

Did You Know?

Chinese astronomers are credited with making the first formal records about star and planet motion. More than 4000 years ago, they were recording highly accurate observations.

12-1A Constructing Constellations

Think About It

Constellations are groups of stars that form what seems to be a recognizable shape in the night sky. There are 88 official constellations. Other subgroups of stars form shapes within constellations. In the northern hemisphere, what we call the Big Dipper is part of the constellation Ursa Major. The interpretations of the patterns of stars are as different as the cultures that name them. In this activity, you and your classmates will be given the same pattern of stars and asked individually to create your own unique constellation.

Materials

- pencil
- pencil crayons
- star sheet (from teacher)

What to Do

1. Study the star sheet to create an idea for a constellation. To help you get some ideas, rotate the sheet to view the stars from different perspectives.
2. Once you have an idea, use the pencil to connect the main stars so that they form a very simple outline of the figure you see in the star pattern. This will be the basic structure of your constellation.
3. Use the pencil crayons to draw and colour the rest of the details of the figure.

What Did You Find Out?

1. How did the constellations of your classmates compare with your constellation? Did anyone interpret the star patterns in the same way?
2. How does your answer to question 1 explain why different cultures see different shapes and figures in the same set of stars?
3. Would using a telescope make creating a constellation easier? Explain.

internet connect

The giant impact theory of the Moon's origin explains much of the evidence we can observe, but there are four other popular theories about its formation. To investigate those theories further, visit **www.bcscience9.ca**.

The Moon

On a clear night, the dominant feature visible from Earth is the closest solar system body to us, the Moon. To us, it is the brightest body in the solar system, outshining even Venus. Earth is the only planet with a single satellite revolving around it.

The formation of the Moon

There are several theories explaining the origin of the Moon. The one most widely accepted is the "giant impact theory" (sometimes also called the "ejected ring theory").

As you learned in section 11.2, the solar system was a very cluttered and disorganized place in the early part of its formation. Dust and rocky materials ranging from sand-sized particles to balls of rock the size of planets orbited the new sun. Collisions were common in this crowded, jumbled environment. At some point early in Earth's formation, scientists believe that a planetary body the size of Mars slammed into the young Earth. The impact was so intense that large pieces of the planet broke off and scattered into space. The fragments ended up orbiting Earth, building up over millions of years into the sphere we now know as the Moon.

The surface of the Moon

Galileo, using the newly invented telescope in the 17th century, was the first to see the Moon's mountains and craters clearly. Today, just using a pair of binoculars, you can see many of the interesting features that cover the lunar surface. These include large circular craters, ancient lava flows, and high mountains.

Figure 12.2 In the folklore of different cultures, the patterns on the Moon have been interpreted in a number of ways. Most commonly seen are a man's face, a woman's face, a hunter, or a rabbit.

The light, heavily cratered areas of the surface are the lunar highlands (Figure 12.2). These are the oldest parts of the Moon's surface. Unlike Earth, the Moon has no atmosphere to protect it from bombardment by debris from space, so its surface is covered in the crater evidence of many impacts. Most of these impacts occurred between 4.1 billion and 3.8 billion years ago. There is no erosion from wind or water to change the shape of the craters, so they remain as they were formed. The dark, less cratered patches on the Moon are called *mare*, the Latin word for sea. When early astronomers first observed the dark areas through telescopes, they thought these patches were oceans, just like those on Earth. In fact, they are large, flat areas composed of an igneous rock called basalt.

The Moon's changing phases

Although the Moon is very bright in the night sky, it produces no light. What we call moonlight is actually the Sun's light reflected from the Moon's surface. Because of the distance between the Moon and Earth, the moonlight we see takes a little over 1 s to travel to Earth. As the Moon orbits our planet, the Sun lights the lunar body from different angles. The changing appearances of the Moon are called **phases**.

It takes the Moon about 29.5 days to revolve completely around Earth. The Moon rotates at about the same rate as it revolves, so we see the same side of the Moon throughout the month. In the full moon phase, the Sun lights up the entire portion of the Moon visible from Earth. In the new moon phase, the Sun is lighting the side of the Moon not visible from Earth. After the new moon, the sunlit portion of the Moon appears as a thin crescent and then increases in size from night to night. The Moon is then said to be waxing (Figure 12.3). After the full moon, the sunlit part of the Moon gradually decreases and is said to be waning.

Word Connect

"Lunar" comes from Luna, the Roman goddess of the Moon. Lunar describes anything relating to the Moon. Folklore suggests that some people act in crazy ways whenever there is a full moon, giving us the word "lunatic."

Suggested Activity

Conduct an Investigation 12-1C on page 422

Figure 12.3 The amount of sunlit Moon increasing (waxing) and decreasing (waning)

The Moon and tides on Earth

Because Earth and the Moon are close together, Earth is affected by the Moon's gravitational pull. The clearest evidence of this is the effect of the Moon on Earth's oceans. As the Moon orbits the planet, the lunar gravity attracts the water in the oceans. The ocean level rises in some areas at the same time as it falls in others. These movements are better known as high and low tides.

Reading Check

1. (a) What are the large circular features on the Moon called?
   (b) How did they form?
2. The surface of the Moon has areas of light and dark patterns. Name each.
3. (a) What are lunar phases?
   (b) Why do lunar phases occur?
4. How long does it take the Moon to make a complete revolution around Earth?

Suggested Activity

Find Out Activity 12-1B on page 421

Earth's Rotation and Tilt

Earth spins on its axis from west to east, taking 23 hours, 56 minutes, and 4 seconds to complete a full rotation. This is why we have day and night and why the Sun appears to rise in the east and set in the west.

Earth's axis is the imaginary straight line through its centre from pole to pole (Figure 12.4). Earth does not rotate in an upright position. Rather, its axis is tilted 23.5° from the flat plane of Earth's orbit. Because of this **axis tilt**, the Sun's light strikes Earth at different angles during Earth's annual journey around the Sun. This is why Earth experiences seasons (Figure 12.5 on the next page).

- When Earth moves into position so that it is tilting *toward* the Sun in the northern hemisphere, the Sun's rays reach us more directly and intensely and we experience summer. At the same time, the southern hemisphere is tilting away from the Sun and experiences winter because the Sun's rays hit at an angle and are less concentrated.
- When Earth moves into position so that it is tilting *away* from the Sun in the northern hemisphere, we experience winter while people in the southern hemisphere experience summer.

At the equator (the imaginary line around the middle of Earth), the Sun's rays strike the surface directly all year long.

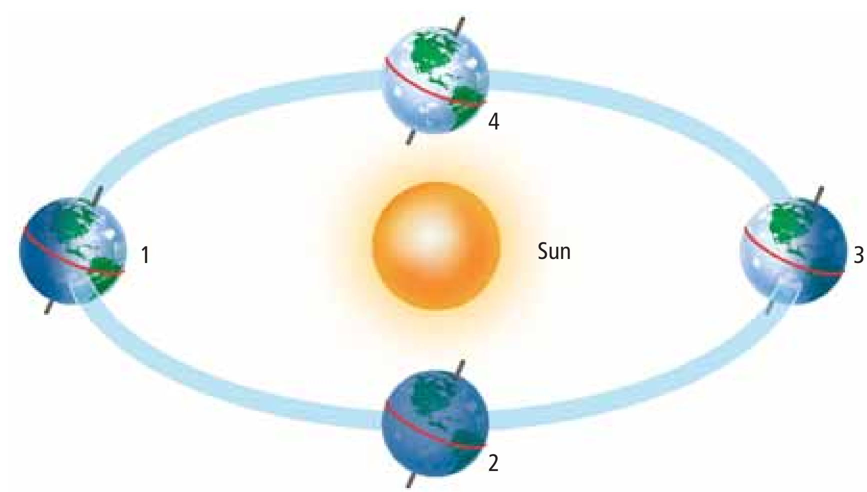


Figure 12.4 As Earth orbits the Sun, Earth's axis always points in the same direction. From position 1 through to position 3, the northern hemisphere begins to tilt away from the Sun. From position 3 through position 4 and back to 1, the northern hemisphere begins to tilt again toward the Sun.

Figure 12.5 In the summer in the northern hemisphere, daylight lasts longer than in winter, so there is more time for the surface to be heated by sunlight (A). In the winter, daylight is much reduced and colder conditions result (B).

Solstices

Two important days celebrated around the world by various cultures are the summer and winter solstices. In the northern hemisphere, the summer solstice marks the longest day of the year. It is the point in Earth's orbit around the Sun when the Sun's path across the sky is the highest. The winter solstice marks the shortest day of the year and the point when the Sun's path is low, closer to the horizon. The summer solstice occurs around June 21 and the winter solstice around December 21 in the northern hemisphere and the direct opposite of those dates in the southern hemisphere.

In far northern latitudes, such as Canada's Yukon Territory, Northwest Territories, and Nunavut, axis tilt is experienced at its extremes. During the summer solstice in those locations, the Sun does not set below the horizon. During the winter solstice in the same locations, it does not rise (Figure 12.6).

Figure 12.6 During the summer in far northern regions of the world, the Sun may remain visible even at midnight.

Did You Know?

Solar and lunar eclipses often occur in a pattern: lunar, solar, and then lunar again. A total solar eclipse can be one of the most breathtaking spectacles in nature.

Eclipses

Early people occasionally witnessed a frightening and unexplainable sight (Figure 12.7). The Sun would slowly shrink from view. After several minutes, the sunlight would be completely gone and in its place would remain a black disk, surrounded by a golden ring. Eventually, the Sun and light would slowly return. This event was interpreted in many ways. Some cultures thought it was a sign to inspire courage in battle. Others thought it meant that the world would soon be destroyed. If it happened at the same time as a natural disaster or the birth or death of a great leader, many people believed the two events were connected.

We now know that this phenomenon is an eclipse. An **eclipse** is the total or partial overshadowing of one celestial body by another. The two types of eclipses discussed below are solar eclipses and lunar eclipses.

Figure 12.7 Just as we may feel frightened by things we cannot explain, early people were terrified by the sight of the Moon blocking the light of the Sun and sending Earth into complete darkness.

Solar eclipses

Every so often, the Moon's path around Earth takes it between the Sun and Earth. When this happens, the Moon blocks the Sun's light and the shadow of the Moon falls across portions of Earth. This is known as a **solar eclipse**. Think of what happens if you hold your hand in front of an overhead projector light. The dark shadow of your hand appears on the screen,

Word Connect

Umbra is the Latin word for shadow. The prefix "pen-" is from the Latin word for almost. So the penumbra is the "almost shadow" around the darkest part of the eclipse.

surrounded by a fuzzy, lighter border. A similar effect occurs in a solar eclipse. There are two parts to the shadow: a central dark area called the umbra and an area of partial shadow called the penumbra (Figure 12.8).

Because the Moon is so small compared with the Sun, the Moon's shadow does not cover the entire surface of Earth during a solar eclipse. People living where the umbra falls see a total eclipse, and people living where the penumbra falls see only a partial eclipse. Other parts of Earth fall under no shadow and therefore do not experience an eclipse.

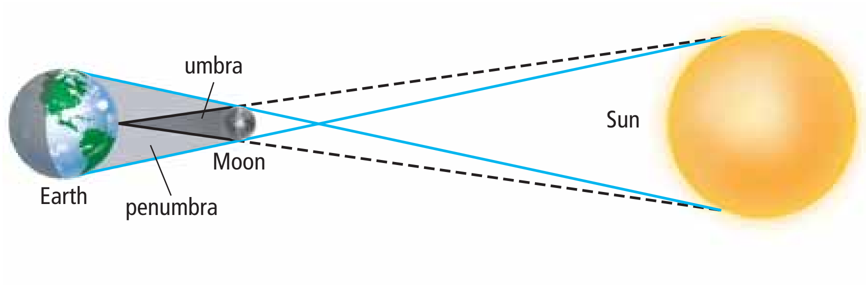


Figure 12.8 During a solar eclipse people living where the umbra touches Earth witness a total solar eclipse. People living where the penumbra occurs witness a partial solar eclipse.

The duration of a total eclipse depends on your location. The longest effects are in the centre of the umbra and can last a few seconds to a few minutes. It is at that time that the Sun's super-hot corona is visible from Earth. The umbra is typically only 160 km wide, although the path of the eclipse can be 16 000 km long. In areas on Earth that experience the penumbra, the Sun appears in partial eclipse. (**Warning:** Never, under any circumstances, look at the Sun directly. Even during a solar eclipse, your eyes could be permanently damaged.)

The Sun's diameter is about 400 times larger than that of the Moon. So, for a total eclipse to occur, the Sun must be 400 times farther away from Earth than the Moon is. Figure 12.9 shows the different shadows of an eclipse, resulting from the unique relationship between the size of the Moon and its distance to the Sun.

Figure 12.9 The path of the Moon in front of the Sun before, during, and after a total eclipse

The Moon takes approximately one month to orbit Earth. Why, then, do we not have a solar eclipse once a month? The reason is that the Moon does not orbit Earth on the same plane, or level, as Earth orbits the Sun. You can simulate this by holding out your fist at arm's length and looking at a distant object. You can easily block the object from your sight with your fist. However, if you lift or drop your fist even just a little, you will see part, or all, of the object. This is the same relationship between the Sun and Moon. The Moon's orbit tilts at about 5° from the plane of Earth's orbit around the Sun (Figure 12.10). As a result, solar eclipses occur only a few times a year, when the Moon moves into the right location.

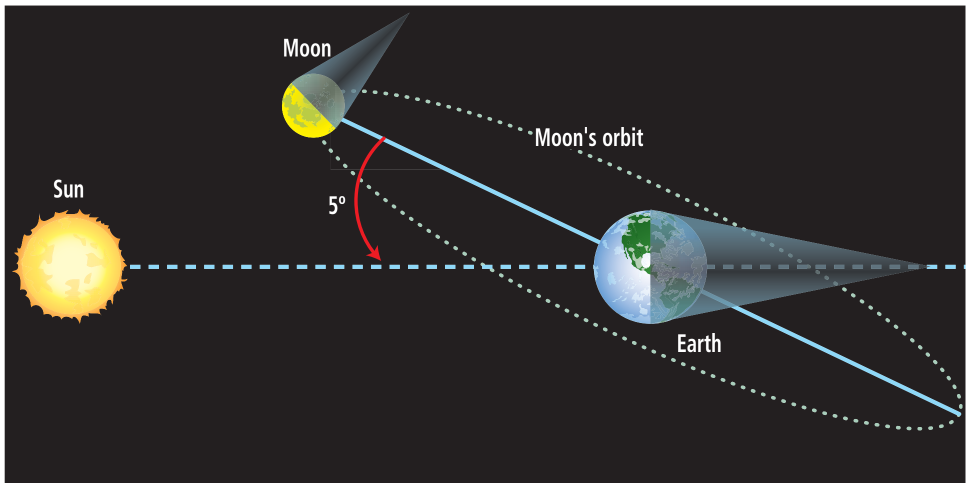


Figure 12.10 The Moon's orbit around Earth and Earth's orbit around the Sun are on different planes. This explains why Earth does not experience 12 solar eclipses every year. (Note that the angle is exaggerated to help you see the tilt of the Moon's orbit relative to Earth and the Sun.)

Lunar eclipses

As the Moon follows its path around Earth, there are times when Earth lies directly between the Moon and the Sun (Figure 12.11). This occurs during a full moon phase. The result is that Earth's shadow is cast on the Moon, causing the Moon to be briefly blacked out. This is called a **lunar eclipse** (Figure 12.12). A total lunar eclipse occurs when the Moon is fully covered by Earth's umbra. As Earth and the Moon move out of line with the Sun, Earth's shadow creeps across the face of the Moon.

Figure 12.12 A total lunar eclipse occurs when the Moon lies entirely in the umbra of Earth's shadow.

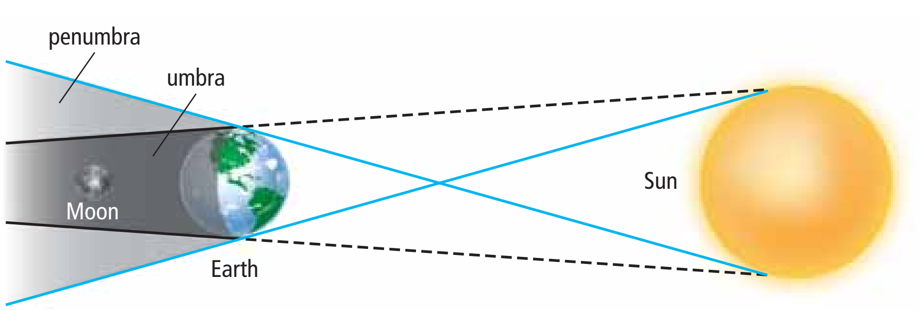


Figure 12.11 When the Moon lies completely in the umbra of Earth's shadow, people witness a total lunar eclipse.

Reading Check

1. What is an eclipse?
2. What blocks the Sun's light during a lunar eclipse?
3. What is the darkest part of the Moon's shadow on Earth called?
4. Why do you see only a partial eclipse if you are standing in the penumbra?
5. Why does a solar eclipse not occur every time the Moon passes between the Sun and Earth?

Constellations

If you were able to watch a clear, moonless sky for an entire night, you would notice several very bright spots of light that do not flicker like the rest. Depending on the time of year, these would likely be the planets Mars, Venus, Jupiter, and Saturn. As well, you would see millions of stars, some twinkling very brightly but most shining more faintly. All of the stars, you would notice, appear to move across the sky gradually. The stars themselves do not actually move, of course. It is Earth's rotation that makes the stars look as though they are moving.

Many groups of stars seem to form distinctive patterns. These patterns are called **constellations**. Although it appears that the stars in these groupings all lie close to each other and at exactly the same distance from Earth, in fact they may be light-years apart. They look close together only because they are so bright and on the same line of sight.

The International Astronomical Union lists 88 official constellations. Examples include Leo, Cassiopeia, and Orion (which contains the stars Betelgeuse and Rigel). Smaller groups of stars forming patterns within constellations are called "asterisms," from the Greek word for star, *aster*. An example of an asterism is one of the most famous and visible patterns in the northern sky, the Big Dipper (Figure 12.13). It is part of the large constellation Ursa Major, the Great Bear. The Big Dipper's two end stars are called the "pointer stars" because they point toward the North Star, Polaris. Long before the invention of the compass, people used the North Star to tell direction.

Figure 12.13 Just about every culture on Earth has legends relating to stars, constellations, and asterisms. This image shows the Big Dipper.

Explore More

The Big Dipper has been seen as a chariot, plough, and bear. Find out more about stories associated with many of the constellations. Begin your research at **www.bcscience9.ca**.

Did You Know?

The oldest map of the stars is believed to be that found in one of the prehistoric caves in Lascaux, France. Estimated to be about 16 500 years old, it is said to represent the stars Vega, Deneb, and Altair.

Meteors

Meteoroids are pieces of rock floating through space. They can be chunks of asteroids or planets broken by collisions with other asteroids or other bodies, or they may even be debris left over from the formation of the solar system. What some people call "shooting stars" are really **meteors**. These are meteoroids that burn up as they pass through Earth's atmosphere (Figure 12.14). Very occasionally, meteors are large enough to survive passing through the atmosphere and they reach Earth's surface. These chunks of rock are called **meteorites**. About once every 100 million years or so, extremely large meteorites hit Earth (Figure 12.15).

Figure 12.14 This meteor shower is made up of particles the size of sand grains that burn up as they pass through Earth's atmosphere.

Figure 12.15 The Manicouagan crater in Quebec shows what can happen when a meteorite reaches Earth's surface. It is 70 km wide.

12-1B Seeing the Reasons for Seasons

Find Out ACTIVITY

In this activity, you will model the relationship between Earth's axis tilt and the seasons.

Safety

- Be careful when using light bulbs. They can become very hot.

Materials

- pencil
- ruler
- 216 mm × 279 mm sheet of paper
- 60 W light bulb
- portable socket
- poster tube or similar cardboard roll (about 50 cm long; the diameter should be slightly larger than the light bulb)
- volleyball or basketball
- protractor or astrolabe

What to Do

1. Use the pencil, ruler, and sheet of paper to draw a grid of 1 cm by 1 cm squares. Make the grid 20 cm by 27 cm.
2. Working with a partner, put the light bulb into the lamp socket and carefully slide the end of the tube over the light bulb.
3. While your partner holds up the grid vertically, hold the lamp and tube horizontally so that the light strikes the paper in a direct line. Shine the light onto the paper from a distance of about 1 m.
4. Count the number of squares the light is touching. If a full square is not completely illuminated, guess at the proportion (such as $\frac{1}{2}$ or $\frac{1}{4}$). Record the number of squares in your notebook. This represents the area covered by the light.
5. Repeat steps 3 and 4, repositioning the light tube at an angle of about 10° from the horizontal (use the protractor). Record the number of squares the light is touching.
6. Repeat steps 3 and 4 once more, repositioning the light at an angle of 20° and record the number of squares lit up by the light. Set the grid aside.
7. While your partner holds the ball 1 m from the tube, shine the light directly on the volleyball's surface. Use the valve to represent the position of the ball's axis. In your notebook, sketch how the light hits the surface of the ball. Next, tilt the volleyball to an angle of about 23° and sketch how the light hits the surface of the ball this time.

What Did You Find Out?

1. How did the area of paper that was lit up by the light change from direct light to light at a 10° angle?
2. How did increasing the angle in steps 5 and 6 affect the area that was hit by light?
3. How did the curvature of the ball's surface affect the amount of light that hit it when it was tilted in step 7?
4. How does this activity simulate the reasons we have seasons on Earth?

12-1C Modelling Moon Movement

SkillCheck

- Observing
- Controlling variables
- Modelling
- Explaining systems

Materials

- Styrofoam® ball (half black, half white)
- pencil
- lamp with bulb
- paper

When viewed from Earth, the Moon goes through a sequence of phases. The amount of sunlit lunar surface visible from Earth changes as the Moon makes its way through its orbit. In this activity, you will design an investigation to model the motion of the Moon relative to Earth and the Sun.

Question

How does the Moon's position affect its phases?

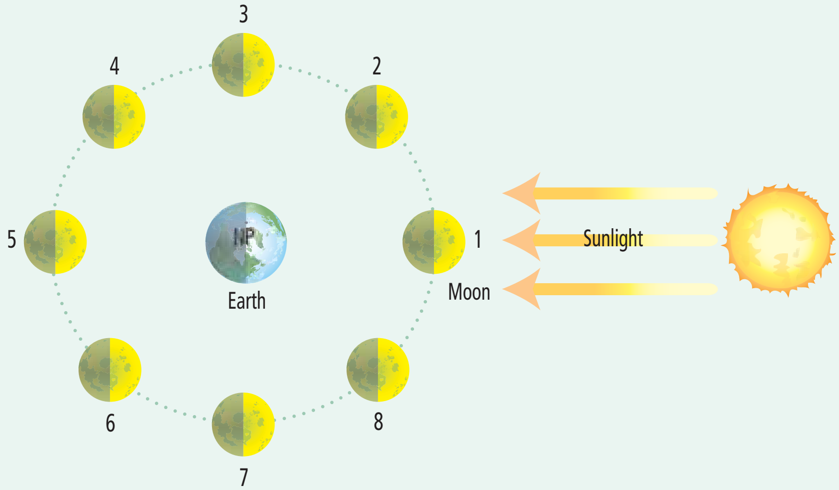
Hypothesis

Formulate a hypothesis about how the position of the Moon affects the phases visible from Earth.

Procedure

1. Stick the pencil into the Styrofoam® Moon right on the line between the black half and the white half. The lamp at the front of the room represents the Sun. The illuminated side of the Moon (white) must always face the Sun.

2. While one partner represents Earth and stays in one place, have the other partner move the Moon around Earth, making observations at the eight positions shown below. The positions represent the phase of the Moon at different points in its revolution. The view below is from directly above the Earth's North Pole (NP). (**Note:** Change roles after the fourth position so each person has a chance to see the phases.)



3. Copy the table below into your notebook.

Pattern on Moon Seen from Earth	Waxing, Waning, or Neither?
1 ◯	
2 ◯	
3 ◯	
4 ◯	
5 ◯	
6 ◯	
7 ◯	
8 ◯	

4. Start at position 1 on the table. In the blank circles, sketch the phases of the Moon you observe in each position. Record in the table whether the Moon is waxing, waning, or doing neither for each position.

Analyze

1. Which phases of the Moon are visible only at night? Which phases are visible only during daylight hours?
2. Make a sketch similar to the position chart that indicates the direction the Moon is revolving around Earth.
3. How many days are there between one new Moon phase and the next new moon phase?

Conclude and Apply

1. Explain what “waxing” and “waning” mean.
2. Why do we see only one side of the Moon even though the Moon rotates?
3. Estimate the approximate times the Moon would be overhead in positions 1, 3, 5, and 7.
4. Imagine you were living in a lunar base on the Moon. How long do you think daylight would last?

Science Watch

The Big Dipper: An Aboriginal Story

Have you ever experienced the delight of gazing up at the night sky to see a display of Northern Lights dancing their way through the Big Dipper? If so, did it excite your imagination as it has done for Aboriginal peoples for thousands of years? The night sky features in numerous Aboriginal stories, emphasizing the belief by many First Nations in the connection between Earth and the sky.

The nomadic lifestyle of the Tr'ondek Hwech'in First Nation of Dawson City, Yukon, meant that they were dependent on each other for survival and well-being. The following story about the Big Dipper served both to explain the distinctive pattern of the stars and to remind everyone who heard it of the importance of respect and peaceful coexistence. It was told to Elder Archie Roberts by his *Ntso ga* (Gramma) Ellen Wood.

As Archie tells it:

"That Big Dipper up there: those seven stars are seven young guys that used to be part of our village. A long time ago, Chief and Council were boss, and they looked after the people very well. All the people listened to them. Chief and Council called a meeting with the people, and one young guy went against Council's orders. They tried to talk to him, but he turned against them. In those days, the Chief was powerful and everybody respected him. You have to because we need to look after each other. Anyway, this young man went against the Chief.

"The Chief and Council talked among themselves and decided to send the young guy away. They gathered all the people together to tell them of their decision and asked if anyone else wanted to go with the young guy. The young guy also called for anyone who wanted to go with him to follow and they would make a new village together. Six other young guys and one young girl went to him. Together, they were sent away from the village because they had turned against their Chief and their people.

"Afterwards, when the people looked up into the night sky, they saw the seven stars shaped like a big dipper. Gramma *Ntso ga* told me that those stars are the seven young guys that were sent away. They always stay up there looking down at us because they have nowhere to go. They want to come back but cannot.

"The young girl who followed them is stuck on the Northern Lights. Sometimes in the night, you will see the Northern Lights moving around and sometimes the lights come down really close to the Earth. The young girl cannot get to the young guys and, when the Northern Lights move down close to us, that is her trying to come back, but she cannot. This is the reason that Gramma and Grampa always told us to be good and listen to what is good for us."

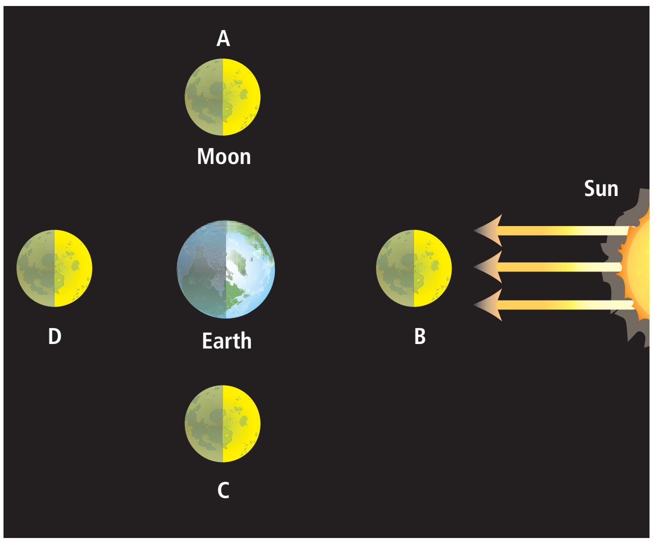
Questions

1. Does the description of the shape made by the seven villagers in this story match the actual shape of the Big Dipper?
2. Imagine that you lived thousands of years ago. Write a paragraph describing a story you would have told other villagers about the Big Dipper.
3. Imagine that you could travel back in time to join the nomadic Tr'ondek Hwech'in First Nation. With your knowledge of modern astronomy, how would you explain the Big Dipper to the Chief and Council?

Checking Concepts

1. What does heliocentric mean when used to describe the heliocentric model of the solar system?
2. Compare and contrast the following.
   (a) mare and highlands
   (b) solar eclipse and lunar eclipse

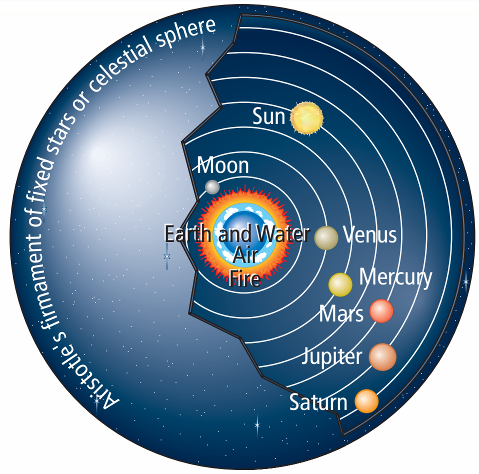
Use the following diagram to answer question 3.



3. State at which Moon location Earth would experience:
   (a) a new moon phase
   (b) a full moon phase
   (c) a solar eclipse
   (d) a lunar eclipse
4. Why would there never be a lunar eclipse during a new moon phase?
5. Why is there night and day on Earth?
6. Explain the reason Earth experiences high and low tides.
7. Define the word "constellation."
8. What name is given to the pieces of rock that burn up passing through the atmosphere?

Understanding Key Ideas

9. Look at the figure of Aristotle's model of the solar system at the top of the next column. Describe at least three errors you see in the model.



10. Why does the Moon have many more craters than Earth does?
11. "If we always see the same side of the Moon that is lit by the Sun, the other side of the Moon should be constantly dark." Does this statement make sense? Explain.
12. Despite being farther from the Sun, the northern hemisphere is warmer in the summer than in the winter. Explain why this is so.
13. Explain why many ancient peoples were afraid of eclipses, even though these events last for only a few minutes.
14. Explain why all of Earth does not experience a total eclipse when the Moon blocks the Sun.
15. Everyone living in the northern hemisphere generally sees the same patterns of stars. If this is so, why are the various constellations and asterisms interpreted in so many different ways?
16. Billions of meteoroids reach Earth every day. Why do very few hit Earth's surface?
17. The position of Earth and the Moon with respect to the Sun dictates what kind of eclipse would occur. Suppose that Earth had two moons, each orbiting on opposite sides of the planet. How would this affect the number of eclipses each body experiences? Draw a picture of the Sun-Earth-Moon system with two moons.

Pause and Reflect

In this section, you have learned about the relationship between the Sun, Earth, and Moon. How would the concept of seasons change if Earth had no axis tilt?