Topic 3.1

What do we see when we look at the night sky?

Key Concepts

- We see stars that we organize into patterns.
- We see celestial objects of the universe.
- We see objects separated by immense distances.

Key Skills

Inquiry
Numeracy

Key Terms

constellation
universe
gravitational pull
orbit
solar system
star
galaxy
astronomical unit (AU)
light-year

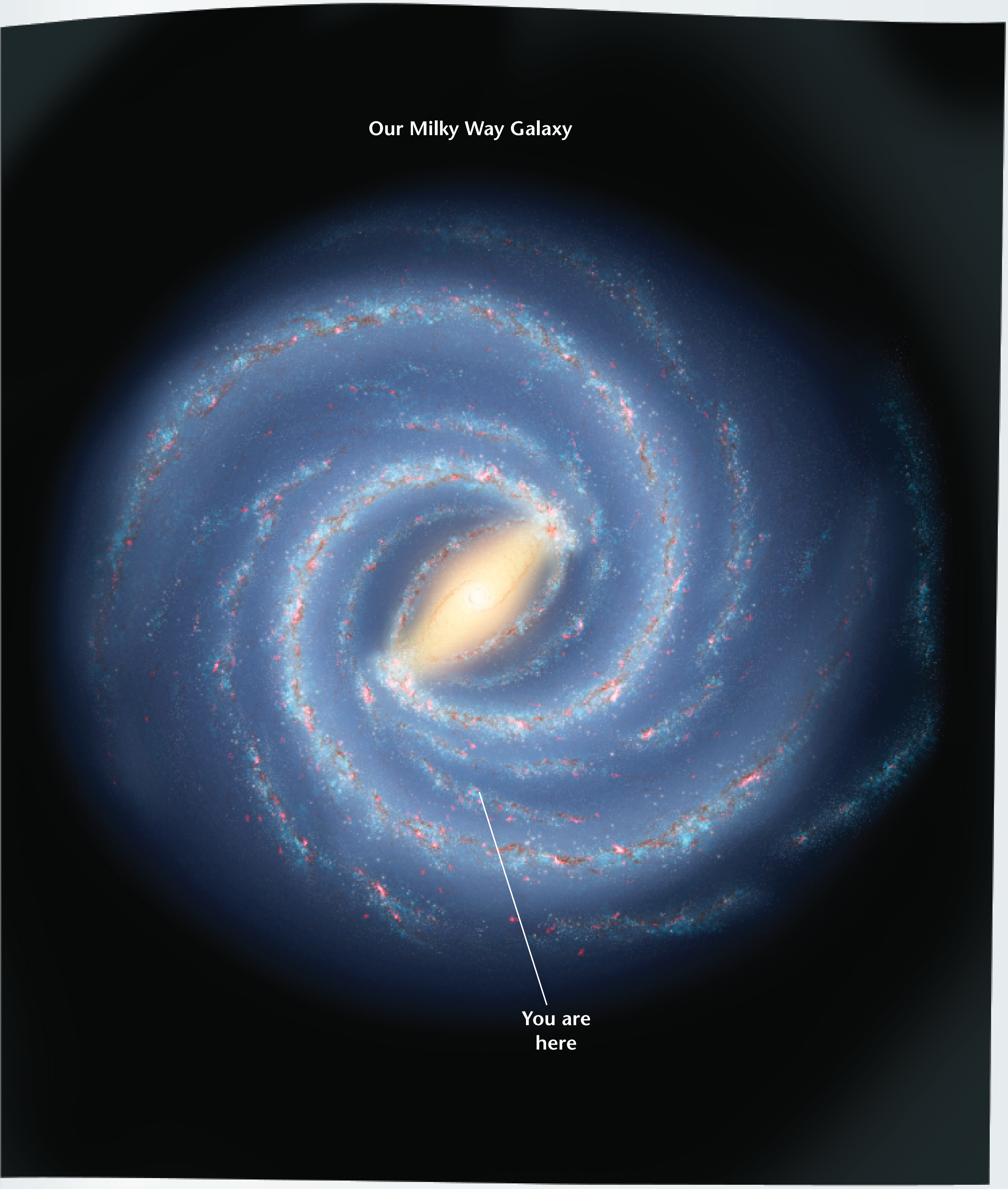
You probably have many ways to describe and share what you see in the sky. Imagine that you and others share your ideas about what you see with friends. Imagine that the friends pass on this information to others. Imagine that this sharing of information takes place over months, years, centuries, and longer. This process of sharing is the act of storytelling. For thousands of years, the sky has inspired us to share stories, to pass on ideas, explanations, guidance, and wisdom. What kinds of stories do we tell? As many as there are stars in the sky. We tell:

- ancient stories about the shapes, patterns, and events that our ancestors saw when they gazed at the heavens
- scientific stories told by astronomers to explain what we see when we look at and beyond Earth
- graphic stories, told with rock walls, animal hides, paper, and pixels, to help us communicate our wonder of and connection to the beauty of space
- visionary stories told by science-fiction authors to amuse us and teach us about our past, our present, and our future
- inspirational stories told by Elders, seers, and spiritual leaders—past and present—to link space, Earth, and all creation in our hearts, minds, and souls

Starting Point Activity

In the book, *The Hitchhiker's Guide to the Galaxy*, we are told: "Space is big. Really big. You just won't believe how vastly, hugely, mind-bogglingly big it is."

What do you see when you look into the mind-boggling hugeness of the sky? What objects, shapes, events, and patterns do you see or recall seeing? For instance, have you ever watched the Moon's changing face from night to night? Have you seen connect-the-dot animals and other objects in the stars? Share what you have seen, what you know, and what you would like to know about space.


Our Milky Way Galaxy
You are here

We see stars that we organize into patterns.

Numeracy Focus

Activity 3.1

ESTIMATE THE NUMBER OF STARS

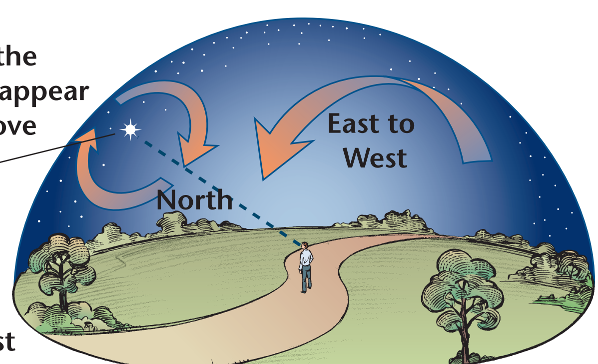
The jar in the photo has as many beans as there are stars that are visible to the naked eye in the night sky of the northern hemisphere. How many are there? Share ideas to come up with a method to estimate the number of beans in the jar. (Hint: What if you counted only a portion of the beans?)

The shape of the sky is like the shape of an upside-down bowl, with the rim of the bowl being the horizon. The stars at night look like dots of light painted on the inside of this bowl. This model of the sky—the upside-down bowl—is called the celestial sphere. The word “celestial” means sky.

If you were to watch the stars for a whole night, you would see them appear to move from east to west across the celestial sphere, just as the Sun does during the day. But the stars are not really moving across the celestial sphere. Earth’s rotation causes the illusion of their movement.

Look at **Figure 3.1**. Notice the east-to-west movement of stars labelled on the diagram. Notice also the movement around the label indicating north. As you look north, the stars look like they are rotating around a single point in the sky. This point is a star. This star happens to be lined up with the North Pole of Earth’s axis. So it seems to stay fixed in place while other stars circle around it. The name of this fixed star is Polaris, which means pole star. You might know it better by its common name: the North Star.

Go to **scienceontario** to find out more

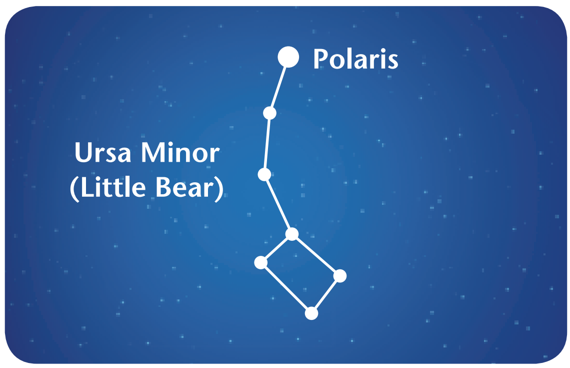


▶ **Figure 3.1** The stars in the night sky seem to move from east to west. In the northern hemisphere, stars seem to rotate around a star that is fixed (unmoving) in the sky.

Navigating the Night Sky with Polaris

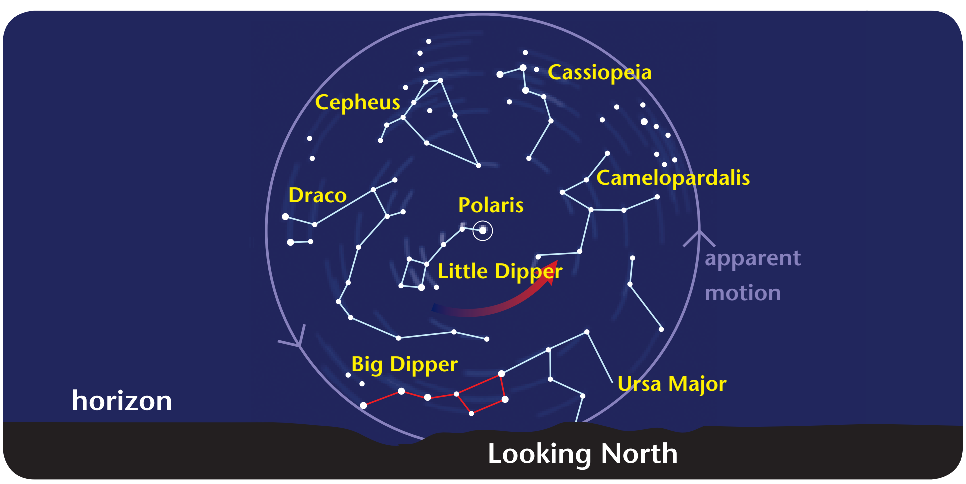
Polaris is useful because it can help people in the northern hemisphere find direction at night. But how can you find Polaris? You can use **constellations**, which are patterns formed by other stars. For instance, find Polaris in **Figure 3.2**. Polaris is the last star in the handle of the constellation called Ursa Minor (Little Bear). Ursa Minor is also called the Little Dipper, because the seven stars that make up this constellation look like the shape of a small ladle or dipping spoon.

constellation: a shape or pattern of stars in the night sky made by imagining that stars are joined together by make-believe lines



◀ **Figure 3.2** Polaris is the last star in the handle of the Little Dipper (part of the Little Bear).

Figure 3.3 shows Ursa Minor and a few other constellations that circle around Polaris. These constellations are called circumpolar, because they travel around (circum-) the pole star, Polaris. Circumpolar constellations are always visible in Canada. They never go below the horizon.



◀ **Figure 3.3** The circumpolar constellations are visible all year long in Canada. Cepheus was a mythical king. Cassiopeia was a mythical queen. Camelopardalis is the Giraffe. Ursa Major is the Great Bear. Draco is a mythical dragon.

LEARNING CHECK

1. Describe the direction the stars seem to move in the sky.
2. Explain why stars do not move the way they seem to.
3. Identify the star that stays fixed while other stars circle it.
4. Refer to **Figure 3.3**. Would you always be able to see these constellations on a clear night? Justify your answer.

INVESTIGATION LINK

Go to Investigation 3A, on page 180.

We see celestial objects of the universe.

universe: everything that exists, including celestial objects such as stars and planets as well as all the matter and empty space surrounding them

The celestial objects that we see in the sky include our Moon, planets, stars, and collections of stars. With the help of telescope technology, we also can see other moons, other planets and planet-like objects, and ever-more distant collections of stars. All the celestial objects that we see in the sky, and all that there is to be seen, make up what we call the **universe**.

Inquiry Focus

Activity 3.2

DRAW ORBITS

Use a mathematical compass to draw a model of a circular orbit that involves the following pairs of celestial objects. Use labels to identify the objects. Explain how you decided which object should be at the centre of the orbit.

a) Earth and the Moon **b)** Earth and the Sun

gravitational pull: the force of attraction that any two masses have for each other

orbit: the circular path of one object around another object

solar system: the system of planets, including Earth, moons and other objects that orbit (revolve around) the Sun

star: a massive ball of superheated gases that radiates heat and light

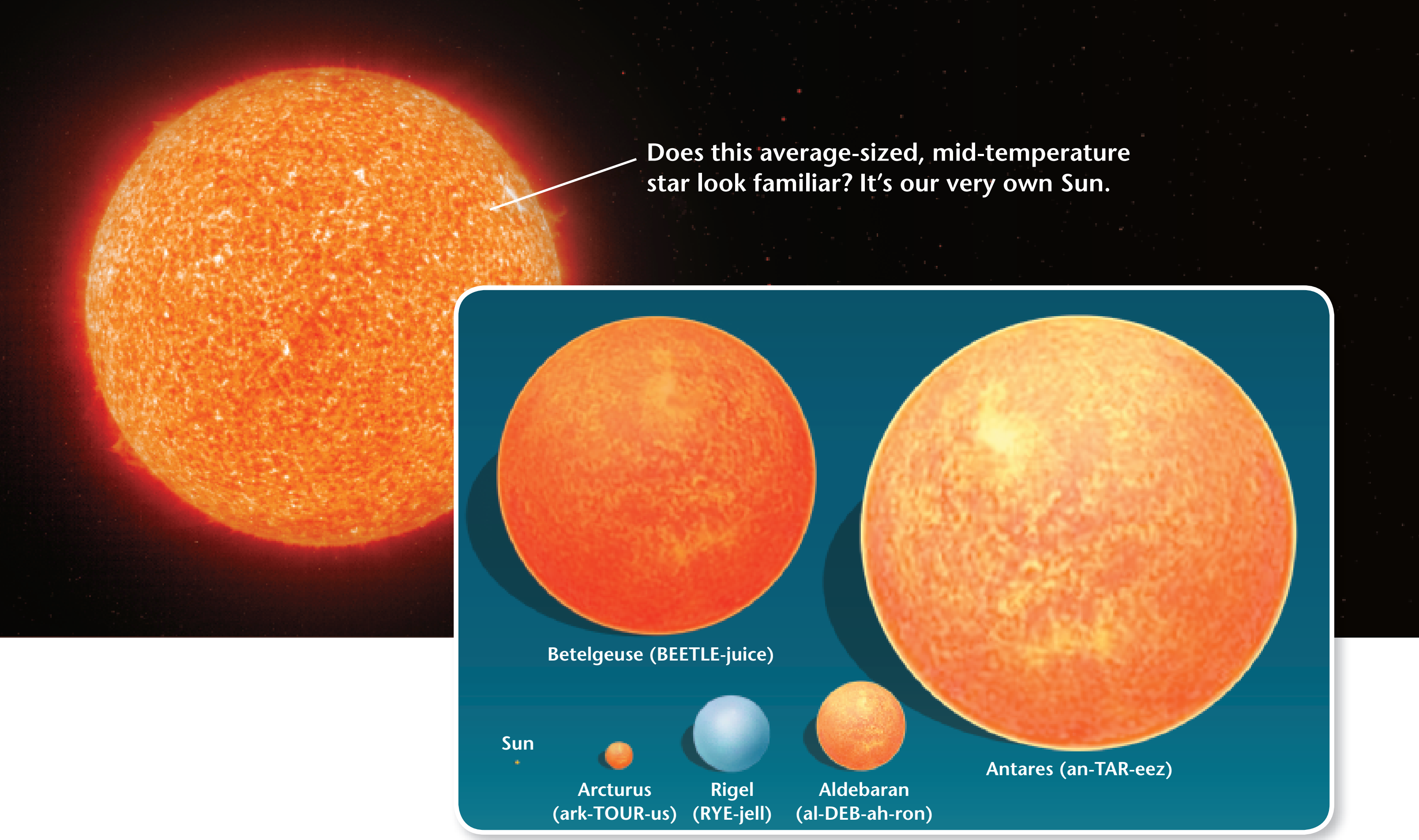
Our Solar System

Our Sun's gravity exerts a powerful pulling force on the planets. This **gravitational pull** is a force of attraction that keeps the planets moving in a circular pattern around it. This circular pattern is called an **orbit**, and the planets are said to *revolve* around the Sun, which means that they move in an orbit around the Sun. Most of the planets also have moons that revolve around them. The Sun, the planets, the moons, and other objects that orbit the Sun due to its gravitational pull make up the **solar system**. (You will explore the solar system in Topic 3.3.)

Stars and Their Characteristics

Our Sun is a star. A **star** is a ball-shaped mass of superheated gases that produces and gives off light, heat, and other kinds of energy. Figure 3.4 shows that stars vary in size, colour, and temperature. These characteristics are also described below, along with a fourth characteristic: density.

- **Size:** Some stars are millions of kilometres in diameter, while others may be only 20 km across.
- **Colour:** Some stars have a reddish, orange, or yellow colour, while others are bluish, white, or bluish-white.
- **Temperature:** Reddish-coloured stars have relatively cool surface temperatures of 3000°C, while bluish-coloured stars can be as hot as 55 000°C. (Our yellowish star is about 6000°C.)
- **Density:** Some stars have such low density they would float on water. Others are so dense a gram of the star would crush the CN Tower.



▲ **Figure 3.4** Compared with other stars, our Sun is considered to be an average-sized star. Notice that some stars can be quite a bit larger than our Sun is.

Galaxies: Collections of Stars

Stars do not exist on their own. A collection of many billions of stars held together by gravity is called a **galaxy**. There are billions and billions of galaxies in the universe. Our solar system is located in the Milky Way galaxy. It gets its name from the way it looks—like a hazy or milky path across the night sky. It appears this way because you are actually gazing into the dense centre of our galaxy from your viewpoint on Earth, near the outer edge of the Milky Way. You saw a picture of the Milky Way galaxy at the start of this topic.

In addition to stars, and any solar systems that a star might have, galaxies also contain masses of gas and dust. The gas is made up mainly of hydrogen atoms. The dust is not like the dust we have on Earth. Instead, space dust is made up of atoms and fragments of atoms. Most of a galaxy, however, has no matter of any kind. It is just empty space. (It's not called space for nothing. On second thought, maybe it *is*!)

galaxy: a collection of many billions of stars, plus gas and dust held together by gravity

LEARNING CHECK

1. Explain how gravitational pull affects planets.
2. Describe what a star is.
3. Explain how stars and galaxies are related.
4. Choose three stars in **Figure 3.4**. Design a table to compare their size and colour.

ACTIVITY LINK

Activity 3.4, on page 176

We see objects separated by immense distances.

On the celestial sphere model of the sky, stars, planets, and other objects look like they are on a flat surface close together. This is just an illusion, though. Most objects in the universe are so far apart that it is hard to imagine how far apart they are. (Remember about space: "You just won't believe how vastly, hugely, mind-bogglingly big it is.")

Distances in space are so large that well-known units such as kilometres are almost meaningless. Using kilometres to measure the distance between Earth and Jupiter would be as silly as using millimetres to measure the distance between Ottawa and Kenora. The units just aren't suitable. (By the way, there are about 2 000 000 000 mm between Ottawa and Kenora. See?)

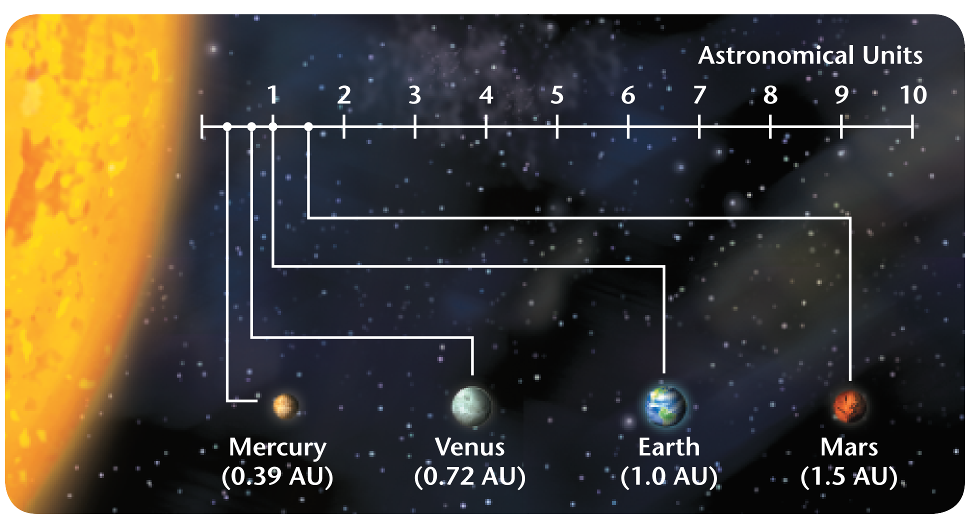
Measuring Distances in the Solar System

astronomical unit: a measurement equal to the distance between the Sun and Earth (150 million km)

Astronomers have created their own unit to measure distances between planets in the solar system. One **astronomical unit (AU)** is equal to the distance between the Sun and Earth. In familiar units, that distance is 150 000 000 (one hundred and fifty million) km. Using AUs, the Sun-Earth distance is much easier to express. It's just 1 AU, as shown in **Figure 3.5**.

Using AUs, the distance from the Sun to the last planet of the solar system (Neptune) is about 30 AU. This means that you would have to travel the distance between Earth and the Sun 30 times to reach Neptune.

Two planets, Mercury and Venus, are closer to the Sun than Earth. So their distance in AUs is expressed as a decimal fraction. The distance from the Sun to Mercury is 0.39 AU. The distance between the Sun and Venus is 0.72 AU.



▸ **Figure 3.5** Using AUs to measure distances in the solar system is much simpler than using kilometres.

Distances involving Galaxies

Distances involving galaxies are much larger than those involving solar systems. In the movies, a spacecraft can travel across a galaxy in less time than it takes its crew to execute a daring rescue plan. Even with our more current advanced technology, however, the distances between stars and galaxies are simply too great to be covered in a human lifetime.

Because these distances are so great, even AUs are inadequate to measure them. Instead, astronomers use a unit called the light-year. A **light-year** is the distance that light travels in one year. Light travels faster than anything in the known universe—a mind-bogglingly fast speed of 300 000 km/s. In one year, light can travel about 9.5×10^{12} km (9.5 trillion or 9 500 000 000 000 km). That might sound like a lot—and it is—but it's nothing in terms of distances in the universe. Most stars and galaxies, such as the one shown in **Figure 3.6**, are hundreds, thousands, and even millions of light-years away!

light-year: a measurement equal to the distance that light travels in one year (about 9.5×10^{12} km)

◄ **Figure 3.6** The Andromeda galaxy is the nearest large galaxy to our own and the most distant object that is still visible to the unaided eye. It is 2.3 million light-years away.

LEARNING CHECK

1. Compare an astronomical unit (AU) to a light-year.
2. Explain why kilometres are inadequate for measuring most distances in the universe.
3. Refer to **Figure 3.5**. Calculate the distance from Mars to the Sun in kilometres. Show your work.

Numeracy Focus

Activity 3.3

CHOOSE YOUR UNITS

Name the most suitable units to measure each of these distances:

1. your home to your school
2. your home to the nearest large city
3. Canada to Saturn
4. the Sun to Polaris

ACTIVITY LINK

Activity 3.5, on page 177

Activity 3.4

CLASSIFY GALAXIES

Scientists have invented a system to classify the millions of galaxies into just a few types. In this activity, you will invent your own system.

What To Do

1. Examine the galaxy photos. Pay attention to the similarities and differences in the features that you see. Record these in a table with headings like this:

Galaxy Number	Description of Features

2. Use your completed table to help you make up a system to classify galaxies.

What Did You Find Out?

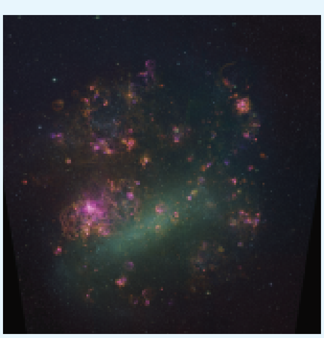
1. What features did you use to invent your classification system?
2. How does your system compare with others in the class? Decide which systems work best, and explain why you think so.

Galaxy M108

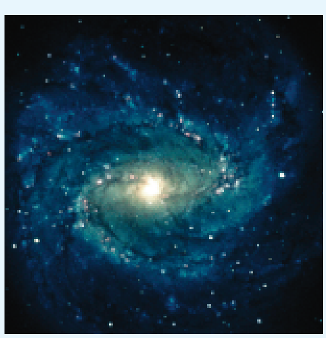
Galaxy M32

Galaxy M82

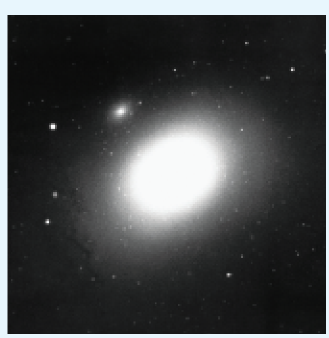
Galaxy M87



Large Magellanic Cloud



Galaxy M83



Galaxy M86

Galaxy M81

Inquiry Focus

Activity 3.5

BUILD CONSTELLATIONS IN 3-D

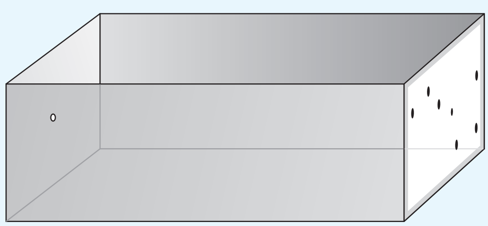
The stars in constellations look like they are all the same distance away, but this is an illusion. In this activity, you will build a 3-D model to show the real positions of the stars in the Big Dipper.

What You Need

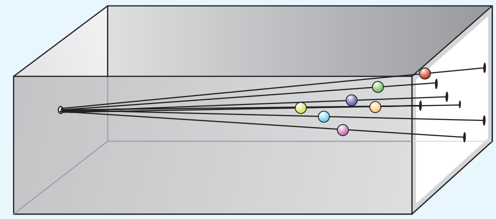
- shoebox (or other small box)
- string, scissors, glue, and tape
- Big Dipper diagram (from your teacher)
- seven small beads with holes

What To Do

1. Glue the Big Dipper diagram to the inside of one end of the box. Poke a hole through the box at each star.
2. At the other end of the box, poke one hole through the middle. This hole will be Earth.



3. Cut seven pieces of string. The string pieces should be a few centimeters longer than the length of the box.
4. Thread each piece of string through a bead. Each bead will be a star of the Big Dipper.
5. Thread the end of one piece of string through the hole at Earth. Tape the end to the outside of the hole.
6. Make sure the bead is threaded on the string. Then thread the other end of the string through a hole on the Big Dipper diagram. Tape the end of the string to the outside of the box.
7. Look at the table. Find the distance from Earth to Star 1. Glue the bead (star) to the string at the correct distance from the "Earth" hole.
8. Repeat steps 5, 6, and 7 for each piece of string.



What Did You Find Out?

1. In the sky, the seven stars of the Big Dipper look like they are the same distance from Earth. How does this model show this is just an illusion?
2. Why do the stars of the Big Dipper look like they are the same distance from Earth? (Hint: Look back on page 170 and read about the celestial sphere.)

Inquire Further

The names of the stars of the Big Dipper are Arabic. In fact, many stars that are visible in the night sky have Arabic names.

- Find out why many stars that are visible in the night sky have Arabic names.
- One of the stars in the Big Dipper is actually two stars. What is this eighth star in the Big Dipper? How is it linked to ancient tests of eyesight?

Stars of the Big Dipper and their Distances on the 3-D Model

Star in the Big Dipper	Distance from Earth on model (in cm)
Alkaid (Star 1)	1.8
Mizar (Star 2)	2.2
Alioth (Star 3)	1.7
Megrez (Star 4)	3.3
Phecda (Star 5)	2.4
Merak (Star 6)	2.3
Dubhe (Star 7)	1.8

Case Study Investigation: A Tale of the Bear

Welcome to the Science Links Planetarium. Today, as part of our Sky Tales series, we are honoured with a traditional story about the Great Bear in the night sky, known to many as Ursa Major. Many stories have been told about Ursa Major. They have been shared by various cultures in the past and still are today. This is one of them.

Madjikiwis and Nanabush, a tale of the Anishinabeg

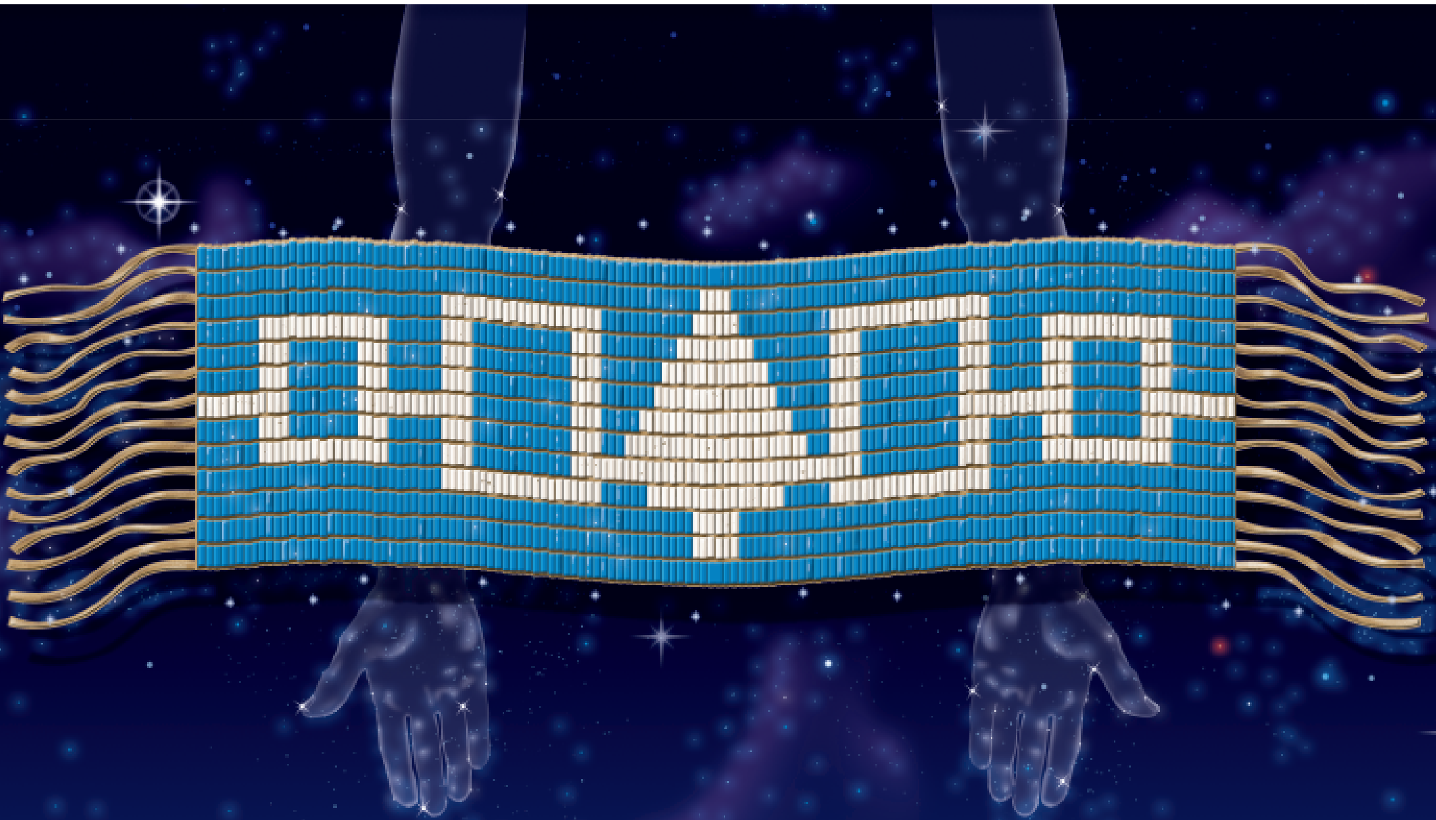
Madjikiwis was young, courageous and cared deeply for his family who had nurtured and taught him. As a young Anishnabe man he learned the skills of a hunter and he loved spending time in the forest where each moment offered better understanding of the four orders of all life and the way people depended on them.

His speed was great and skills excellent but in his heart he felt something was missing in his understanding which kept him from finding his own place in his world. His family was good and his needs were sufficiently met but what was the outcome of their efforts to be? Each passing of the long Winter brought another reawakening of Spring when all life once more was renewed but where could each of these steps lead?

Madjikiwis could not find the answer.

Finally, near the end of a fine Summer, he gathered his hunting equipment and left home for hill country. After traveling for days he came to the home country of the Bear and began to feel concern for how he might be received since his provisions were almost gone and he had no gifts to offer. As darkness fell and mists floated above the valleys Madjikiwis became fearful that his journey had been unwise as his preparations had been hasty and maybe a bit careless. He stopped walking and prepared a bough lean-to as the sky filled with stars.

Just then Nanabush, a spirit-guide (able to take the form of different animals) adopted the image of Bear high above Madjikiwis and spoke in a language the young man could understand. All of the usual night time sounds stopped as Nanabush explained to Madjikiwis the place of



human beings in the natural world and the necessity of remembering the Nokomisog and the Mishomisog (Grandmothers and Grandfathers) throughout all time since their lives had made possible each succeeding life. In this way meaning and knowledge were passed from generation to generation and the symbolic map of these events is depicted in the Wampum belts like the one Nanabush then gave to Madjikiwis that night. Slowly the comforting sounds of the forest at night returned and the young man drifted off in a comfortable sleep.

From that day Madjikiwis gained in wisdom which he then shared with his people through care for and teachings of the Wampum belts.

High above in the heavens the constellation of the Bear symbolizes this gift of understanding and meaning which has provided understanding for thousands of years even to this day—or night.

Investigate Further

1. Create the next story for the Star Tales planetarium series. Your story can be in the form of a narrative, graphic novel, song, mural, or other creative work about a constellation of your choice.

Investigation 3A

Skill Check

Initiating and Planning

✓ **Performing and Recording**

✓ **Analyzing and Interpreting**

✓ **Communicating**

What You Need

- Star-Finder Wheel template (from your teacher)
- cardboard
- scissors
- tape

Make a Star-Finder Wheel

How can you use a model of the night sky to identify and find constellations on any day and at any time?

What To Do

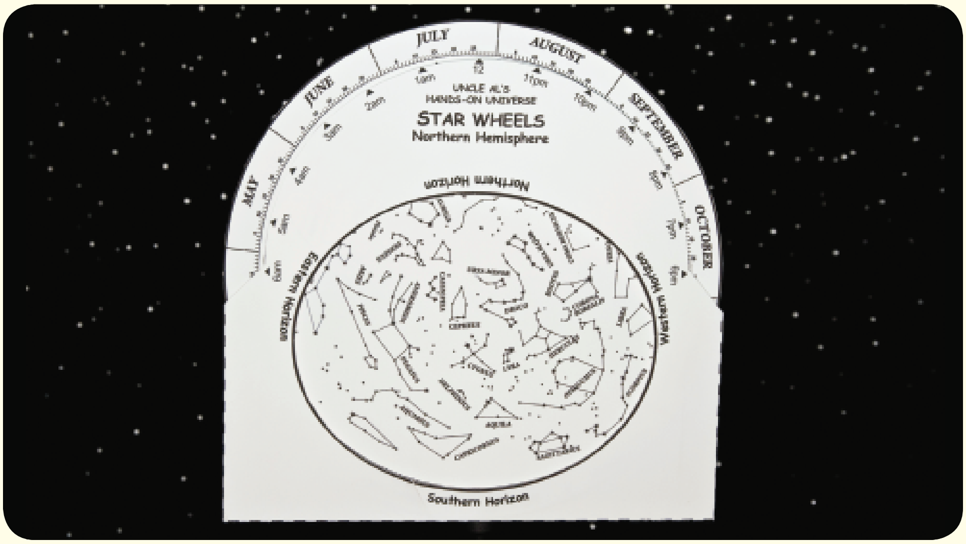
1. Follow the directions on the Star-Finder Wheel template to make your Star-Finder Wheel.
2. Set the Wheel to today's date.
3. Use the Wheel to help you name five constellations that you would be able to see in the sky tonight at 10 P.M. (Only two of your choices can be circumpolar.)
4. Use the Wheel to determine if you would be able to see these same constellations at 12 A.M., 2 A.M., and 4 A.M.
5. Design a table to record the five constellations you named and whether you would be able to see them at 10 P.M., 12 A.M., 2 A.M., and 4 A.M.

What Did You Find Out?

1. Would you be able to see the two circumpolar constellations that you named any night of the year? Explain why or why not. Then use the Wheel to verify your answer.
2. During which seasons of the year would you be able to see the other three constellations you named at 10 P.M.?

Inquire Further

You can use the Big Dipper to tell time. Use the library or the Internet to find out how. Or ask your teacher for an activity that you can use to find out instead.



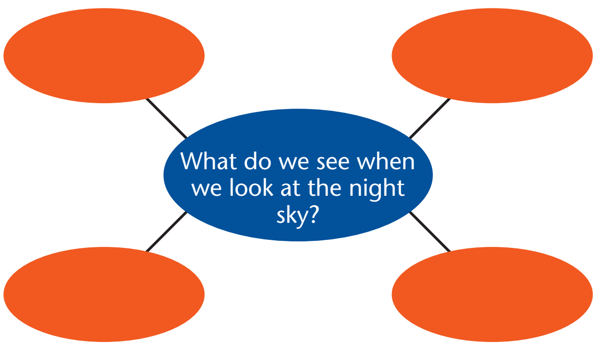
Topic 3.1 Review

Key Concepts Summary

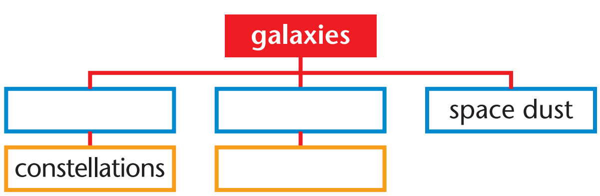
- We see stars that we organize into patterns.
- We see celestial objects of the universe.
- We see objects separated by immense distances.

Review the Key Concepts

1. **K/U** Answer the question that is the title of this topic. Copy and complete the graphic organizer below in your notebook. Fill in four examples from the topic using key terms as well as your own words.



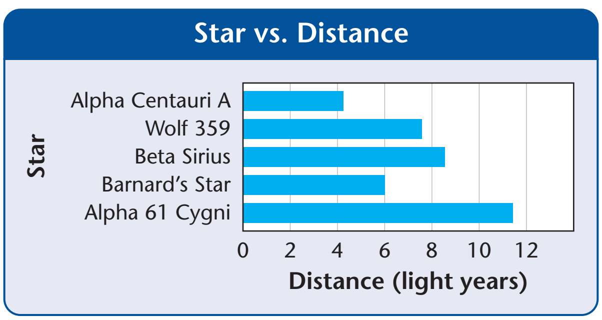
2. **C** Copy the graphic organizer below into your notebook. Complete it to show the relationship among these key terms: stars, constellations, planets, solar systems, space dust, and galaxies.



3. **A** Space dust is composed of extremely small particles. Scientists believe this dust is composed of heavy elements such as carbon, magnesium, iron, and calcium. The particles of dust pose no threat to planets such as Earth. However, they can chip away at the solar panels on spacecraft. Explain why space dust presents a serious problem for astronauts orbiting Earth on the International Space Station (ISS).

4. **C** Draw a Venn diagram to compare an astronomical unit (AU) to a light year. In your diagram, identify when astronomers would use astronomical units (AU) and when they would use light years.

5. **T/I** Look at the graph shown here and answer the questions. Identify which star is the farthest from Earth and which star is closest to Earth. Justify your answer.



6. **K/U** Use the term "gravitational pull" in a sentence.

7. **T/I** Which star below would exert the greatest gravitational pull on its orbiting planet? Explain your reasoning.

8. **A** Imagine that you are lost in a desert at night. The desert is in the northern hemisphere. Explain how could you determine the four directions.