Topic 3.1
What do we see when we look at the night sky?

Specific Expectations

- **D2.1** use appropriate terminology related to space exploration, including, but not limited to: *astronomical units, gravitational pull,* and *universe*
- **D2.2** investigate patterns in the night sky and the motion of celestial objects, using direct observation, computer simulations, and/or star charts, and record the information using a graphic organizer or other format
- **D3.1** describe the major components of the universe, the motion of the different types of celestial objects, and the distances between certain objects, using appropriate scientific terminology and units

Skills

- identify and locate sources
- gather and organize data
- analyze and interpret data
- draw conclusions
- communicate in a variety of formats
- use appropriate units of measurement
- express results accurately and precisely

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-43 for a summary of the materials required in this topic.

Overview

In this topic, students will learn about the celestial bodies of the universe, the patterns they form, and the vast distances between them. Students will be introduced to the units we use to measure these enormous distances and about how humans through the ages have seen patterns in the stars and used these patterns to navigate on Earth.

Common Misconceptions

- **Students with an interest in science fiction may not realize how large space is, because—in the science fiction genre—it takes very little time to travel between celestial bodies.** Emphasize the enormity of space. Have students reread the first paragraph of Measuring Distances in the Solar System on page 174. Remind them that 1 AU = 150 million km. To provide a point of perspective, tell students that the circumference of Earth (at the equator) is only approximately 40 075 km. With students, calculate how many circumferences of Earth are equal to 1 million km. Then multiply this result by 150 to see just how much larger an astronomical unit is, compared to the circumference of Earth.
- **Students who live in large cities may not be aware that many celestial objects that are normally visible to the naked eye are not visible due to light pollution.** These students may have seen only the brightest of stars and planets, such as the Moon, Polaris, and Venus. Use "Starry Night®" software or organize a stargazing evening for the class.
- **Students may confuse stars with planets in night-sky viewing.** Explain that the brightest objects can often be planets, rather than stars. Using binoculars or a telescope, help students discern one from the other by having an evening stargazing outing. Alternatively, explain that stars twinkle, while light from a planet is constant and does not twinkle.
- **Students may have trouble understanding that Earth is within a galaxy, the Milky Way.** Ask students why we cannot see the Milky Way as a spiral galaxy as shown in the Topic Opener image. (We are inside the galaxy. To see the entire spiral galaxy, we would have to be outside the galaxy, looking at it.) To further clarify, ask students if they know what Canada looks like on a (topographical) map. Then ask them why they cannot see Canada right now. Explain that this is the same situation as not being able to see the Milky Way, but on a smaller scale.

Background Knowledge

Galaxies are extremely large (100 000 light-years across) and contain billions of stars, as well as gas, dust, and dark matter. Galaxies are held together by gravity and slowly rotate over millions of years.

Earth is located in the Milky Way galaxy. When we look up at the sky on a very clear night, away from city lights, we can see stars from the Milky Way and from other galaxies. Because there is so much dust in our Milky Way, we can see only the stars that are near Earth. The light from the millions of other stars is less intense because of all the dust, so these stars are not bright enough to see with the naked eye.

Our Sun is one of the estimated 100 billion stars that are held in this galaxy. It takes the Sun more than 200 million years to make one complete trip around the galaxy's centre. If we could design a rocket that could travel at the speed of light, it would take 1000 centuries for a person to leave Earth and cross to the other side of the Milky Way.

Literacy Strategies

Before Reading

- ELL Draw students' attention to the organization of the topic. Show them where to look for Key Term definitions (margins) and how the sections are split into main headings and subheadings. Demonstrate how to quickly find an important fact or a reference by scanning through the headings and subheadings, and simplify any difficult language. This skill will be especially useful for English language learners and other students who find reading challenging. Explain that being able to navigate through a textbook and find what you need is a skill that will be useful throughout high school.
- ELL Preview the Key Terms, as well as other unfamiliar words, with English language learners. Draw a concept map together to show how the terms relate to one another. Encourage students to use sketches to assist them.

During Reading

- Model how to make jot notes and have students make jot notes of key concepts as they read, including diagrams if appropriate. Recording important information during reading will help students retain that information and review it later.

After Reading

- As a review, select a few key concepts and have students find the relevant section on that concept.
- Allow time for students to express what they did not understand.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Learning Check question 4, page 171	Students explain that the constellations in Figure 3.3 on page 171 are always visible because they are circumpolar; that is, they rotate around Polaris.	• Read the caption for Figure 3.3 together with students. Have pairs of students act out this concept by using the edge of the desk as the horizon, and a picture of stars with a pencil or long stick poked through the centre as the sky. One student can stand or sit at one end of the desk and the other students can stand or sit at the other end of the desk. The first student can hold the pencil or stick so the star picture is facing the student on the opposite side of the desk. The student can rotate the star picture around the pencil or stick so that the stars near the centre are always above the horizon, and other stars appear and disappear.
Activity 3.2, page 172	Students correctly draw a) the Moon orbiting Earth or b) Earth orbiting the Sun.	• If students are unclear about which object orbits which, have them do both a) and b) and compare. For bodily-kinesthetic learners, you may wish to have students take on the role of the objects in the solar system and act out the orbits. With a partner, students could act out the orbit of the Moon around Earth, or you could incorporate this into the larger solar system model.
Learning Check question 3, page 173	Students convey that a galaxy is a collection of billions and billions of stars.	• Have students use a flowchart or concentric circles to show how Earth fits into the solar system with the Sun, and then how the Sun fits into the Milky Way. Spatial learners may benefit from using cups or jars in graduated sizes, with the smallest labelled "Sun," then "solar system," and then "Milky Way galaxy."
Learning Check question 2, page 175	Students explain that using a small unit such as a kilometre would be too awkward to measure extremely large distances.	• If students have trouble communicating their understanding, they can show you mathematically. Or, you could refer to Learning Check question 3 and have them write a concluding statement for their calculation.
Topic 3.1 Review question 1, page 181	Students provide four correct answers to the question "What do we see when we look at the night sky?"	• Have students review their jot notes from the During Reading literacy strategies. Have them summarize the notes as a review.

Topic 3.1 (Student textbook pages 168–181)

Using the Topic Opener (Student textbook pages 168–169)

- DI Start the topic with a class discussion about stories that students have heard about the objects in the night sky. To benefit interpersonal learners and students who need to develop this skill, Encourage active and considerate listening. Then have students read the text on page 168 and look at the image on page 169.
- Read aloud or have a student volunteer read aloud a story about a celestial object that would be familiar to students. You can find these stories at **www.scienceontario.ca**. You may wish to read two or more stories about the same celestial object to have students compare them.
- Have students sit or stand in a circle to participate in a storytelling activity. Choose one celestial object that is familiar to all (or most) students, such as the Moon or Polaris (the North Star). Explain that you will be creating your own class story about this object. Start off the story for students, or have a volunteer begin the story. You could start with the traditional "once upon a time," and then allow students to contribute a sentence or two before passing the story to the next student in the circle. Remind students that they must incorporate and build on the ideas of the previous storytellers—they cannot ignore the new information. Once all students have contributed, have a student volunteer scribe the story for the class. Ask how this process is similar to ancient storytelling and oral traditions.
- Ask students why our ancestors may have created stories about celestial objects (to explain, to entertain, to inspire).

Starting Point Activity (Student textbook page 168)

Pedagogical Purpose

Students reflect on their personal experiences with the night sky and share them with the class. Students will also set goals for what they would like to learn.

Planning	
Materials	**BLM G-29 K-W-L Chart** (optional)
Time	20 min

Skills Focus

- communicate in a variety of formats

Background Knowledge

Douglas Adams' *The Hitchhiker's Guide to the Galaxy* was a 1970s radio show that aired on Britain's BBC Radio 4. The science fiction comedy was later adapted into a series of books, a 1981 TV series, and a 2005 movie. *The Hitchhiker's Guide to the Galaxy* has an enormous international following. The books have been translated into more than 30 languages. A clip from the 1981 television series can be found at **www.scienceontario.ca**.

Activity Notes and Troubleshooting

- This activity is intended to engage students' interest and have them make a personal connection with the material. Be sure to create a comfortable forum for class discussion. Students may not have the vocabulary to explain the celestial objects that they have seen. Introduce the Key Terms as they apply throughout the discussion.

- Light pollution in large cities may have limited some students' experiences with seeing objects in the night sky. If possible, plan a trip to the Ontario Science Centre's Space hall—in particular, their CA Planetarium. Alternatively, plan a stargazing night with the class. Visit **www.scienceontario.ca** to help you plan your evening. The magnification on most commonly available telescopes is not significantly better than that of standard binoculars, so you may wish to provide a few pairs of binoculars for students.
- Students could use **BLM G-29 K-W-L Chart** for this activity. Students can fill in the first two columns before they begin the activity, and the last column at the end of the topic.

Additional Support

- ELL Students who were born in the southern hemisphere will have different views of the night sky than what is visible in the northern hemisphere. Many students will have heard different stories and have seen different patterns in the stars based on their particular culture or the locations where they have lived. Provide a positive forum for these students to share their experiences with the class.
- DI Students with musical intelligence may wish to transform the class story into a song or a verse. Additionally, students with bodily-kinesthetic intelligence may wish to create movement to accompany the story. Encourage all appropriate adaptations.
- DI Students with linguistic and interpersonal intelligence will enjoy the storytelling activity. Reinforce the importance of these stories to early cultures.

Answers

Most students will have seen the phases of the Moon. Many students will have seen Ursa Major (the Big Dipper) and Ursa Minor (the Little Dipper). Planets, such as Venus and Mars, are often visible as well, but are often mistaken for stars.

Instructional Strategies for Topic 3.1

We see stars that we organize into patterns. (Student textbook pages 170–171)

- Consider the following as a class demonstration. To explain the celestial sphere, you may wish to create a model from an inexpensive plastic bowl (perhaps from the dollar store). Using a permanent marker, draw simple line drawings of a few major constellations on the inside of the bowl. Then have students hold the bowl over their heads to help them understand how the celestial sphere would work. To avoid misconceptions, ask students to explain the difference between where the stars actually are compared to where they appear to be. If necessary, you could have students use small round objects, such as beads, and hold them at various distances above the bowl to show that the stars are actually **not** stuck in a two-dimensional sphere around Earth.
- Have students connect the concept of the celestial sphere to the stories listed in the topic opener. Ask students how this observation of the celestial sphere might make people think of the universe (for example, the stories might involve people or objects that are inside a large dome-like structure). Have students refer to Figure 3.1 on page 170 to help them organize their thinking.
- DI Ask students if they have been able to see the constellation Ursa Minor in the sky. Refer them to Figure 3.2 on page 171 as a reference. Then have students refer to Figure 3.3. Explain that Ursa Minor can be a difficult constellation to spot at times. However, the Big Dipper—part of Ursa Major—is usually very easy to see. Have students locate Ursa Major in Figure 3.3. Then, to support spatial learners, explain that you can draw an imaginary line from the last star in the Big Dipper to the centre of the sky and find Polaris. This last star in the Big Dipper, called Dubhe, is also referred to as the Pointer Star as it points to Polaris.

- Ask students why finding Polaris would be useful for navigation. (It can help people find direction at night.) Ask, "Why is a star that is a fixed point more useful for navigation at night than a star that seems to move—such as Betelgeuse, located in the constellation of Orion?" Explain that some stars will not be visible at all times of the year and that even circumpolar stars will appear to rotate around the sky throughout the year. Polaris is the only star that stays in one place in the sky no matter what time of the year it is.
- Have students who have lived in the southern hemisphere share their experiences with viewing the night sky. (Polaris is not visible in the southern hemisphere.)

We see celestial objects of the universe. (Student textbook pages 172–173)

- ELL Before reading the subsections, have students suggest a simpler subtitle while still capturing the essence of the section (for example, for "Stars and Their Characteristics," students might suggest "What Stars Are Like").
- Bring in a news article about a recent astronomical discovery. Discuss with students how the discovery was made, and what scientists might hope to learn from it.
- DI Refer students to Figure 3.4 on page 173. You may want to use visuals to help students see the size differences. For example, use a small bouncy ball for Earth, a golf ball for Arcturus, and so on. Explain that if we could replace the Sun with Betelgeuse in our solar system, Earth would be engulfed by the larger star. Students with spatial intelligence, or those who need to develop this skill, would benefit from using these models.
- ELL Have English language learners preview the Key Terms in the margin before reading the text to themselves. Doing so will aid them in understanding the concepts as they encounter them. On the chalkboard, draw a diagram to illustate the meaning and relationships among the Key Terms.
- Enrichment—Have interested students research where to find each star (for example, both Betelgeuse and Rigel are in the constellation of Orion) and report back to the class. Students who show continued interest could research a particular star and present their findings.
- For students who need support organizing information, provide copies of **BLM G-38 Venn Diagram** to help students compare stars and galaxies in Learning Check question 3 on page 173.
- For students who need support drawing a table, provide copies of **BLM 3-4 Star Comparison Table** to help students organize their answer to Learning Check question 4 on page 173.

We see objects separated by immense distances. (Student textbook pages 174–175)

- Before students begin to read, have a discussion about measuring distances and the units you would use. Use this discussion as a review of basic metric units. Ask students what the largest unit of distance is and what the smallest unit of distance is. Have them practise their estimating skills by guessing how many millimetres there are between their desk and the door. Then have them measure the distance. Use this discussion and activity as a launching point for the reading on astronomical units and light-years.
- Students who require remediation in the metric system can use **BLM G-24 Using Scientific Notation**. You may also refer students to Numeracy Skills Toolkit 1: Scientific Notation on page 366 of the student textbook.

Activity 3.1 Estimate the Number of Stars (Student textbook page 170)

Pedagogical Purpose

This activity will help students understand the sheer number of visible objects in the night sky.

Planning	
Materials	A glass or clear plastic jar with a lid (optional) 3000 beans or other small objects (optional) **BLM G-27 Estimating** (optional)
Time	20 min in class
Safety	Remind students that the jar is glass and will break if dropped. Have a glass clean-up kit ready.

Skills Focus

- use appropriate units of measurement

Background Knowledge

Estimating is different from guessing. Every day, we estimate time, distance, and quantities of many things. Estimating how far it is from students' homes to school, or how long it takes students to walk to their next class, provides reasonable and logical results based on previous experiences.

Activity Notes and Troubleshooting

- Begin the activity with a class brainstorming session on how to estimate the number of beans in the jar that is shown in the photograph.
- You may wish to provide a jar of 3000 beans (or other small objects) for this activity. Some students may find it easier to estimate this way, rather than just using the photograph. Allow students to handle the jar carefully. Students can open the jar and count a small portion of the beans to help them estimate. If you would prefer not to provide a jar of beans or other objects, you could provide an enlargement of the photograph in the textbook for students to consider.
- Use large graph paper or the board to record students' estimates.
- To develop thoughtful estimating skills, students can work with a partner or in small groups for this activity. With their partner or in their groups, instuct students to make an estimate and then justify their answer. Have them explain to their partner or group members why their estimate is reasonable and their thought processes in selecting that number.

Additional Support

- Students can review the concept of estimating by viewing a short video explaining the difference between measuring and estimating, found at **www.scienceontario.ca**. You may also have students use **BLM G-27 Estimating** for more practice.
- DI This activity will appeal to students with logical-mathematical intelligence and will allow other students to develop and practise these skills. Encourage students to share the strategies they use to estimate.
- Enrichment—Explain to students the concept of a Fermi problem. (Visit **www.scienceontario.ca** for more information on Fermi problems.) Have students practise their estimating skills by asking them, based on the number of stars visible to the naked eye in a small section of the sky, to estimate the number of stars in the entire northern hemisphere. Remind them that there are no wrong answers, but their estimates must be logically worked out.

- ELL This activity engages students' prior knowledge by providing a simple analogy (estimating beans in a jar) related to estimating large numbers of stars in the sky. You might provide more analogies for English language learners, or have them come up with their own analogies (for example, estimating the number of people in a school or stadium or estimating the number of cars in a parking lot).

Activity 3.1 Answers

Once students have their estimates for a small portion of beans in the jar, encourage them to estimate how many times that portion of beans would fit in the entire jar. For example, students may have counted a small portion of 30 beans. They can multiply 30 by the number of times that portion of beans would fit in the jar. Then remind students that the total number of beans in the jar is the same as the number of stars that are visible to the naked eye in the northern hemisphere.

Learning Check Answers (Student textbook page 171)

1. The stars seem to rise in the east and set in the west.
2. The rotation of Earth creates the illusion that the stars are moving.
3. Polaris, or the North Star, seems to remain fixed in place.
4. Circumpolar constellations, as shown in Figrure 3.3 (on page 171), are always visible in Canada. They travel around Polaris, so they never go below the horizon.

Activity 3.2 Draw Orbits (Student book page 172)

Pedagogical Purpose

Students use mathematical compasses to draw circular/elliptical orbits of the Moon around Earth and of Earth around the Sun. This activity will help establish and cement students' understanding of which celestial objects orbit which.

Planning	
Materials	Mathematical compasses
Time	20 min in class

Skills Focus

- communicate in a variety of formats

Background Knowledge

The heliocentric universe (the Sun at the centre with the planets, including Earth, orbiting it) was first theorized by Copernicus (1473–1543). Copernicus' theory was later supported by Galileo (1564–1642). Galileo's position was unpopular at the time and condemmed by the Church, which supported a geocentric (Earth-centred) model. Galileo was tried by the Inquisition and kept under house arrest for the rest of his life.

Neither the Moon's orbit around Earth, nor Earth's orbit around the Sun (or any of the planetary orbits), is perfectly circular. Orbits are characterized as ellipses (similar to ovals), with the Sun at one of the focal points of the ellipse. Although Earth's orbit around the Sun and the Moon's orbit around Earth are very nearly circular, the farther planets and comets have dramatically elliptical orbits.

Activity Notes and Troubleshooting

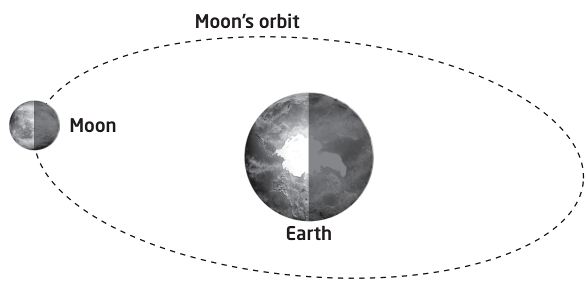
- If mathematical compasses are not available, have students trace a round object to draw the orbits.
- One of the key parts of this activity is having students reason which celestial body orbits which. After orbits are drawn, have students share their explanations with a classmate and ask questions to clarify, if necessary.

Additional Support

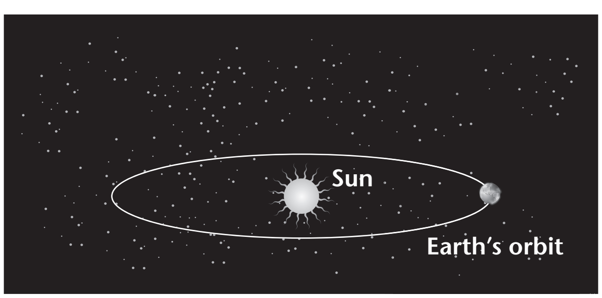
- Students who are having difficulty understanding Earth's nearly circular orbit around the Sun may benefit from viewing an animation of the orbit. Similarly, a video of the Moon orbiting Earth can be helpful as well. Visit **www.scienceontario.ca** for some examples.
- DI Students who have logical-mathematical intelligence will enjoy this simple activity and can demonstrate for others. Students can work on their own to develop intrapersonal skills.
- Students with fine motor-control challenges may wish to use a computer graphics program for this activity.
- Enrichment—Interested students could draw the Moon's orbit to scale, with more accuracy, given that the closest the Moon comes to Earth is about 364 000 km and the farthest is about 406 000 km. Ensure students understand that these distances are approximate only. Provide graph paper or access to a computer graphics program.
- ELL To help English language learners explain their drawings, you might provide them with a Venn diagram to compare the orbits of Earth and the Moon, and Earth and the Sun. Encourage students to use sketches in their explanations as well. Alternatively, students could create a Venn diagram with three overlapping circles for Earth, the Sun, and the Moon. They could work in teams of six, each filling in their own Venn diagram and then discussing their answers and creating a master Venn Diagram as a group.

Activity 3.2 Answers

a) Earth and the Moon



b) Earth and the Sun



Learning Check Answers (Student textbook page 173)

1. Gravitational pull keeps the planets moving in a circular pattern around the Sun.
2. A star is a ball-shaped mass of very hot gases, which produces and gives off light, heat, and other kinds of energy.
3. A galaxy is a collection of billions and billions of stars that are held together by gravity.
4. Students may make connections between three of the following stars:

Sun	Arcturus	Rigel	Aldebaran	Betelgeuse	Antares
• smallest out of these six stars • yellowish colour	• second smallest out of these six stars • orange colour	• third smallest out of these six stars • bluish colour	• third largest out of these six stars • orange colour	• second largest out of these six stars • reddish colour	• largest out of these six stars • reddish colour

Learning Check Answers (Student textbook page 175)

1. An astronomical unit (AU) is equal to the distance between the Sun and Earth (150 000 000 km). A light-year is the distance that light travels in one year. Light travels at the speed of 300 000 km/s, and in one year, light can travel about 9.5×10^{12} km. So, there are about 63 333 AU in one light-year.
2. Kilometres are too small to measure most distances in the universe.
3. The distance between the Sun and Mars is 1.5 AU, or 225 000 000 km.

Activity 3.3 Choose Your Units (Student textbook page 175)

Pedagogical Purpose

Students revisit numeracy skills and incorporate the introduction of new units of measure, the astronomical unit (AU) and the light-year, into their mathematical skillset.

Planning	
Materials	Various measurement materials (centimetre rulers, metre sticks) **BLM G-28 Metric Conversions** (optional)
Time	10 min in class

Skills Focus

- use appropriate units of measurement

Background Knowledge

Choosing the most suitable unit to measure distances will ensure that the values are not difficult to understand, visualize, or work with. For example, kilometres are an appropriate unit to measure the distance between two cities; however, kilometres are not an appropriate unit to measure the distances in space because the values would be too great. Students are introduced to astronomical units (AU) and light-years in this section. Astronomical units are used to measure distances in solar systems, and one astronomical unit is equal to the distance between the Sun and Earth (150 million km). Light-years are used to measure distances in galaxies, and one light-year is equal to the distance that light travels in one year (about 9.5×10^{12} km).

Activity Notes and Troubleshooting

- Working in groups, have students practise measuring distances in their classroom with a ruler and a metre stick, and then choose the appropriate unit for each distance. Explain that, although accurate, this method of measuring is not practical for long distances.
- Ask students why distances in space are measured in astronomical units or light-years rather than kilometres. (Very large numbers are difficult to manipulate. For example, the distance from the Sun to the nearest star is about 300 light-years. Since a light-year is 9.5×10^{12} km or 9 500 000 000 000 km, the distance from the Sun to this star is 2 850 000 000 000 000 km. That is a lot of zeros and a huge number to manipulate in mathematical equations.)
- Some students may mention, or use, imperial units, such as inches, feet, or miles. Encourage students to use metric measures, especially for science class. You may wish to have students practise their metric skills with **BLM G-28 Metric Conversions**.

Additional Support

- DI If possible, have students with strong logical-mathematical intelligence work with students who are struggling.
- Provide a metre stick and have students measure the length of the school hallway. Then ask them if a metre stick would be useful in measuring the distance from school to their home. Explain that for longer distances, a larger unit of measurement is easier to manage. Students can use **BLM G-28 Metric Conversions** for more practice.
- If students are having difficulty with scientific notation, or if they would benefit from more practice, refer them to Numeracy Skills Toolkit 1: Scientific Notation on page 366 of the student textbook.
- DI Students with strong bodily-kinesthetic skills, but who are having difficulty with the activity, can pace out the length of the school hallway. As mentioned above, ask them if this method of measurement would be useful in measuring the distance between Toronto and Ottawa.
- Students who need support in question 3 can talk to a classmate about the steps that they might follow, and then determine the answer on their own.
- ELL Read the activity aloud to students. After each example, draw a diagram on the chalkboard using simple symbols to represent each object, with an arrow pointing from one symbol to the other. You might also suggest that English language learners come up with their own distances to use, perhaps between locations in another country.

Activity 3.3 Answers

1. home to school—kilometres (possibly metres)
2. home to the nearest large city—kilometres
3. Canada to Saturn—astronomical units
4. the Sun to Polaris—light-years

Activity 3.4 Classify Galaxies (Student textbook page 176)

Pedagogical Purpose

Students will develop their observation and analytical skills by developing their own system of classification for galaxies.

Planning	
Materials	Enlargements of text photographs
Time	30–40 min in class The day before, photocopy colour-enlargements of the galaxies shown in the student textbook.

Skills Focus

- gather and organize data

Background Knowledge

The *M* in the galaxy names stands for Messier, after the French astronomer Charles Messier (1730–1817). Messier is known for compiling a catalogue of about 100 celestial objects. Galaxy M108 is also known as Messier 108. It is a spiral galaxy located in Ursa Major. Galaxy M32 is a dwarf elliptical galaxy and a satellite of the Andromeda galaxy, M31. M82 is a starburst galaxy in Ursa Major. It has an irregular shape bisected by a disk. M87 is an elliptical galaxy in the Virgo cluster. The Large Magellanic Cloud galaxy, a dwarf galaxy, is one of the brightest galaxies orbiting the Milky Way. M83 is a spiral galaxy with red and blue spiral arms. It is sometimes called the Southern Pinwheel. M86 is a large elliptical galaxy in the Virgo cluster. It is moving at such a high rate of speed that it is ripping gas from the galaxy and forming a tail. M81 is a spiral galaxy located in Ursa Major with a gigantic black hole at its heart.

One of the best sources of astonishingly beautiful images of celestial objects is the Chandra Space Telescope, but there are also other sources of images on the Internet. More information about, and images of, these galaxies can be found at **www.scienceontario.ca**.

Activity Notes and Troubleshooting

- Show students a large photograph, or projected image, of a galaxy. Invite them to contribute words that could be used to describe it. As they do, list the words they use on the board. Then have students place those words into categories related to the characteristics of the galaxy that they describe, for example, shape, colour, size. Leave the describing words and the categories on the board to serve as a model as students complete Activity 3.4.
- Use a colour photocopier to enlarge the images of the galaxies and post them in the class for students to study. Alternatively, find images on the Internet and print them out or find posters.

Additional Support

- DI Pair students who have strong logical-mathematical skills with those whose skills need developing to activate their pattern-recognition abilities.
- Students with visual challenges will find this activity difficult. Allow these students to look at the images on-line, or using interactive technology, where they can change the resolution and size of the images, developing their manipulation skills. Alternatively, have a classmate with excellent communication skills describe each galaxy to them.
- DI If you print the images of galaxies, spatial learners can move the images around and classify them into groups. Alternatively, the images can be classified using interactive technology, and the document can be saved when completed. Each group or student can have a turn, compiling a class book on galaxies.

- Enrichment—Have interested students select one of the galaxy images, or another galaxy image of their choice, and research the galaxy. Research should include an image, the galaxy's location, and its classification. Students could present their findings to the class.
- ELL You may choose to provide English language learners with cutouts from the photocopied galaxy photographs. They can then paste each galaxy photograph in their table beside the corresponding galaxy number, and then use arrows and labels to describe the features of each galaxy. Brainstorm suitable adjectives to describe these galaxy formations (for example, spiral, dense, circular, elongated, oval, elliptical, dispersed, disc-like, lopsided, horizontal, and vertical). English language learners can then search for the definitions of these words as needed, and use them to describe the galaxies.

Activity 3.4 Answers

What Did You Find Out?

1. Answers may vary. Students may use shape, brightness, or colouring for their classification system.
2. Answers may vary. Students may suggest that a classification system is preferred over another because it is easier to use.

Activity 3.5 Build Constellations in 3-D (Student textbook page 177)

Pedagogical Purpose

Using a model, students will understand that constellations, although they appear two-dimensional, are actually composed of stars that are different distances from Earth.

Planning	
Materials	shoebox (or other small box) string, scissors, glue, tape **BLM G-41 Big Dipper Diagram** 7 small beads with holes **BLM G-4 Group Roles** (optional) **BLM A-19 Group Investigation Group Assessment Checklist** (optional)
Time	40–60 min in class A week before this activity, ask students to bring in a shoebox from home. You may wish to prepare the boxes ahead of time to save class time.
Safety	Ensure that students are responsible with scissors.

Skills Focus

- draw conclusions
- identify and locate sources

Background Knowledge

The stars in the Big Dipper appear to be placed on the inside of the celestial sphere the same distance away from Earth, but they are actually various distances away from Earth, ranging from just under 80 light-years to over 120 light-years away.

Activity Notes and Troubleshooting

- Provide students with copies of **BLM G-41 Big Dipper Diagram** to glue to the inside of one end of the box.
- You may wish to have students use a hole punch to make the "stars" rather than scissors.
- To save time, precut the pieces of string.

- You may want students to work in small groups for this activity to save time and materials. Have groups designate tasks, such as one student to measure and cut the string, one to punch holes, and so on. Students could review **BLM G-4 Group Roles** before they begin.
- You may wish to use **BLM A-19 Group Investigation Group Assessment Checklist** to assist you in reviewing students' group work. If you choose to assess students in this way, provide them with a copy of the assessment beforehand so they are aware of how they will be evaluated for this activity.

Additional Support

- Prepare a model ahead of time for students with fine motor challenges, or have them work with a partner for this activity.
- You may wish to refer students who need support understanding and working with models to Science Skills Toolkit 7: Using Models and Analogies in Science on page 356 of the student textbook.
- ELL Have English language learners work with an English-speaking partner who reads the procedure aloud while demonstrating. When there are repeat steps, the English language learner can do the constructing while reading.
- Enrichment—Ask students to consider what the Big Dipper (or Ursa Major) would look like if they were standing on a different celestial body, such as a planet in the Andromeda galaxy. Ask, "Would the constellation remain the same, or look different?" Direct interested students to an astronomy computer program that can actually plot stars in this way, such as Starry Night® or Astrostack. See **www.scienceontario.ca**. You could also have students figure out how to use their model to demonstrate how the Big Dipper would look from a different observation point. (Every angle that the group of beads is observed from will provide a different pattern.)

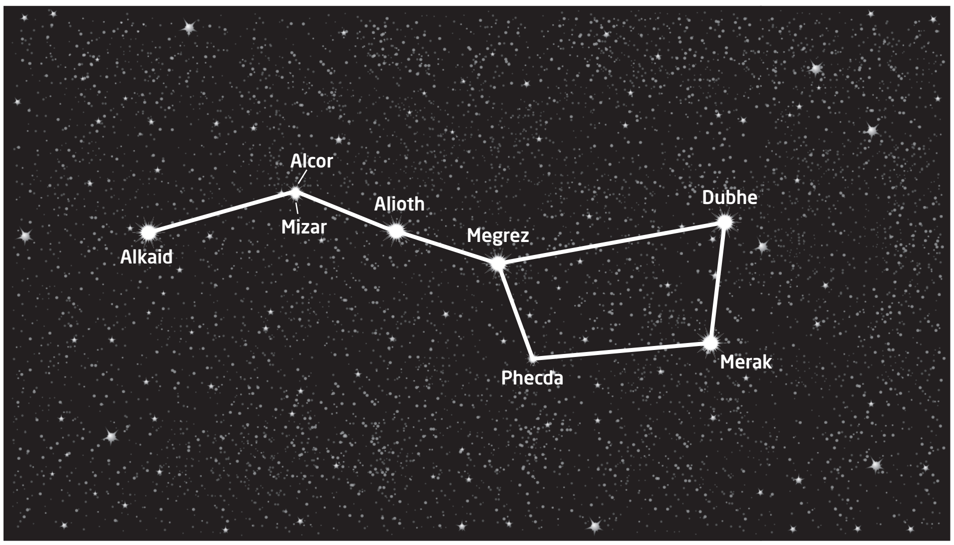
Activity 3.5 Answers

What Did You Find Out?

1. The model shows that the stars only appear to be the same distance away and that they are, in fact, all different distances from Earth.
2. The rotation of Earth makes stars appear like they are all stuck on the celestial sphere—the same distance away.

Inquire Further

- The study of astronomy, and therefore the naming of a great many visible stars, is thought to have developed in the area of ancient Babylonia, circa 1400–1000 B.C.E. Babylonia is now the area we call the Middle East, with much of it in Iraq and Iran. After the collapse of the Greco-Roman Empire, the Arabic community preserved the astronomical knowledge, and during the Renaissance in Europe, these Arabic names were once again adopted. More information, as well as an excellent website for information and animations of the Big Dipper, can be found at **www.scienceontario.ca**.



- The second star in the handle of the Big Dipper is Mizar. However, Mizar is actually part of a multiple star system—a double-double in which two binary stars orbit each other. Mizar is very close to another star, Alcor. Being able to see two distinct stars instead of only one is considered a test of good eyesight.
- Mizar and Alcor are sometimes referred to as the Horse (Mizar) and Rider (Alcor). Oddly, Alcor is designated as the rider even though its name is derived from the Arabic word for black horse. (Although Alcor does appear to be placed on top of Mizar, as a rider would be placed on the back of a horse.) Mizar and Alcor are quite close, but it is unlikely that they orbit each other.

Using the Case Study Investigation
A Tale of the Bear (Student textbook pages 178–179)

Literacy Support

Before Reading

- Before students begin reading, have them create a story glossary of terms. You may have them create a two-column table, or simply list the terms in their notebooks. Have them scan the story and record any unfamiliar words. Then have them look quickly at the story context for the meaning of the word, use a dictionary to look up the word, or search on-line if Internet access is available.
- Have students look at the presentation of the text—the visuals. Ask why the words at the top are in a box, and what the author/designer might be trying to convey. (This text is spoken and not part of the actual story.) Ask why there are silhouettes of people at the bottom, and what this art implies. (The silhouettes are people in the planetarium audience. The image shows that we, as readers, are also part of the audience.)

During Reading

- While they are reading, have students refer to their glossaries as they encounter the unfamiliar words that they listed. Encourage them to add to, or refine, their definitions as meanings become clearer.

After Reading

- Have students share their glossaries with the class and create a class glossary that lists all the challenging and unfamiliar words and their definitions. Post this glossary where students can refer to it.
- Before assigning the activity, have students work as a class or in groups and reread the story, this time focussing on the story's construction. As they read, have them make notes to summarize the story. Writing a brief summary reveals how a story is "built." Explain that narratives have a structure, just like scientific or research-based writing. You might provide copies of **BLM 3-5 Story Writing** for students to review and organize the components of the story. [Summaries should show the introduction of a character (Madjikiwis), and then present the problem encountered in the story (Madjikiwis felt something was missing). The character struggles with the problem (he left home for hill country), something happens (he is visited by Nanabush), his problem is resolved (Nanabush provides understanding), and the story concludes (Madijikiwis shares his wisdom).]
- Provide students with clean copies of **BLM 3-5 Story Writing** or produce an overhead to display for the class. Have students select their favourite constellation, and refer to the story-writing model for guidance as they write.
  - Using a story-writing model will also help students who choose to create their story in song, a poster or mural, or another creative work. Even a mural or poster should have a central character or theme and a "story" that flows through the work.
- ELL English language learners can survey their parents and relatives, as well as research on the Internet or in the library, to gather information about their ancestors' interpretation of celestial bodies and their significance.

Activity Notes

- **DI** Students with linguistic intelligence, musical intelligence, and bodily-kinesthetic intelligence will enjoy the creative opportunities in this activity. Encourage these students to express their creativity, but to also meet the criteria you require for assessment.
- **ELL** English language learners may find this activity intimidating initially. They may wish to write their story in their first language and then translate it, or have a student scribe for them to allow them to concentrate more on the creativity, rather than the writing. Then they can rewrite the scribed draft. Alternatively, encourage them to explore the other creative options, such as songs, dances, and murals or posters. They might also like to use a format with picture frames and captions. It is important to be clear about the expectations for this assignment, perhaps by providing students with a rubric: "I picked a constellation; I described its origin (how it got started); I described its purpose (why it is important to people); I used my own ideas; I reread it to make sure it made sense"; and so on.
- Students with an aptitude for using technology may wish to use computers to create their story using animation, Web pages, or music. Discuss their plan ahead of time and ensure that they will still meet evaluation criteria, but encourage all reasonable creative outlets.
- You may have students present a plan for the medium that they will use, which you can approve before they begin. This will allow you the opportunity to help them refine their ideas.
- You may find that the majority of students will want to use Ursa Major for their constellation choice. Encourage students to choose a selection of different constellations for their stories. Students could research at the library or on the Internet for other constellation stories to help create interest.
- Before beginning the story, have students discuss their experiences at planetariums as a class. Many may not be familiar with planetariums.
- If possible or practical in your community, invite an Elder to visit and share a story about the night sky or a celestial object. The Government of Canada has an Aboriginal Portal website with information on how to find Elders and storytellers in your community. Visit **www.scienceontario.ca**.
- You might ask students to invite grandparents who have star stories from a range of cultures to visit and share their stories. Or students could share these stories themselves. Provide a comfortable, safe forum for students who wish to share their stories.

Answers

Investigate Further

1. Students' stories will vary. Ensure that each story (written story, graphic novel, mural or poster, song) shows a clear reference to students' chosen constellation and some explanation about its origin or purpose.

Investigation 3A Make a Star-Finder Wheel

(Student textbook page 180)

Pedagogical Purpose

Students will use a model of the night sky to find and identify constellations.

Planning	
Materials	cardboard scissors tape cardstock or file folders (optional) glue (optional) telecopes or binoculars (optional) **BLM G-42 Star-Finder Wheel Template** **BLM 3-6 Investigation 3A, Make a Star-Finder Wheel** **BLM 3-7 Five-Column Table** (optional) **BLM 3-8 Star-Finder Wheel Grid** (optional)
Time	40–50 min in class 30 min preparation if you plan to prepare the star-finder wheels in advance

Skills Focus

- analyze and interpret data
- draw conclusions

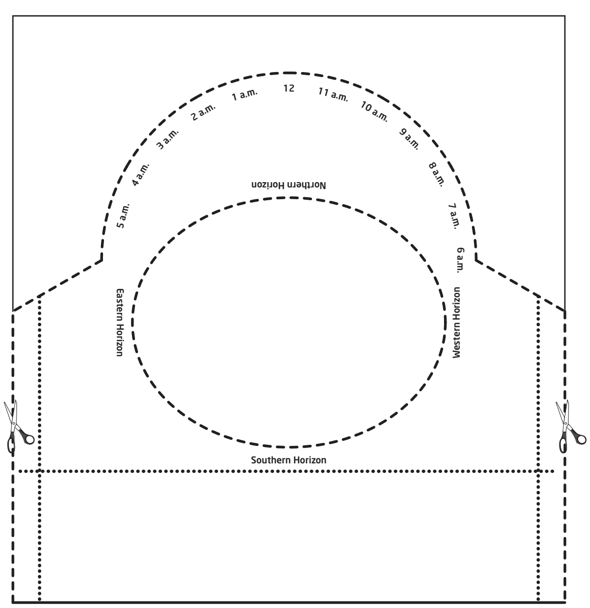
Background Knowledge

Orion is a very bright, easily found constellation. It is found on the southern horizon, but only in the fall and winter months. Orion is not visible in the northern hemisphere in the summer. A very useful video about the Orion constellation is available at **www.scienceontario.ca**. You can also find a video about Ursa Major, as well as many interesting and useful astronomy videos by the Hila Outdoor Centre near Ottawa, Ontario.

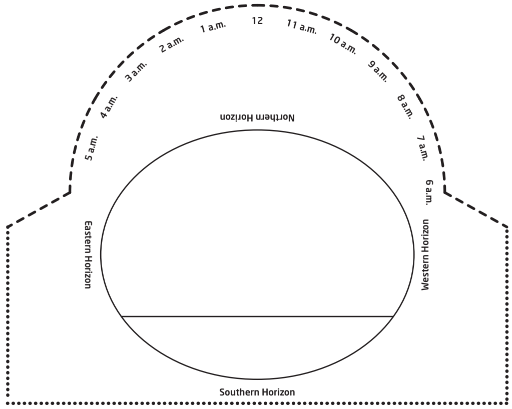
Activity Notes and Troubleshooting

- Make a sample Star-Finder Wheel for students to use as a guide. Use these detailed diagrams to help you.

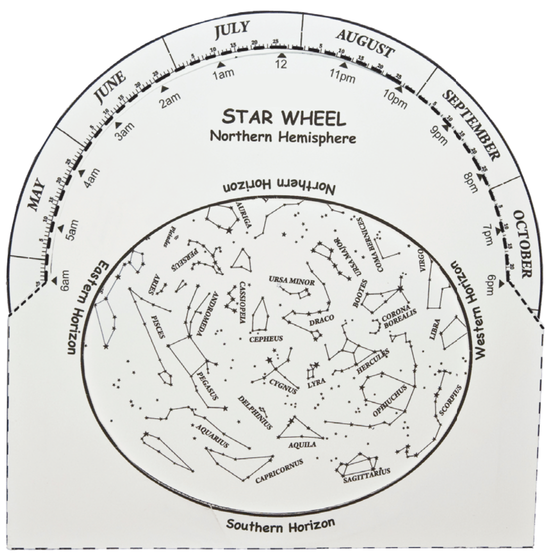
1. Cut along the dashed lines on the Wheel Holder in **BLM G-42 Star-Finder Wheel Template**. Fold along the dotted lines.



2. Fold the smaller portion up to make a pocket. Fasten the sides with glue, staples, or tape.



3. Cut along the outer dashed line on the Star-Finder Wheel. Place the wheel inside the holder.



- To save class time, you may wish to prepare several Star-Finder Wheels ahead of time, so students can focus their time and attention on the activity and not on the preparation.
- If you plan to have students use the Star-Finder Wheels several times over the course of the topic or unit, have students glue the cut-out holder and wheel onto card stock or old file folders to give the pieces more strength. To save drying time and keep the Star-Finder Wheels neat, use glue sticks rather than white glue, which can be messy and take a long time to dry.
- Before students begin using their Star-Finder Wheels outside, have them practise in the classroom. Have them choose a favourite constellation (Orion is a good suggestion, if students are not quick to speak up), and turn the Star-Finder Wheel to the correct month. Can they still see the constellation? (Orion will not be visible in the summer months, but Ursa Major will remain visible the entire year, although it will change position on the horizon.)

Additional Support

- You may wish to provide a table template or **BLM 3-7 Five-Column Table** for students who need additional support.
- Students who have challenges with fine motor skills, or those with difficulties following step-by-step instructions, can be given a completed Star-Finder Wheel, or they can prepare their own Star-Finder Wheels in advance. Distribute **BLM G-42 Star-Finder Wheel Template** and the materials the day before for students to assemble as homework.
- Enrichment—Have interested students use **BLM 3-8 Star-Finder Wheel Grid,** so they can plot other objects they see in the sky (for example, planets, comets, and asteroids).
- ELL English language learners can work with an English-speaking partner to help them read and understand the instructions. Students can also visit the kid's astronomy section at **www.scienceontario.ca** for an interactive demonstration of the Star-Finder Wheel.

Answers

What Did You Find Out?

1. Yes, circumpolar constellations are visible any time of the year because they travel around Polaris and never go below the horizon.
2. Answers will vary, depending on which constellations students have selected. Check to make sure that their answers are correct and reveal an understanding of the Star-Finder Wheel and how the constellations move across the night sky throughout the year.

Inquire Further

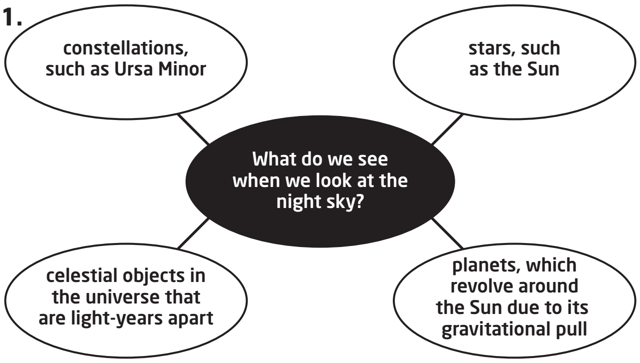
Have students research time telling using the Big Dipper in the library or on the Internet. They can begin their search at **www.scienceontario.ca**.

Topic 3.1 Review (Student textbook page 181)

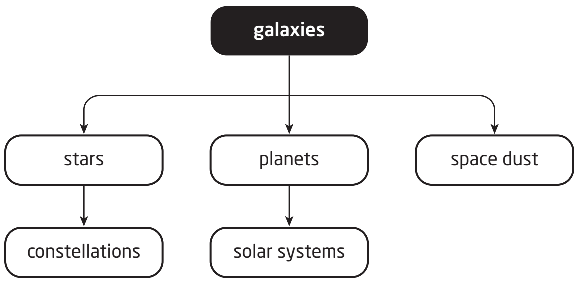
Please see also **BLM 3-9, Topic 3.1 Review (Alternative Format)**.

Answers

1.



2.



3. Space dust may damage solar panels, leaving the ISS without power. It would be impossible for astronauts to survive on the ISS without power to make oxygen and perform other necessary functions.
4. Students' Venn diagrams should include the following ideas:

Astronomical Unit (AU)	Both	Light-year
• equal to the distance between the Sun and Earth (about 150 million km) • used to measure distances in solar systems	• used to measure great distances	• equal to the distance that light travels in one year (about 9.5×10^{12} km) • used to measure distances in galaxies

5. The star that is the farthest from Earth would be Alpha 61 Cygni. The star that is the closest to Earth would be Alpha Centauri A.
6. The Sun's gravitational pull is like a magnet that keeps the planets in orbit around it so that they do not move away.
7. Star B would exert the greatest gravitational pull on its orbiting planet, planet B, because star B is much larger than star A. A larger star has more mass and therefore greater gravitational pull.
8. You could find the Big Dipper in the sky, and look for the two end stars on the handle of the ladle. These stars point toward the North Star, Polaris. Once you know which direction is north, you can find south, west, and east.