8.9

Observing Celestial Objects from Earth

Celestial objects are visible from Earth both by day and by night. In the daytime you can see the Sun and, sometimes, the Moon. Looking up at the night sky on a cloudless night far away from bright cities, you can see as many as 2000 stars. Even in the city, where light pollution makes it difficult to see stars, you can still observe dozens of celestial objects.

Most of the pinpoints of light in the sky are stars—similar to our Sun, but much farther away. Some of the brighter pinpoints of light, such as Venus and Jupiter, are planets (Figure 1).

Figure 1 Venus and Jupiter are two of the brightest objects in the night sky.

CITIZEN *ACTION*

Saving the Night Sky

SKILLS HANDBOOK 4.A.7., 4.C.1., 4.C.3.

How many stars you can see on a clear night depends on where you are on Earth (Figure 2). From a sports park filled with floodlights, you may see only a few stars. From a dark, remote countryside location in northern Ontario, this number jumps to more than 2000 stars.

Figure 2

Unfortunately, many major observatories are fighting light pollution from nearby growing towns and cities. Some have lost the battle and are closing. The David Dunlap observatory just north of Toronto is one such victim of light pollution. Others are adapting by using new technologies and observing only certain celestial objects that are not greatly affected by light pollution. Light pollution is also a significant waste of energy because the light is released up into the sky, where it is of no use.

Use the Internet and other electronic and print resources to investigate the causes and effects of light pollution, and ways that individuals and municipalities in Canada are reducing it.

GO TO NELSON SCIENCE

Then choose one of the following:

A. Compile a list of different ways that you personally can help cut down on light pollution in your neighbourhood.

B. Write an article for your school newspaper suggesting how the school can reduce light pollution.

C. Write a letter to your town or city council suggesting measures they could take to reduce light pollution.

The Ecliptic

Over the course of a year, the Sun appears to move against the constellations of the celestial sphere. The path taken by the Sun (as it appears to us on Earth) across the celestial sphere is called the **ecliptic**. This apparent motion of the Sun is caused by Earth's revolution around the Sun. The Moon, planets, and some constellations also appear to move from east to west along the ecliptic. The ecliptic is best observed when looking up at the sky toward the southern horizon (Figure 3).

ecliptic the path across the sky that the Sun, the Moon, the planets, and the zodiac constellations appear to follow over the course of a year

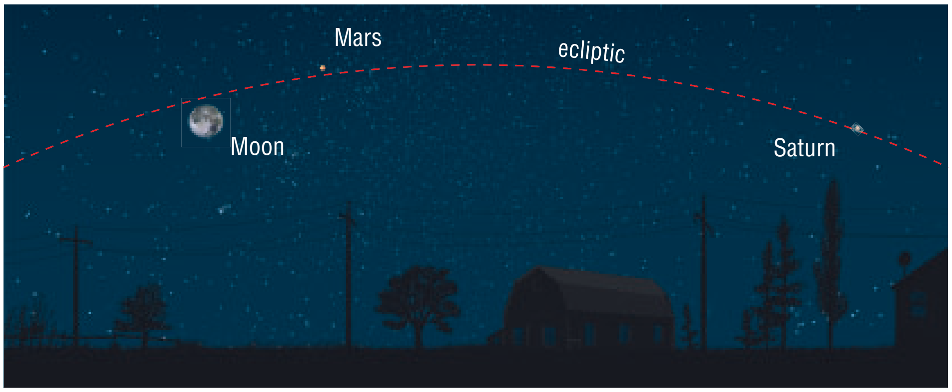

Figure 3 The ecliptic is an important reference pathway that helps us locate the positions of the Sun, the Moon, the planets, and the constellations.

DID YOU KNOW?

Ecliptic

The word "ecliptic" is derived from the word "eclipse" because eclipses of the Sun and the Moon always occur along the ecliptic—the imaginary line in the sky along which the Sun and the Moon appear to move.

Changing Views of the Night Sky

Earlier, you learned that Earth's rotation from west to east causes celestial objects to appear to move across the sky from east to west. This explains the apparent motion of the Sun, the Moon, and other celestial objects during a 24 h period (which is the time it takes for Earth to complete one full rotation).

The distance of celestial objects can also play a role in how they are observed from Earth. For example, because the planets are much closer to Earth than the stars, their path along the ecliptic over time appears to change with respect to the constellations. A planet can be distinguished from a star in the night sky by observing its motion over weeks or months.

In addition, our view of the night sky changes with each passing season due to Earth's revolution around the Sun. For example, if we observe the northern hemisphere's night sky in winter we see stars that are opposite the Sun. The stars that are in the same sky as the Sun will only be in the northern hemisphere's sky during the day and will not be visible (Figure 4). Therefore, the constellations we see in the night sky are not the same at all times of the year.

READING TIP

Finding the Main Idea

Normally, the last sentence concludes a paragraph by reminding the reader of the main idea. Sometimes words or phrases such as "therefore" or "as a result" are used to signal a conclusion. The last sentence of a paragraph is a good place to check for a rewording of the main idea.

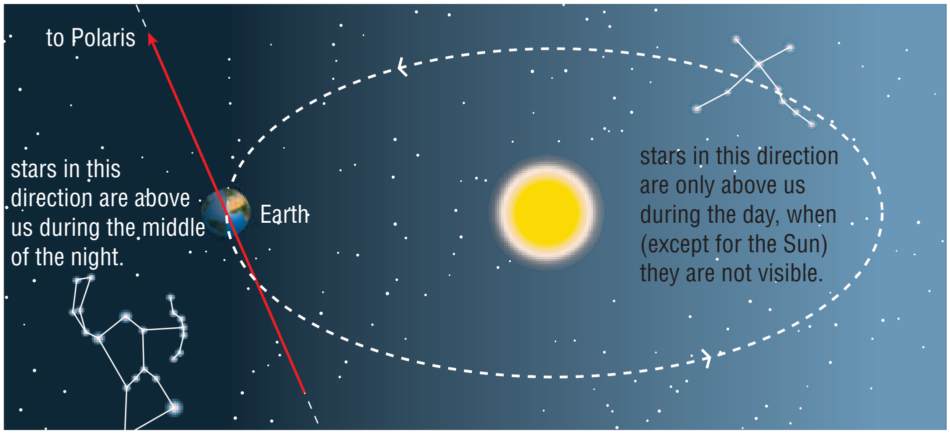

Figure 4 Orion is visible in the northern winter sky because it is opposite the Sun at that time. Cygnus is in the northern winter sky during the day, however, and cannot be seen. Stars that are close to Polaris are visible in all seasons.

retrograde motion the apparent motion of an object in the sky, usually a planet, from east to west, rather than in its normal motion from west to east

Figure 5 A time lapse photo of the retrograde motion of Mars

DID YOU KNOW?

Planet Wanderers

The word "planet" comes from the Greek word *planetes*, which means "wanderer."

To learn more about retrograde motion,

GO TO NELSON SCIENCE

Some stars appear to never set, due to their proximity to one of the celestial poles. For example, Polaris is near the North Celestial Pole. From North America, Polaris is visible for the entire night on every night of the year. The same is true for constellations near the celestial poles. In the northern hemisphere, these include Cassiopeia, Cepheus, Draco, Ursa Minor, and Ursa Major.

Retrograde Motion

Ancient astronomers observed an usual planetary motion that was not explained until the Sun was discovered to be the centre of the Solar System. Certain planets appeared to change their path in the sky relative to the background stars, slowing to a stop, reversing direction, and then looping across the sky—a phenomenon known as **retrograde motion**. This apparent motion occurs because Earth travels around the Sun faster than the outer planets. For example, as Earth passes Mars in its orbit, Mars appears to at first stop and then travel backward in the sky. Earth continues past Mars, and forward motion appears again in the sky (Figure 5). We observe retrograde motion of only those planets that are farther from the Sun than Earth.

We can observe the retrograde motion of Mars, Jupiter, and Saturn with the unaided eye. However, we need to use a telescope to observe the retrograde motion of Uranus and Neptune. Each of the outer planets retrogrades for different lengths of time. Jupiter spends 4 of every 13 months in retrograde motion, for example, whereas Neptune retrogrades for 5 months of every year.

TRY THIS DEMONSTRATE RETROGRADE MOTION

SKILLS: Observing, Communicating, Analyzing

SKILLS HANDBOOK 3.B.

Occasionally, a planet undergoes retrograde motion. When this happens, its path in the sky appears as a series of loops. In this activity, you will model this phenomenon.

Equipment and Materials: paper; markers

1. Find a partner. One of you will represent Earth and one will represent Mars. Use the paper and markers to create labels. Each person will hold the label indicating what planet they represent.
2. Stand beside your partner. Mars walks slowly forward from the starting point. Earth stays at the starting point, pointing at Mars as Mars moves forward (Figure 6).

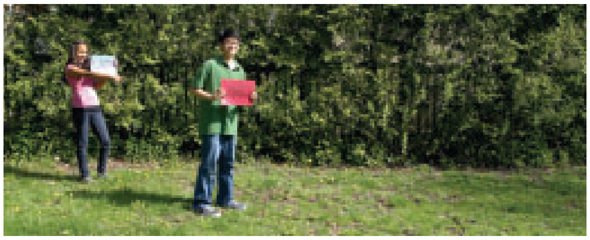

Figure 6 step 2

3. Earth leaves the starting point, moving quickly to overtake the slower-moving Mars.
4. As Earth overtakes Mars, Earth begins to point backwards (Figure 7). This illusion of backwards motion is retrograde motion.

Figure 7 step 4

5. Repeat the experiment, switching roles with your partner.

A. Mars undergoes retrograde motion only when it is very close to Earth. Do you think that Mars appears at its brightest or dimmest when it retrogrades? Explain.

GO TO NELSON SCIENCE

B. The farther a planet is from the Sun, the slower it moves. Why is retrograde motion visible only with planets that are farther from the Sun than Earth is? T/I

C. While in retrograde motion, in which direction does Mars appear to move with respect to the background stars? T/I

Navigating the Night Sky

Finding your way around the night sky can seem confusing at first. The first step is to learn how to describe the location of celestial objects that you can see with the unaided eye.

In geography, latitude and longitude are used to pinpoint a place or object on Earth. In astronomy, celestial coordinates called azimuth and altitude can be used to describe the position of a celestial object in the sky relative to an observer on the ground for a particular time and place.

Azimuth and Altitude

Azimuth is the distance measured from north along the horizon to a point directly below the celestial object. North has an azimuth of 0°, east has an azimuth of 90°, south has an azimuth of 180°, and west has an azimuth of 270° (Figure 8). **Altitude** is the angular height of a celestial object, measured from the horizon. Figure 8 shows how the degrees of azimuth and altitude are measured.

azimuth the horizontal angular distance from north measured eastward along the horizon to a point directly below a celestial body

altitude the angular height a celestial object appears to be above the horizon; measured vertically from the horizon

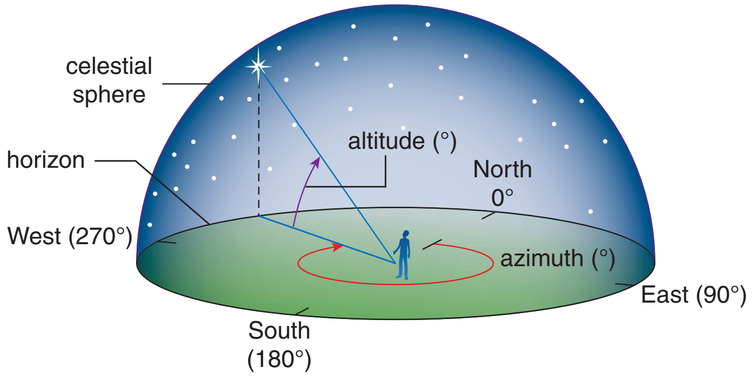

Figure 8 Altitude and azimuth are measured with reference to the horizon.

You can use your hands to measure angles for determining the positions of celestial objects. For instance, when you hold your hand out at arm's length, the width of your index finger is approximately equal to 1° (Figure 9). The width of a fist at arm's length is approximately equal to 10° (Figure 10). If you extend the fingers of your hand, the width from the tip of your pinky finger to the tip of your thumb is approximately equal to 20° (Figure 11). In this way, you can estimate the altitude and azimuth coordinates of any celestial object in the sky. Data obtained in this manner are relative to your position on Earth.

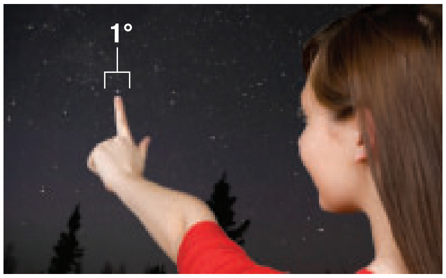

Figure 9 The width of a finger measures approximately one degree.

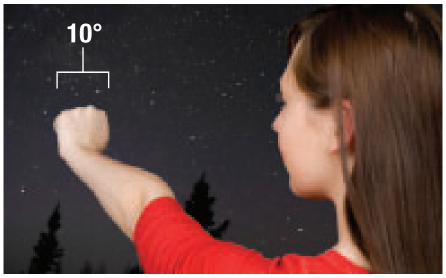

Figure 10 The width of a closed fist measures approximately ten degrees.

Figure 11 The width of an outstretched hand measures approximately twenty degrees.

TRY THIS MEASURING ALTITUDE AND AZIMUTH

SKILLS: Performing, Observing, Analyzing, Communicating

SKILLS HANDBOOK 3.B.

In this activity, you will determine the altitude and azimuth of the Moon using your hands.

Equipment and Materials: compass; pencil; notebook

1. On the date and time determined by your teacher, go outside to an open area such as a park or parking lot.
2. Using the compass, determine the direction north.
3. Begin by facing north with your fists outstretched at eye level.
4. Keeping your arms straight out in front of you at eye level, use your fists as measuring tools while you slowly turn in a clockwise direction toward the east (Figure 12). Continue measuring until you reach the spot on the horizon directly below the Moon. Remember that each fist represents 10°.

Figure 12

5. You can also use your fingers to measure smaller increments as you get closer to the Moon. Each finger width is 1°.
6. When you reach the spot directly below the Moon, stop counting. The value you have counted is the azimuth of the Moon from your location on Earth.
7. With your arms still outstretched at eye level, begin counting degrees with your fist in an upward direction until the top of your fist reaches the Moon (Figure 13). Again, use your fingers to measure smaller increments as you get closer to the Moon. When your fist reaches the Moon, you have determined the altitude of the Moon from your position on Earth.

Figure 13

8. Record your results.

A. What was the altitude and azimuth of the Moon from your position on Earth? T/I

B. The next day, compare your answers with those of your classmates. Why do you think they are not exactly the same? T/I

C. Would the altitude and azimuth of the Moon be the same for people in different parts of the country? Why or why not? T/I

GO TO NELSON SCIENCE

UNIT TASK Bookmark

You can apply what you learned about measuring azimuth and altitude in this section to the Unit Task described on page 446.

IN SUMMARY

- The Sun appears to follow an annual path in the sky called the ecliptic.
- Some planets exhibit retrograde motion—a reversal of direction in their apparent path.
- Astronomers can describe the positions of celestial objects with altitude and azimuth.
- Stargazers can use their hands to approximate the altitude and azimuth of celestial objects.
- Light pollution can affect our view of the night sky in cities and other areas with a lot of light.

CHECK YOUR LEARNING

1. Name three different objects you can see in the night sky even if you are in a city. K/U
2. What is meant by the term "light pollution," and how does it affect our view of the night sky (Figure 14)? A

Figure 14

3. What is the name of the apparent annual path the Sun, the Moon, and the planets follow across the sky? K/U
4. How does Earth's rotation affect your view of stars and constellations in the night sky? K/U
5. How does Earth's revolution affect your view of stars and constellations in the night sky?
6. In a brief paragraph, explain the astronomical phenomenon shown in Figure 15.

Figure 15

7. Explain why planets farther from the Sun than Earth exhibit retrograde motion. Use a diagram to aid in your explanation. C K/U
8. Write an explanation of the terms "altitude" and "azimuth." K/U C
9. If you are facing north and the Moon is directly behind you over the southern horizon, what is its azimuth? T/I
10. If you are observing a star that is directly overhead, what is its altitude? K/U
11. Describe two different ways of using your hands to determine the position of an object with an azimuth of 42°. T/I
12. An astronomer sees an interesting star in the night sky and wants to know its azimuth. She holds her hand outstretched at arm's length and notices that the width of her finger fits four times between the point on the horizon below the star and the direction north. What is the star's azimuth? T/I
13. A stargazer uses his fist to determine the altitude of the Moon. He notes in his journal that the altitude is approximately 30°. How many times does his fist fit between the Moon and the horizon? T/I