Unit 3

Unit 3 The Study of the Universe

BIG IDEAS

- Space exploration has generated valuable knowledge but at enormous cost.
- Different types of celestial objects in the solar system and universe have distinct properties that can be investigated and quantified.
- People use observational evidence of the properties of the solar system and the universe to develop theories to explain their formation and evolution.

Overall Expectations
The Study of the Universe

- **D1** assess some of the costs, hazards, and benefits of space exploration and the contributions of Canadians to space research and technology
- **D2** investigate the characteristics and properties of a variety of celestial objects visible from Earth in the night sky
- **D3** demonstrate an understanding of the major scientific theories about the structure, formation, and evolution of the universe and its components and of the evidence that supports these theories

Materials

Please see page TR-35 for a list of the materials required for this unit and other units.

In this unit, students will learn about our universe—its beginnings with the big bang, the formation of stars and galaxies, as well as the beginnings for our own solar system. Students will study the features and motion of the Sun, the planets, and other components of the solar system. They will learn about the contributions made by ancient astronomers and will have an opportunity to observe the sky for themselves, identifying the brighter stars and constellations.

In Chapter 7, students will study how ancient astronomers determined that the solar system is Sun-centred (heliocentric). Students will also learn how to identify some basic constellations and star patterns, and will have an opportunity to see these features for themselves in the night sky. They will study characteristics of planets, comets, meteors, and asteroids. Students will model and analyze the movements of Earth and the Moon, and discuss the reasons for seasons, eclipses, and tides.

In Chapter 8, students will study the exploration of space with telescopes and spacecraft (crewed and uncrewed). Students will weigh the benefits of space exploration against the costs and risks of space exploration. They will also learn about the characteristics of the Sun and other stars.

In Chapter 9, students will study the evidence used to form theories about the origin of the universe and the solar system. Students will be presented with current theories about galaxies and mysterious dark energy and dark matter.

Using the Unit Opener (Student textbook pages 264 and 265)

- The unit opener photograph features an astronaut on the end of Canadarm2—the Canadian-made robotic arm at the International Space Station. The inset photograph shows a spinoff of this robotic technology—neuroArm, used by brain surgeons to perform precise surgery. Students will likely be familiar with the fact that astronauts use Canadian technology, but do they know how important the Canadian contribution is? Do they know how much it cost? How much do they know about technology used on Earth that is a result of Canadian contributions to space technology? Use this photograph as a starting point to diagnose students' current ideas about space exploration. Consider focussing a discussion around one or more of these ideas:
  - Canada has contributed to space exploration since the early 1960s—it was the third country to place a satellite in orbit, after the United States and the Former Soviet Union. *Alouette 1,* a Canadian science satellite, was launched in 1962.
  - Space spinoffs are technologies developed for use in space but later used for applications on Earth. These are important aspects of space exploration and can help to indirectly offset the high price for exploring space.
  - Robotics developed by Canada has been critical to the success of the space shuttle and International Space Station programs.
  - Understanding the universe helps us to understand who we are and where we came from. We can learn more about Earth by studying other planets and learn more about the Sun by studying other stars.
  - Ultimately, humans will almost certainly have to leave Earth—whether because of a threat from an asteroid or a comet, or some other threat. To survive, the human species will have to learn how to travel to the other stars.
  - Students could be invited to discuss how space travel has affected them in their daily lives (space technology, cellphones, satellites, GPS, computers, satellite TV, medical advances, Earth resources technology).

- Consider having students draw separate spider maps to show what they already know about the topics in each of the three chapters, shown at the bottom of page 265. Refer students to Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on page 566 of the student textbook. They can revisit and revise these maps when they complete the Make Your Own Summary section in the Chapter Reviews.
- Check what students know and believe already about exploring space using **BLM 7-1 Unit 3 Anticipation Guide.** When you have completed the unit, have students reflect on how and why their understandings and attitudes may have changed.

Assessment OF Learning for Unit 3		
Activity	**Evidence of Learning**	**Supporting Learners**
Unit 3 Inquiry Project	Choose one cosmic event and research to learn about it.	If students have little knowledge about cosmic events, ask the class to find information about some that have occurred and bring it to class. Create a display with an introduction to several cosmic events that students can refer to. Students can use **BLM G-13 Research Worksheet,** to plan and organize their research.
	Formulate a hypothesis about observations that might occur before, during, soon after and long after the cosmic event.	Invite students to collaborate as a class to write predictions about the events soon after and long after comet SL9 collided with Jupiter. Use this as a model to guide students in formulating their own hypotheses.
	Create a simulation with teacher approval of the cosmic event using one of the suggested media presentation formats. Present the simulation to the class.	Review features of each of the presentation formats in simulating a cosmic event. Students can use **BLM A-6 Developing Models Checklist** or **BLM A-33 Developing Models Rubric,** to guide the development of their simulation.
Unit 3 An Issue to Analyze Project	Outline the risks, benefits and costs of three Canadian space missions from a variety of perspectives.	Use a past mission and create with students a sample risks, benefits and costs table. Post in the classroom as a sample for students to follow.
	Using the criteria provided, evaluate each mission, and draw conclusions based on the analysis of whether Canadians should continue to contribute to space research and technology.	Students can use **BLM G-16 Tips for Investigating Many-Sided Issues,** or **BLM G-17 Worksheet for Investigating Issues,** to help them organize their analysis and draw conclusions.
	Create and deliver a speech outlining your position and provide recommendations for future courses of action.	Watch a famous speech and review with students criteria that make the speech convincing, engaging and enjoyable to listen to. For example, President Obama's Inaugural Speech, 2008.

Get Ready (Student textbook pages 266 and 267)

Prerequisite Learning

Students would benefit from understanding

- characteristics of planets, moons, and other celestial objects. (questions 1 and 2)
- effects of Earth's rotation and revolution. (question 3)
- causes of common phenomena, for example, the seasons and day and night. (question 4)
- features of technology that have helped us to explore space. (question 5)

Prerequisite Skills

Students need to be able to

- think critically about the requirements of living in space. (questions 6 and 8)
- analyze challenges to plan a strategy to overcome them. (question 7)
- express large numbers in scientific notation. (question 9)
- compare large numbers in standard notation and in scientific notation. (question 10)
- express an opinion in writing, providing evidence to support it. (question 11)

Students can review some of these skills using **BLM 7-2 Skills for Unit 3.**

Answers

Concept Check

1. **a.** vi
   b. vii
   c. i
   d. iii
   e. ii
   f. iv
   g. v
2. Stars: made primarily of hydrogen gas, are hot, emit light, are very massive
   Planets: revolve around stars; reflect light; some have a hard surface on which you can stand; may have surface water, life
3. **a.** rotation—day (9 h, 50 min, 30 s)
   b. revolution—year (11.86 Earth-years)
   c. rotation—23 h 56 min; revolution—365.25 days
4. **a.** Earth's rotation on its axis causes day and night.
   b. Earth's revolution around the Sun causes yearly periods.
   c. The Moon's gravitational pull on Earth causes ocean tides.
   d. Earth's tilt on its axis causes the seasons.
   e. The Sun's gravitational pull on Earth causes Earth's orbit.
5 **a.** 4
   b. 1
   c. 3
   d. 2

Inquiry Check

6. Students may list three to five of the following: food, oxygen, removal of CO_2 from the air, protection from solar radiation, spacecraft returning to Earth, ability to fix broken space-station parts, radio communication with Mission Control, communication with families, and/or entertainment (books, movies)

7. For example, food and water will come from Earth on supply spacecraft. Someday, food could possibly be grown at the station. Water is recycled from the air and urine and turned into drinking water onboard. Garbage and human waste are stored in uncrewed supply spacecraft that burn up in the atmosphere. Astronauts fix some broken parts, and spares are sent from Earth. Lithium hydroxide canisters remove CO_2 from the air and are supplied from Earth.

8. The main reason is that the Russian *Soyuz* spacecraft that is used to get home in an emergency has a six-month lifetime.

Numeracy and Literacy Check

9. 1.2756×10^4 km

10. 9.281×10^3 km

11. Students' letters may include the following ideas: The space exploration budget is small compared to other expenses. It provides work for highly technical people and spinoffs help society (See the Case Study in Chapter 9, on pages 370 and 371).

Assessment FOR Learning		
Tool	**Evidence of Learning**	**Supporting Learners**
Get Ready questions 1 to 5	Students describe some characteristics of astronomical objects, phenomena, and technologies.	Assign each of the five questions to a small group of students. Have the group work together to develop an answer to their question and present that answer to the class. Have simple reference books available that students can use to find information.
Get Ready questions 9 and 10	Students write and compare numbers in scientific notation.	Refer students to Math Skills Toolkit 1, The Metric System and Scientific Notation, on page 554 of the student textbook, as well as **BLM G-29 Using Scientific Notation.**
Spider maps suggested in Using the Unit Opener	Students' maps show an understanding of some of the basic concepts.	Have students work in pairs to compare and discuss their spider maps, adding to them or revising them, as they wish.

Using Making a Difference (Student textbook pages 280, 328, and 379)

Making a Difference on page 280 of the student textbook describes how a student studied the light pollution in her community and won an award at the 2005 Canada-Wide Science Fair. She created a project that showed how light pollution could be prevented.

Students can study light pollution issues on-line. Start at **www.ontarioscience.ca**. Ask where students have seen dark skies and light-polluted skies. What do they see in a dark sky compared to a light-polluted sky? How can students help to fight light pollution? What would the result be in using low-wattage light bulbs for outdoor lighting? Students can create posters promoting correct outdoor lighting and the advantages of using this lighting. Students can also write to their local city council asking that proper street lighting be used and to express why this is important.

Making a Difference on page 328 of the student textbook describes how Canadian Astronaut Roberta Bondar studied to become an astronaut and fly on a space shuttle mission. Students could write a report about a Canadian role model (famous or not) who has made an impact on their lives.

Making a Difference on page 379 of the student textbook describes how Sudbury native Joel Zylberberg studied to become an astrophysicist. Here are some sample questions that some astrophysicists struggle with:

- How do astronomers know how old the universe is?
- Do we know what the universe was like before the big bang?
- How do we find dark matter if it cannot be seen?

Encourage students to work in small groups to come up with some other questions.

Using Science at Work (Student textbook pages 388 and 389)

Students may think that all space science is carried out by astronauts and astronomers. Science at Work will introduce them to other roles that people play in studying space. You might begin by asking students to brainstorm all the careers they can think of that can play a role in space science. Some are described in the textbook, but there are many others.

Students could present the information they gather for question 4 in the form of an imaginary interview with a person in the career they have researched.

As well as the many careers that are involved in space science, amateur astronomers have also played an important role in helping us to learn about our universe. For example, amateur astronomers are often involved in monitoring changes in brightness of celestial objects, and searching for overlooked phenomena among the masses of data collected and available electronically. Societies have been developed to coordinate the contributions of amateur astronomers to large research projects. If possible, invite a member of a local astronomy club to talk to the class about the work of amateur astronomers.

Introducing the Unit 3 Projects

By the end of this unit, students should have learned enough about cosmic events and objects that they will be able to design and create a simulation of a known cosmic event. They will have also developed an understanding of enough benefits and risks of space research that they are able to formulate their own opinion about its merits, and support that opinion with data. Students will have the opportunity to do one of these things in the Unit 3 Projects. Read the introduction to each project with students now, and encourage them to think about which one they might prefer to complete. Then, as students work through the unit, draw their attention to the first few descriptions of cosmic events, and talk about similar events. For example, have students list several ways to complete this sentence: “Solar flares are like [blank].” Point out any information about space research from which students can infer benefits, costs, or risks. Encourage students to keep notes about any information that will help them with their project as they read the remainder of Chapters 7, 8, and 9. If possible, record a short, simple speech for students to listen to as they plan their own speech for An Issue to Analyze, on page 391 of the student textbook.

Using the Case Studies

The suggestions below provide opportunities for students of multiple learning styles to engage in and explore issues. The strategies chosen support bodily-kinesthetic, spatial, and interpersonal learning styles. The strategies also serve as pre-reading strategies and scaffolds for English language learners.

Chapter 7 (Student textbook pages 304 and 305)
Before reading the "Can We Prevent the Next Big Impact?" case study, have students work in groups and discuss some ways in which asteroids and comets that are on a collision course with Earth might be diverted. Have the groups present their ideas to the class, using a presentation method of their choice. Have the class then list the five ideas that have the best chance of success.

Hollywood has covered this topic in movies such as *Deep Impact* (1998) and *Armageddon* (1998). Students may have preconceived ideas that these movies depict current technology and that we are safe from collision; however, this is not the case.

After they have read the case study, have students return to their list of possible strategies to divert asteroids and comets, and re-evaluate them in light of what they have learned.

Chapter 8 (Student textbook pages 330 and 331)
Before reading the "Space Junk" case study, ensure that students understand the term "space junk" and where the junk comes from. Have students work in groups and brainstorm ways in which space junk may be collected or knocked out of orbit. There is not an easy answer because you would not want to send a spacecraft to space to collect pieces of space junk, as there are just too many. A more fruitful solution is likely to be a way to slow down all the small debris so that it falls to a lower orbit where it will eventually re-enter the atmosphere and burn up. In the orbit that most of the space junk is in now, it will take years to re-enter the atmosphere on its own. After reading the case study, students can refine their strategies to take into account any new information that they have learned.

Chapter 9 (Student textbook pages 370 and 371)
Talk with English language learners about the idiomatic expression "spinoff." Invite students to give examples of books, movies, or TV shows that are spinoffs and to explain why they can be called that. Before reading the "Space Exploration Spinoffs" case study, have students create a list of space spinoffs with which they are familiar that affect their own daily lives. They can add to this list after reading the case study. Many of the spinoffs are serendipitous in nature; that is, the applications to daily life come accidentally, without prediction. This is a pattern seen in many creative endeavours. Students could conduct additional research on a spinoff of their choice and present some of its benefits to the class.

Chapter 7 The Night Sky

In this chapter, students will investigate the location, motion, and characteristics of stars, planets, and other celestial objects. In hands-on investigations, they will model the Moon's movements, eclipses, the sunlight we receive through the seasons, and crater formation, to develop their understanding of these phenomena.

Using the Chapter Opener (Student textbook pages 268 and 269)

- Engage students in a discussion about what they know about the objects in the sky. As mentioned in the Chapter Opener, people have been observing the night sky for thousands of years. Using students' input, make a list of things people have tried to learn from the objects they see in the sky.
- As an alternative, bring in a news clipping about a recent astronomical discovery. Discuss with students how the discovery was made, and what scientists might hope to learn from it. Ask them why they think people are interested in space. Answers could range from finding life on other planets, to learning more about our own planet, to basic human curiosity.

Activity 7-1 Create Your Own Constellation (Student textbook page 269)

Pedagogical Purpose

In this activity, students will create their own constellation. The activity demonstrates how the actual constellations might have developed thousands of years ago.

Planning	
Materials	1 piece of blank paper Coloured markers **BLM 7-4 A Star Field** (optional)
Time	15–20 min to prepare and develop constellations, to write a story or draw a picture, and to trade and discuss the story or picture with other students Some students may wish to finish their story at home.

Background

Thousands of years ago, people looked up and imagined patterns in the sky. They created the constellations based on mythological stories to describe these patterns. What might someone who is living in the 21st century imagine in the sky when they "connect the dots"?

It is believed that the first people to use constellations were farmers. Recognizing the time of year in which certain patterns appeared in the sky was essential to keeping track of time and, more specifically, keeping track of the start and end of seasons. For example, the constellation Scorpius, the scorpion, is visible only in the summer in the northern hemisphere. Knowing when to plant, grow, and harvest was necessary for supplying food for ancient peoples. Anthropologists believe that the legends, myths, and lore associated with the constellations were created to help the farmers keep track of the appearance and disappearance of the star patterns.

There are only 88 official constellations; other star patterns are called *asterisms*. This official delineation of constellations was created in 1929 by the International Astronomical Union (IAU), the same organization that defined a planet and demoted Pluto from planetary status in 2006.

This activity will allow students to express their creativity while using the science foundation of historical astronomy.

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-35 for a summary of the materials required in this chapter and other chapters.

Advance Preparation

- Tell students to observe the night sky and note anything they see that they find interesting. When students do bring in questions or observations, take a few minutes to talk about them. Designate a space in the classroom for students to write or post questions about space.
- Pay attention to news sources for upcoming celestial phenomena. Post the information in the classroom.
- Set up a calendar in the classroom. Have students report daily on the Moon's phases, and have one student sketch each day's phase on the calendar. Note when students saw the Moon (early evening, late evening, early morning before sunrise).
- Post recent news clippings about celestial phenomena or discoveries.
- Gather a model of Earth and a few balls of different sizes to demonstrate some of the phenomena in Chapters 10, 11, and 12.
- Students can review the Key Terms in Chapter 7 using **BLM 7-3 Chapter 7 Key Terms.**
- ELL Viewing high-quality video documentaries and using simulation software, such as *Starry Night* software, are excellent ways for English language learners to preview or review sections in this chapter.

Activity Notes and Troubleshooting

- Prior to this activity, there should be a classroom discussion about constellations. Place a set of well-known star patterns on an overhead slide. Have students try to guess the constellation, and then place the picture of the constellation over top of the star pattern. Reading a few short stories about the mythology behind constellations would serve to capture students' interest and be a natural segue into this activity.
- Stress that students should not add too many stars to their constellation.
- Each star has a different brightness, so the dots should be different sizes. Have students look at the stars on page 269 of the student textbook as a guide. Even though stars look primarily white to us, they are actually white, blue, orange, and red. Students can use blue, orange, and red felt markers, as well as larger dots, to emphasize aspects of their constellation (the red eye of a dragon, for example).
- Suggest items of the 21st century that may influence students' choices (for example, portable music players, laptops, and favourite book or movie characters).
- The initial part of this activity (namely, creating the constellation) may be done in class, with Procedure step 3 being used as a take-home assignment. Completing step 3 at home will give students an opportunity to be creative with their drawings.

Additional Support

- If students have trouble developing their own star field, you may wish to use **BLM 7-4 A Star Field.**
- DI You may have linguistic or intrapersonal learners dramatize their story and present it to the class.
- ELL Explain the activity to English language learners as a group, and then ask them to tell you what they are to do. You may need to give them verbal cues while they paraphrase how to do the activity. Correct any misunderstandings. English language learners can write a story in picture-book or comic-strip format, if they choose.

Answers

1. Students' answers may vary. Some students might have different interpretations of the pictures drawn by their classmates.
2. Different cultures created different stories because they had their own beliefs and mythologies. The night sky gave them a way of illustrating those stories. It also provided a way to pass down stories from generation to generation.

Study Toolkit

Strategy	Page Reference	Additional Support
Making Connections to Prior Knowledge	Based on pages 286 to 289, students can make connections among what they already knew about the Moon, what they have read, and what it makes them think of in the real world.	Students can find more information about concept maps and other graphic organizers in Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on pages 566 and 567. See also **BLM G-34 Concept Map.**
Identifying Cause and Effect	Based on page 303, students can draw a cause-and-effect graphic organizer to show the effects of the meteor that entered Earth's atmosphere above Siberia.	Students can find more information about cause-and-effect maps and other graphic organizers in Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on pages 566 and 567. See also **BLM G-33 Cause-and-Effect Map.**
Word Origins	Tell students that *aster* comes from the Greek word *astron*, meaning star. Have them use this information to predict the meanings of *asteroid* (page 300), *astronomer* (page 273), and *astronomical unit* (page 293).	Refer students to Study Toolkit 3, Word Study: Common Base Words, Prefixes, and Suffixes in Science, on page 565.

Section 7.1 Ancient Astronomy (Student textbook pages 271 to 276)

Specific Expectations

- **D2.1** use appropriate terminology related to the study of the universe
- **D3.6** describe various reasons that humankind has had for studying space and the conceptions of the universe held by various cultures and civilizations

In this section, students will learn why ancient people paid more attention to the sky than we do today—it was important to their survival. They used the sky to find out when to sow and reap harvests, when the floods would come, and when animals would migrate. Students will also learn how early astronomers used their observations to develop calendars and to determine that Earth was spherical.

Common Misconceptions

- **Many students confuse the terms *revolution* and *rotation*.** To highlight the difference, have students act out the motions of Earth rotating (spinning on an axis) and then revolving around the Sun.
- **Some students may believe that astrology has a scientific basis.** Many years ago, astrology was used to predict future events using the stars. While horoscopes are still available, astrology is now recognized by most people as only entertainment with no scientific foundation.

Background Knowledge

Earth revolves around the Sun once every 365 $\frac{1}{4}$ days. To help account for the extra one quarter of a day in every year, we add one extra full day every leap year. Year numbers that are exactly divisible by four are called leap years, except that years ending in 00 are leap years only if they are evenly divisible by 400. 1700, 1800, 1900, 2100, and 2200 are not leap years, but 1600, 2000, and 2400 are leap years.

Staring directly at the Sun—with or without an optical aid—is dangerous because the heat energy from the Sun can damage the sensitive cells in the retina. These cells do not have nerves, so if a person's retina cells are damaged, he or she would not feel it. Staring at the Sun on any day, or during a partial solar eclipse, results in the same damage. Using an optical aid (binoculars, for example) results in even greater damage.

In describing observations in the sky, astronomers refer to the *horizon*. An observer's horizon is the edge of a plane that is drawn tangent to the surface of Earth where the observer stands. Everything above this tangent plane is above the horizon.

Literacy Support

Using the Text

Before Reading

- Invite students to share what they already know about each subtopic and to ask questions to which they would like to find the answers in the text. They can record on **BLM G-30 K-W-L Chart.**
- ELL Assign groups of English language learners a subsection of text to preview, and ask them to list words that they do not understand. Talk with them about the meanings of these words or create a glossary handout for them to refer to.

During Reading

- Provide time for students to read the text quietly. At the end of each subsection, have them monitor their comprehension by listing the important points of the subsection. Refer them to Study Toolkit 2, Reading Effectively: Monitoring Comprehension, on page 564. If they need practice summarizing, ask them to write a summary of what they have read by using the points they listed.
- ELL Have English language learners use sticky notes to indicate words and ideas that they do not understand as they read. After each subsection, clarify meanings with them. Model, using context and other clues, how to find the meanings of unknown words. Use cloze activities (fill-in-the-blank) to have English language learners practise contextual cueing as a reading strategy.

After Reading

- Have students identify the three or four main ideas of the section from their notes, and then work with a classmate to agree on the main ideas for the section.
- Students can summarize what they have learned using **BLM 7-5 Ancient Astronomy.** If English language learners need help, give them a list of words to choose from to fill in the blanks.

Using the Images

- Have students examine Figure 7.4, on page 274, and read the caption. Without reading the rest of the page, have students infer what conclusions could be reached by this observation. Invite a student to choose props in the classroom to demonstrate what is happening in this diagram.
- On page 271, Figure 7.1 illustrates the careful planning that went into the design of the pyramid. Students also read about the image of the diamond-backed snake that is built into the design. Have them look carefully at the photograph to find the snake shadow that is described. Ask why the pyramid might have 365 stairs.
- In Figure 7.3, on page 273, have students visualize the shadow's placement at different times. Ask them to describe where the shadow might be in the morning, at noon, and in the evening.
- Figure 7.5, on page 275, shows why we cannot see the sky beyond the southern part of the world. Some students may need to use a physical model—perhaps a globe or a ball—to understand how it is possible to see different views of the sky from different locations on Earth.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Discussion/Learning Check questions, page 274	Students explain why early astronomers studied space.	Have students consider and describe what life would have been like for early peoples if there had been no way of predicting changing seasons or times of day.
Discussion/ Section 7.1 Review questions, page 276	Students explain why early astronomers studied space, and describe the effect of different points of view on observations of the sky and of the horizon.	Allow students to hold a ball or globe and to use it as a model as they answer orally.

Instructional Strategies

- Many concepts in this section can be demonstrated with easily accessible materials in the classroom. To show the shape of Earth's shadow, use a light source in a darkened room (for example, an overhead projector) and a globe to represent Earth. Project the globe's shadow on the wall. Using a small ball as the Moon, simulate a lunar eclipse by holding the small ball on the opposite side of the globe from the light source, but not in the shadow. Then show that as the Moon revolves around Earth during a lunar eclipse, it passes through Earth's shadow, making the Moon appear dark.
- Use a ruler or sheet of cardboard against a globe of Earth to show how only certain areas of the sky are visible at a time. Rotate the globe and notice that stars in the southern hemisphere never rise for observers in northern mid-latitudes. Do the same for a site at the equator.
- Some students may find it hard to believe that ancient people could be frightened of the sky. Ask students to think of astronomical events today that some people are frightened of.

Learning Check Answers (Student textbook page 274)

1. One Earth rotation corresponds to one Earth day.
2. The Mesopotamians were the first astronomers for whom we have evidence of detailed astronomical observation.
3. A calendar allows people to plan agriculture. Planned agriculture means people can plan to produce extra food.
4. Computerized calendars might eliminate our understanding of why a day is 24 hours or why a year is $365\frac{1}{4}$ days. They might make us feel more separate from the natural world.

Section 7.1 Review Answers (Student textbook page 276)

Please see also **BLM 7-6 Section 7.1 Review (Alternative Format).**

1. A celestial object is any object in the sky (for example, the Moon, a planet, or a star).
2. One Earth revolution around the Sun corresponds to one Earth year.
3. Some early cultures needed to know when rains or floods were coming, for agriculture; some early cultures needed to know when herds of animals came back to their locations, for hunting; fishers, mariners, and travellers used the sky for navigation.
4. Organized agriculture was important to the lives of people in ancient civilizations. In order to have organized agriculture, an accurate astronomical knowledge of the seasons was required. Early civilizations developed calendars to predict events—such as rains, seasons, and flooding—which led to organized agriculture.
5. Ships disappear below the horizon; the appearance of the sky changes as we travel farther north and south; Earth has a curved shadow during a lunar eclipse.
6. A ship that sailed away on a flat surface would simply get smaller and smaller, until it was too small to recognize, but it would never really disappear from sight. Even thousands of kilometres away, it could, in principle, be seen with a telescope. This observation is contrary to what is actually observed, and hence, one can conclude that Earth is not flat.
7. The star would be near the horizon.
8. Because the surface of Earth is curved, the view from the crow's-nest allows sailors to see farther over the horizon than a person standing on the deck of the ship. From really tall masts, sailors can spot land long before anyone else can from the helm of the ship.

Section 7.2 The Constellations (Student textbook pages 277 to 282)

In this section, students will learn about the motion and appearance of constellations and well-known stars.

Specific Expectations

- **D2.2** use direct observation, computer simulation, or star charts to determine the location, appearance, and motion of well-known stars and other celestial objects that are visible in the night sky

Common Misconceptions

- **Students may believe that the North Star, Polaris, is the brightest star in the sky (apart from the Sun)**. In fact, the brightest star in the sky is actually Sirius in Canis Major (the Big Dog).
- **Students might have trouble understanding that stars are arranged in three dimensions, since the stars seem to be fixed in the night sky.** Use Figure 7.8, on page 278, to illustrate the three-dimensional nature of constellations. You may also wish to work with students to build a three-dimensional model of a constellation, such as the one shown in Figure 7.8.
- **Some students might think that they can "buy" a star**. Although some companies sell stars and will gladly take your money, there is nothing official about it—no one can sell you a title or deed for a star or for an acre on the Moon. Your ownership, and any name you give a star, will not be recognized by astronomers.
- **Students may think that they need sophisticated telescopes to view the night sky.** In fact, they can observe a lot using only their eyes or simple binoculars.

Background Knowledge

Constellations are patterns of stars that humans have imagined. The stars in a constellation are not really related in any way. Because they may be different distances away from Earth, they may not even be related by proximity.

Because Earth revolves on its axis, we see the constellations in different places at different times of night. Because Earth rotates around the Sun, we see some different constellations at different times of the year.

All the stars appear to rotate around the North Star, which is a coincidence. Polaris just happens to be in the sky where the extension of Earth's polar axis would meet it. There is no bright star close to the South Celestial Pole. In fact, because Earth slowly precesses (wobbles like a top), the North Star will no longer be close to the North Celestial Pole thousands of years from now.

Literacy Support

Using the Text

Before Reading

- Predict-Read-Verify: Have students preview the text features in the section, especially the subheads, Key Terms, and figures and captions. Ask students to predict what each subsection might be about based on these features. Refer students to Study Toolkit 1, Preparing for Reading: Previewing Text Features, on page 563.

During Reading

- Help students summarize the text material into its most important ideas or concepts. For each chunk of text, have students analyze the text and summarize the key ideas. Challenge students to reduce the given chunk of text to just 20 words or fewer with the aid of sketches (for example, the westward creep of the constellations around Polaris). Refer students to Science Skills Toolkit 6, Scientific Drawing, on page 543.
- ELL English language learners can make point-form notes about each section. Summarize the first subsection with them to model how to choose information to include. Offering key words to use in the point-form format will guide students to focus on the main idea.

After Reading

- Students can summarize what they have learned by creating a spider map about constellations (see Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on page 566 of the student textbook). Students might include topics such as constellation names, navigating using constellations, and the movements of constellations.
- Ask students to reflect on the predictions they made before reading by thinking about what was surprising, confusing, complicated, or simply new.

Using the Images

- Figure 7.8, on page 278, provides a useful illustration of the three-dimensional nature of star groups that we see as two-dimensional constellations. Have students use the diagram to explain the difference between what we see in the sky and where the stars really are. If some students have trouble interpreting the diagram, enlist the help of five students. Give them each a large ball to represent one of the stars in Cassiopeia, and have them stand in positions similar to those in the diagram. Have other students look from one side, to see what we see from Earth, and then have these students walk around the volunteers, to appreciate the actual position of each star in three dimensions.
- Star maps help us find objects in the sky, but they take some getting used to. Have students hold their textbook so that they are facing north, and the *N* on Figure 7.9, on page 278, is pointing down. Then have them point to where in the sky they would see some of the items shown in the figure. Additional star maps with instructions appear in Appendix B, Using Star Maps, on student textbook pages 570 and 571, and on **BLM G-42 Star Maps for Fall, Winter, and Spring.**
- Figure 7.14, on page 281, illustrates a concept similar to that illustrated in Figure 7.4, on page 274. Because Earth is a sphere, we cannot see a ship or the sky that is behind the sphere. Consider using a globe and an imaginary observer in two different locations such as Ottawa and Miami to show what part of the sky each observer would be able to see, and why the observer in Miami would see Polaris near the horizon.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Discussion/ Section 7.2 Review questions, page 282	Students describe Polaris's role in navigation and explain what constellations are, and the roles that constellations have played in many civilizations.	Show students an example on a star chart of a well-known constellation that they have seen before. Ask them to name the constellation and describe what the constellation really is (a group of stars in three dimensions that humans have seen as a pattern).
BLM 7-7 Constellations	Students fill in the constellation names on **BLM 7-7 Constellations.**	Give students the names of five constellations that appear on **BLM 7-7 Constellations,** and have them match each name to the pattern of stars that it refers to.

Instructional Strategies

- Ideally, you would introduce this section by taking students outside after dark to observe the night sky. As an alternative, however, you can assign night-sky viewing (with supervision by parents or guardians) as homework before you begin this section. Sketch the Big Dipper, show how it can help us find Polaris, and tell students to look for these two features in the sky on a clear night. Ask students what they noticed about the brightness of different stars, and if they saw anything else that they recognized or wondered about.

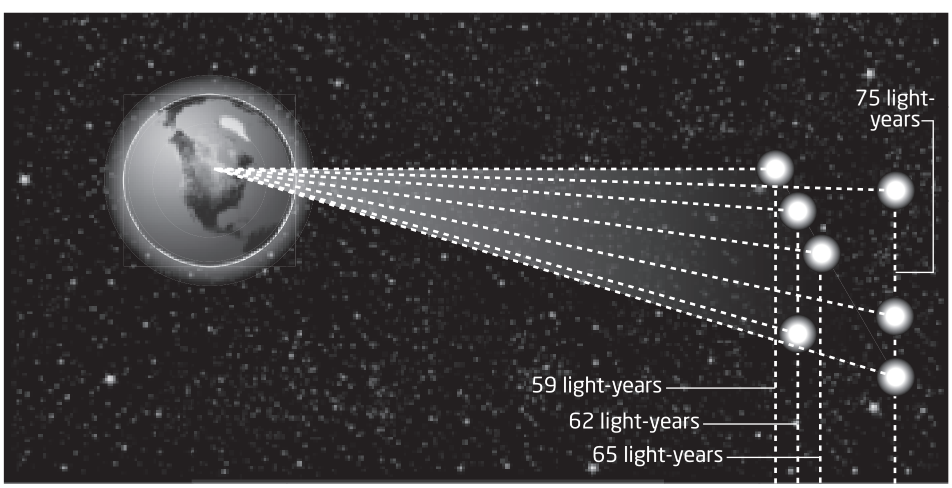
- If students have access to software such as *Starry Night,* they can use it to predict the locations of constellations, and then check their predictions when they observe the sky.

- ELL English language learners may know other legends or stories about objects in the sky. Encourage them to share these stories and legends with the class.
- Enrichment—Encourage students to see how many stars, planets, and constellations they can find in the sky using star maps for this time of year. Students can use the star maps in Appendix B, Using Star Maps (student textbook pages 570 and 571) or **BLM G-42 Star Maps for Fall, Winter, and Spring.** Discuss their observations as a class.

Section 7.2 Review Answers (Student textbook page 282)

Please see also **BLM 7-8 Section 7.2 Review (Alternative Format).**

1. Both constellations and asterisms are star groupings. A constellation is a pattern of stars that seem to be close to each other, for example, Orion. An asterism is a smaller grouping of stars within a constellation, for example, the Big Dipper.
2. The ancient Chinese saw the Big Dipper as a chariot for the emperor of the heavens. The early Egyptians saw the thigh and leg of a bull. Several North American Aboriginal cultures saw the bowl of the Big Dipper as a bear, with the stars in the handle representing the hunters who are following the bear. According to some Aboriginal stories, the bear is low enough in early autumn evenings to brush the maple trees, and blood from its wounds turns the leaves red.
3. A star's apparent magnitude is a measure of its brightness as seen from Earth.
4. Earth's axis points right at Polaris, so as Earth rotates, it seems as if we are revolving around Polaris.
5. A light-year is the distance that light travels in one year. At the speed of 300 000 km/s, light travels about 9.5×10^{12} km in one year.
6. Students' answers will vary, but students might find it easier to see the figures of the Great Bear and Orion the hunter, rather than the scales of justice.
7. Polaris always indicates the direction of north. So if you can see Polaris, you know which way is north. As you move northward, constellations along the southern horizon slip below the horizon and you cannot see them anymore. If you were to move southward, then formerly unseen constellations would rise above the southern horizon (as you travel southward).
8.



Section 7.3 Movements of Earth and the Moon (Student textbook pages 283 to 290)

Specific Expectations
- **D3.2** describe observational and theoretical evidence relating to the formation of the solar system
- **D3.5** explain the causes of astronomical phenomena (e.g., the aurora borealis, solar eclipses, phases of the Moon, comets) and how various phenomena can best be observed from Earth

In this section, students will study the motion of Earth around the Sun, model the changing angles of sunlight on Earth's surface to explore the cause of the seasons, and analyze the Moon's motion around Earth to understand the cause of the Moon's phases, eclipses, and tides.

Common Misconceptions

- **Some students may not understand why the Moon exhibits phases, and they may believe that the Moon rotates, showing its "dark side."** Show students Figure 7.17, on page 286, and point out that the features of the Moon that we see from Earth are always the same, regardless of the Moon's phase. The Moon does not rotate. It is the Moon's angle relative to Earth and the Sun that causes parts of it to be in shadow at different stages of its orbit.
- **Some students may believe that Earth is farther from the Sun in winter and that this change in location causes Earth to be colder.** In fact, Earth is closer to the Sun during the northern hemisphere's winter. Colder temperatures in winter are caused by the angle at which the Sun's rays strike Earth. Students will read about this concept in this section and explore it in Activity 7-2, Angle of Sunlight, on page 285 of the student textbook.

Both of these misconceptions can also be overcome using video or on-line simulations. See **www.scienceontario.ca**.

Background Knowledge

Moon phases, Earth seasons, and eclipses all are best demonstrated using models of the Earth-Moon system and a strong light source. These demonstrations may take some practice. Use a large ball or globe for Earth and a smaller ball for the Moon. Earth and the Moon cannot be too close together and the light source has to be a fair distance away.

There are several solar and lunar eclipses every year, but not all are visible from Canada. Because solar eclipses depend on an exact alignment of Earth, the Moon, and the Sun, they are visible only from one small area of Earth's surface. That location varies from one eclipse to the next. So while we in Ontario may have one chance in several years to see an eclipse, other eclipses will be visible from other parts of the world. You can find lists of all future and past eclipses on the Internet.

Viewing the Sun directly is safe when using special solar viewing mylar glasses or #14 welder's glass. Because you cannot control students' viewing completely, however, it is safer to have them view the Sun indirectly, by projecting its image on a piece of white paper, for example.

During a total eclipse—in the few minutes when the Moon totally covers the Sun—the bright part of the Sun (the photosphere) is totally hidden, revealing the fainter corona that is as bright as the full Moon.

Literacy Support

Using the Text

- ELL Preview the new terms and their meanings: *lunar, solar, ellipse, eclipse,* and *tides.* Help students distinguish between terms that seem similar.

Before Reading

- Help students make connections to prior knowledge. For each of the topics on pages 283 to 288 of the student textbook, ask students what they have experienced about the phenomenon. What evidence have students observed related to the phenomenon? Why do they think it happens? Students can record on **BLM G-30 K-W-L Chart.**

During Reading

- Ask students to read each section of text independently and then to pair up with another student to check comprehension by discussing the main ideas of what they have read. Tell students to include the causes of each phenomenon in their notes. Students can compare notes with a classmate, and revise their own notes as necessary. You could refer students to Study Toolkit 2, Reading Effectively: Monitoring Comprehension, on page 564 of the student textbook.
- ELL Pair English language learners with fluent English speakers.

After Reading

- Ask students to reflect on the causes and effects that they have read about. Five main effects are discussed in this section: Earth's seasons, the Moon's phases, lunar eclipses, solar eclipses, and tides. Have students use a cause-and-effect map (see Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on page 567 of the student textbook, and **BLM G-33 Cause-and-Effect Map**) to show the cause(s) of each phenomenon and to describe the mechanism by which the phenomenon's effect is created. Consider assigning students to work in groups of five, where each student prepares one diagram to present to the group. Provide time for students to make suggestions to one another, to amend their own diagrams, and to record their group's diagrams.
- Students can demonstrate their understanding of seasons and of phases of the Moon using **BLM 7-9 Seasons on Earth and Phases of the Moon.**

Using the Images

- DI The diagrams in this section will be very helpful to spatial learners who are trying to understand the concepts. After students have read the section, have them work in small groups to explain the diagrams. Have one student study each figure and explain it to the group. Others can ask questions and make sketches to help clarify the concept. In the end, everyone in the group should feel able to explain what each figure is showing.
- Discuss the lunar phases with students (Figure 7.17, on page 286) and have them describe times that they have seen different phases of the Moon. Is there a pattern when they see each phase? (crescent Moon just after sunset in the west; full Moon rising in the east at sunset, visible all night) Ask students to try to explain the pattern.
- Have students talk about solar eclipses. Have they seen one? Ask, "At what phase does a solar eclipse occur?" "At what phase does a lunar eclipse occur (refer to Figure 7.17)? Why?" Ask students, "Since a new Moon and a full Moon occur every month, why do we not see an eclipse every month?"

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Discussion/Learning Check questions, page 285	Students draw direct connections between phenomena and their causes.	Refer to the cause-and-effect diagrams that students made in "Using the Text." Have them model the relevant diagrams in the textbook using balls, and explain what is happening and why.
Discussion/Section 7.3 Review questions, page 290	Students clearly explain phases of the Moon, eclipses, tides, and daylight hours.	Have students answer the review questions orally, while they refer to the diagrams in the textbook to help them explain.
BLM 7-9 Seasons on Earth and Phases of the Moon	Students correctly label the seasons and phases of the Moon.	Provide the phase names, and allow students to match the name to the correct phase.
Activity 7-2, Angle of Sunlight, page 285	Students use their results in this activity to explain why we have seasons and why the angle of sunlight hitting the northern hemisphere makes it colder in winter.	Use a T-chart, or **BLM G-3 T-chart,** for students to record on. On the left, students can write what they observed in the activity. On the right, they can write what happens on Earth.
Inquiry Investigation 7-A, Modelling the Moon's Movement, page 307	Students demonstrate the phases of the Moon and answer the questions.	Have students work with a teacher-selected partner to answer the questions. Make each pair of students responsible for both students understanding every answer.

Instructional Strategies

- Begin with a graffiti exercise. Invite students to write brief sentences on the board about experiences they have had with any of the phenomena discussed in this section: seasonal changes, phases of the Moon, solar or lunar eclipses, or tides. Then have the whole class take a few moments to read what was written. Focus a discussion on what they observed, and what they know about causes.
- Some students may have lived in a tropical environment and may be able to share with the class some observations about seasonal changes, or changes in lengths of days in that environment.
- **DI** All figures in this section can be modelled using a large ball, a small ball, and a light source. Spatial or bodily-kinesthetic learners would benefit from acting out these three-dimensional models to help them understand the main ideas of the section. English language learners would also benefit from acting out the figures. Computer simulation software can also be used to model these figures.
- **ELL** Use an overhead transparency to demonstrate for English language learners how to refer back to the textbook to answer the Learning Check questions. Scan for key words from the questions in the textbook (for example, trans-Neptunian objects, gas tail, ion, asteroid). Have students practise this skill by using highlighters and photocopied segments. Each fact-finding question can be highlighted in a given colour and the corresponding key words from the textbook can be highlighted in the same colour.
- Inquiry Investigation 7-A, Modelling the Moon's Movement (student textbook page 307), provides reinforcement for the causes of the Moon's phases, solar eclipses, and lunar eclipses. It would be beneficial to assign the activity at this time.

Activity 7-2 Angle of Sunlight (Student textbook page 285)

Pedagogical Purpose

The angle of the Sun determines the amount of sunlight that reaches and heats any given area of Earth's surface. In this activity, students model the changing angles of sunlight to investigate the cause of the seasons we experience.

Planning	
Materials	Non-LED flashlight with a wide beam Sheet of graph paper Ruler Protractor Notebook String (optional) Calculator (optional)
Time	15–20 min to take the measurements and answer questions

Background

The changing position of the Sun in the sky during the year is the main reason for the changing seasons. When the Sun is directly overhead, its light falls directly on Earth's surface. When sunlight reaches Earth on an angle, it is dispersed over a larger area of Earth, and is less concentrated. Because of this dispersion, the Sun transfers less heat per unit area to Earth. In the northern hemisphere, summer and winter seasons are opposite to those in the southern hemisphere. The months of December through March are summer months for those in the southern hemisphere.

Activity Notes and Troubleshooting

- It may not be obvious to students that the Sun's altitude at noon varies over the year. Discuss with students what they notice. If possible, take them outside at noon one day to observe the position of the Sun. No matter what time of year it is, the Sun will not be directly overhead in Canada, but the closer the date is to December 21, the closer the Sun will be to the horizon. Also, the changing length of the day and position of the rising and setting Sun all account for the changing altitude. The Sun is not always visible for the same length of time before and after noon.
- This activity works best when students are divided into groups of three. One person can hold the protractor and a piece of string at the base of the protractor. The other person can hold the flashlight and the other end of the string at some point on the flashlight to ensure the light source is at a constant distance from the paper for each measurement. A third person can count the number of squares that are lit on the sheet of graph paper. Then the three students can rotate jobs.
- The string can be used to extend the angle measured with the protractor to ensure that the light source is coming from the desired angle at a constant distance from the paper.
- For this activity and others in this unit, refer students to Science Skills Toolkit10, Using Models and Analogies in Science, on page 551 of the student textbook.

Additional Support

- ELL To help English language learners participate fully, demonstrate the steps of the activity before students begin. "Thinking aloud" while demonstrating the activity helps English language learners to make connections between language and actions.
- Holding and moving apparatus and counting squares to determine area involve different skills. Tell students to watch the other members of their group to ensure that everyone is correctly performing their job, and also to see what they will need to do when they exchange roles.

- DI Spatial learners may wish to answer question 4 by drawing and labelling a diagram.
- Enrichment—Students could research features that help to reduce energy use in homes and that are based on the angle of sunlight (for example, awnings over south windows and solar panels that tilt).

Answers

1. 90°
2. If the flashlight is farther from the paper, the area of light will be greater. This result occurs because the rays from a flashlight are not exactly parallel.
3. the angle of sunlight
4. The lower the Sun is, the more the sunlight is spread over Earth. In the summer when the Sun is closer to the overhead point, more energy per unit area is concentrated on Earth, making it warmer.

Learning Check Answers (Student textbook page 285)

1. The stars appear to rise in the east and set in the west because Earth rotates from west to east.
2. An ellipse is an oval shape with two foci. Earth's orbit is an ellipse with the Sun at one of the foci, which makes Earth's orbit unsymmetrical. Earth is closer to the Sun in January and farther away in July.
3. Latitudes close to the equator are always hot because the Sun is always close to being overhead at noon. At no time of year does sunlight hit Earth at a low angle, as it does for northern latitudes like Canada in the winter.
4. Students' answers may vary, but students should mention that understanding Earth's motion through space helps us to make sense of what we see in the sky, and it also allows us to predict the seasons.

Learning Check Answers (Student textbook page 288)

5. The umbra is the darkest portion of Earth's shadow, and the penumbra is the lighter portion of Earth's shadow. In a lunar eclipse, Earth is between the Sun and the Moon. The Moon passes through Earth's shadow as the Moon goes through its monthly orbit around Earth. If the whole Moon goes through the umbra, then a total lunar eclipse occurs. If the Moon goes through the penumbra only or just part of the umbra, then a partial lunar eclipse occurs. In a solar eclipse, if you are in a location where the umbra touches Earth's surface, you will see a total solar eclipse. If you are in a location where the penumbra touches Earth's surface, you will see a partial solar eclipse.
6. For a lunar eclipse to happen, Earth must be between the Sun and the Moon. In this positioning, there will be a full Moon.
7. Students' illustrations should be similar to Figure 7.20, on page 288.
8. Suggested answer: I always see the same side of the Moon because the Moon rotates once in about 27.3 days, which is the same length of time as its revolution around Earth.

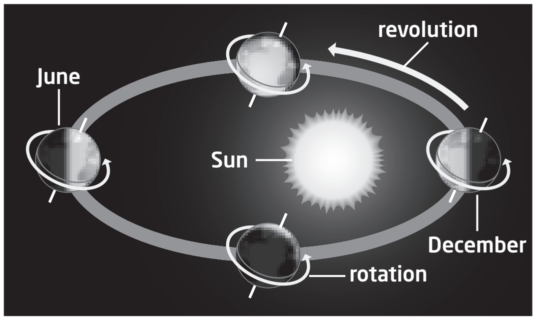
Section 7.3 Review Answers (Student textbook page 290)

Please see also **BLM 7-10 Section 7.3 Review (Alternative Format).**

1.

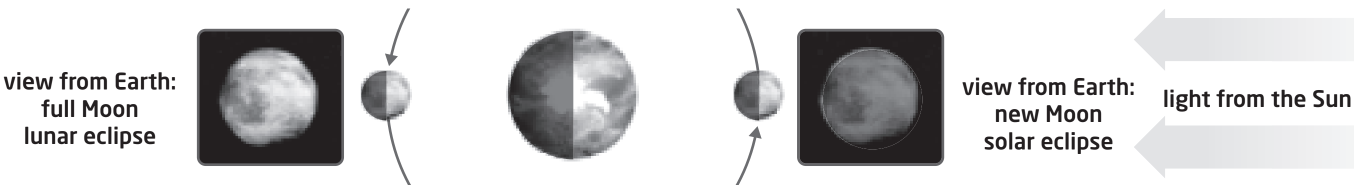
Rotation	Shared	Revolution
• around Earth's axis • once per day • the cause of night and day	• cause what we see in the sky to change	• around the Sun • once per year • caused by gravity • a cause of our seasons

2.



3. In the summer, the northern hemisphere is tilted toward the Sun so that region is warmer. It receives sunlight at a higher angle and for a longer period of time.

4.



5. Tides are the rising and falling of ocean waters, caused by the Moon's gravity. The amount of gravitational force between two objects depends on the masses of the objects and the distance between them. The side of Earth that is closest to the Moon experiences the largest gravitational pull, and the waters on Earth move toward this side slightly. The difference between the force of gravity on the side of Earth nearest the Moon and the force of gravity on the side of Earth farthest from the Moon creates an effect called tidal force. Students' diagrams should look similar to Figure 7.22, on page 289.

6. A lunar eclipse is safe to watch, because the Moon reflects some sunlight, but absorbs some, too. Light reflecting from the Moon is not as bright as light coming directly from the Sun. Looking at the Sun is always dangerous, whether or not there is a solar eclipse. The light from the Sun can burn your retina and blind you, so eye protection must be worn.

7. There is not a lunar eclipse every month because the orbit of the Moon is tilted approximately 5° to Earth's orbit, so most months, the Moon passes above or below Earth's shadow.

8. **a.** June 21

b. Day and night are equal in length for all latitudes on March 21 and September 21.

c. No, the Sun does not set because there are 24 h of daylight during that time.

d. Summer and winter in the southern hemisphere are opposite from summer and winter in the northern hemisphere, so the date for the least amount of daylight hours in the southern hemisphere would be June 21.

Section 7.4 Meet Your Solar System

(Student textbook pages 291 to 296)

Specific Expectations

- **D2.1** use appropriate terminology related to the study of the universe, including, but not limited to: *celestial objects*, *orbital radius*, *retrograde motion*, and *satellite*
- **D2.4** gather and record data, using an inquiry or research process, on the properties of specific celestial objects within the solar system
- **D2.5** compare and contrast properties of celestial objects visible in the night sky, drawing on information gathered through research and using an appropriate format
- **D3.3** describe the major components of the solar system and the universe, using appropriate scientific terminology and units

In this section, students will build a model of the solar system to investigate the size of the planets and the distances between them. They will learn about planetary motion and the characteristics of the planets in our solar system.

Common Misconceptions

- **Some students may believe that life has been found on Mars.** This is not true. Some of the conditions that would be necessary to support life have been found, however (for example, water, as ice). See also **www.scienceontario.ca**.

Background Knowledge

Venus, Mars, Jupiter, and Saturn are visible from Earth without a telescope. Mercury is sometimes visible. Technically, Uranus can be seen too, but it is just a very tiny dot.

Venus and Mercury appear to stay near the Sun because their orbits are small. Jupiter and Saturn have larger orbits than Earth, and they often appear far from the Sun.

On a given night, planets appear to move from east to west, with the stars. From one night to the next, however, planets usually appear to change position from west to east. For some stretches of time, however, some planets appear to change their position nightly from east to west. This is called retrograde motion, and is a result of our observing an orbiting planet from another orbiting planet. Retrograde motion is shown and described in Figure 7.24, on page 292.

Literacy Support

Using the Text

Before Reading

- Have students examine Figure 7.23, on page 291, which shows the planets in order from the Sun. Ask students to relate what they already know and what they see in this diagram to predict some characteristics of each planet.

During Reading

- Students can summarize each subsection, stating the main idea and a few important supporting details. You can model this process by reading the Models of the Solar System section aloud, and summarizing it on the chalkboard with students' help.
- For pages 294 and 295, have students work in groups. Each group member can be responsible for relating three or four key facts about one planet to the group.
- ELL Encourage English language learners to use sticky notes to indicate any words that they cannot understand and to ask group members to help them.

After Reading

- Each group can work together to use the facts reported about each planet to create a table or other graphic display summarizing the characteristics of all eight planets.
- Have students complete **BLM 7-11 Properties of the Planets** or **BLM 7-12 Properties of the Planets (Alternative Version)** to summarize what they have learned.

Using the Images

- Figure 7.24, on page 292, illustrates the retrograde, or backward, motion of Mars. Animated illustrations of this effect can be found on the Internet and shown to students. See **www.scienceontario.ca**.
- Discuss with students the different characteristics of the planets shown on pages 294 and 295. Ask, "Which planets are more Earth-like?" "Which would be the best candidates for us to live on, apart from Earth? Why?"

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Discussion/Learning Check questions, page 292	Students define and describe the characteristics of inner and outer planets.	English language learners could answer question 2 by drawing a diagram. Students could answer question 3 in a group by contributing to a large Venn diagram.
Discussion/ Section 7.4 Review questions, page 296	Students explain the heliocentric solar system model and compare and contrast the characteristics of planets, in words and graphs.	Provide students with a blank graph to use for question 8. As students work on question 5, encourage them to use a highlighter to highlight similarities in their notes, or in their group's notes.
Activity 7-3, Modelling the Solar System, page 293	Models show correct scale for size and distance.	Have groups compare and talk about the differences in their models and about how they arrived at the distances they used. Provide students who are unable to navigate the mathematics with scale diameters and distances to use for their models.

Instructional Strategies

- If students have observed the night sky earlier in the chapter, ask them if they saw any planets. If so, ask them how they knew the objects were planets. Have students work in pairs to make Venn diagrams that compare planets and stars. Then have each pair discuss their diagrams with another pair.
- Many simulations of retrograde motion exist on the Internet, and can help students understand why planets sometimes appear to move backward. See **www.scienceontario.ca**.
- Enrichment—Students could complete the activity on **BLM 7-13 Modelling Retrograde Motion.**
- After this section—to give students an opportunity to apply what they have learned about observing stars, planets, and constellations—assign Inquiry Investigation 7-B, The Changing View of the Night Sky, on pages 308 and 309 of the student textbook.
- Data Analysis Investigation 7-C, Gravity on Other Planets, on page 310 of the student textbook, would be a good follow-up to this section.

Activity 7-3 Modelling the Solar System (Student textbook page 293)

Pedagogical Purpose

Creating a model of the solar system gives students an understanding of the great distances between the planets.

Planning		
Materials	Calculator Coloured markers or pencils Long white paper tape Long measuring tape (optional) **BLM G-28 Metric Conversions** (optional)	Construction paper Scissors Glue or tape Metre stick
Time	45 min in class	

Background

It is difficult to build a model solar system that will fit inside a schoolyard and that will show planets of reasonable size. In this model, planets are very small so that students can build the solar system in the classroom.

Using the scale factors given in the textbook, students should complete their models with the distances shown in the answer to question 2 on the next page.

Activity Notes and Troubleshooting

- Completed models will be more than 6 m long. You may want to move desks aside before beginning this activity, or have students build their models in the hallway.
- Consider posting one or more models on a wall for reference in future sections.
- This activity can be expanded to determine how far it is to the nearest star or galaxy.

Additional Support

- Students who are interested could build a spreadsheet showing the different sizes of the planets based on the size chosen for the Sun, allowing them to construct a model at any scale.
- DI To ensure groups are able to accurately plan and construct their models, try to have both bodily-kinesthetic and logical-mathematical learners in every group.
- Students who struggle with mathematics may have more success with this activity if you provide the measurements to use in the model, rather than having students calculate them. See the table in the Background section.
- To review the relationship among metric units, use **BLM G-28 Metric Conversions.**

Answers

1. 6.04 m

2.

Celestial Object	Diameter (cm)	Distance from Sun (cm)	Distance from Earth (km)	Time (h) It Would Take for an Airplane to Reach Each Celestial Object from Earth at a Speed of 800 km/h
Sun	139.3		149 600 000	187 000 (7792 days or 21 years)
Mercury	0.5	8	91 690 289	114 613 (4776 days or 13 years)
Venus	1.2	145	41 390 430	51 738 (2156 days or 6 years)
Earth	1.3	20		
Mars	0.7	30	77 439 534	96 799 (4033 days or 11 years)
Jupiter	14.3	104	628 694 598	785 868 (32 745 days or 90 years)
Saturn	12.1	190	1 274 272 155	1 592 840 (66 368 days or 182 years)
Uranus	5.1	395	2 726 560 232	3 408 200 (142 008 days or 389 years)
Neptune	5.0	604	4 366 265 992	5 457 833 (227 409 days or 623 years)

Learning Check Answers (Student textbook page 292)

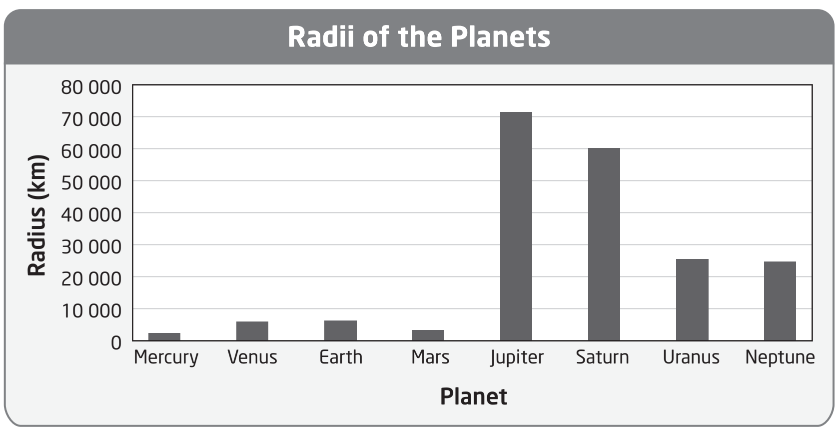
1. A planet is a celestial object that orbits one or more stars, is spherical, and does not share its orbit with another object.

2. The geocentric model of the solar system has Earth at the centre and all objects, including the Sun, orbiting Earth in perfect circles. The heliocentric model of the solar system has the Sun at the centre and all objects orbiting the Sun.
3. Inner planets are relatively small, have solid cores, and have rocky crusts. Outer planets formed from large clumps of gas, ice, and dust; have large gaseous bands; and have cold temperatures. Both the inner planets and outer planets orbit the Sun in the same direction, and roughly the same plane.
4. Answers will vary but may include the following: If a planet were at the centre of the solar system, there would be less gravity and some outer planets would drift off; it would be colder; lengths of days and seasons would be different.

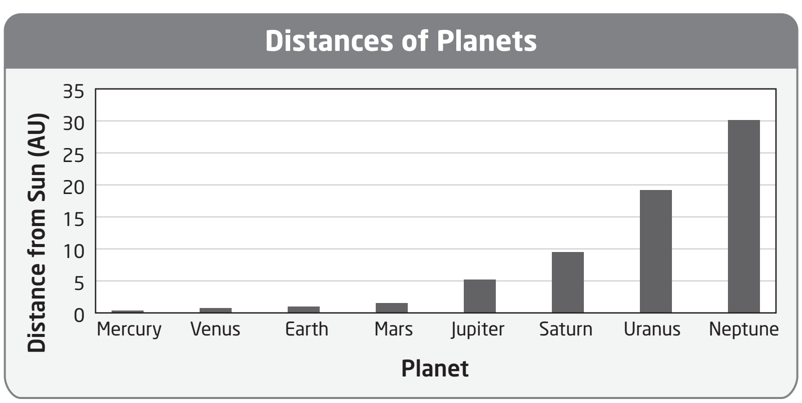
Section 7.4 Review Answers (Student textbook page 296)

Please see also **BLM 7-14 Section 7.4 Review (Alternative Format).**

1. Example: My Very Excellent Mother Just Served Us Noodles.
2. The Sun is holding all the objects in orbit.
3. The path of the Sun would look the same.
4. The distances to the planets from Earth and the Sun are so large that it is difficult to work with them. Using the astronomical unit is easier than using powers of 10.
5. Hydrogen and helium are the most common gases in the gas giants. Students' tables should show atmospheres as follows: Mercury: none; Venus: sulfur, carbon dioxide, nitrogen; Earth: nitrogen, oxygen, water vapour; Mars: carbon dioxide; Jupiter and Saturn: hydrogen and helium; Uranus and Neptune: hydrogen, helium and methane.
6. Uranus's axis is tilted so much that it seems to be lying on its side.
7. Longer. It takes Saturn almost 30 Earth years to revolve around Earth.
8. a. The outer planets are called gas giants because they are so big compared with the terrestrial planets and because they do not have solid surfaces.



b.



Section 7.5 Other Objects in the Solar System

(Student textbook pages 297 to 306)

Specific Expectations

- **D3.1** describe observational and theoretical evidence relating to the origin and evolution of the universe
- **D3.5** explain the causes of astronomical phenomena and how various phenomena can best be observed from Earth

In this section, students will learn about objects in our solar system other than planets—objects in the Kuiper Belt and Oort Cloud, comets, asteroids, meteoroids, meteors, and meteorites. They will study the objects' formation, orbits, and how we observe them. Students will model and investigate the creation of craters by meteorites.

Common Misconceptions

- **As a result of popular movies like *Armageddon* and *Direct Impact,* students may believe that it is possible to stage missions to prevent asteroids or comets from hitting Earth.** This belief is fiction; we do not possess this capability today. Celestial bodies are much too massive for us to move. It is true that scientists are working to detect objects that pass close to Earth, and are working to develop technology to redirect them (see the Case Study on page 304 of the student textbook), but this technology will not be available for many years to come.

Background Knowledge

There are many objects orbiting our Sun other than planets. Beyond Neptune, the Kuiper Belt and Oort Cloud contain trillions of orbiting bodies. Millions of asteroids orbit in the asteroid belt, between Mars and Jupiter. Comets, which may originate in the Oort Cloud, have an orbit that brings them from the outer edges of the solar system close to the Sun, and then out again.

There are groups working on the problem of asteroid/comet impact with Earth. For an example, see the Case Study on page 304 of the student textbook. Additional information about this work can be found on the Internet.

Literacy Support

Using the Text

Before Reading

- Have students preview the text features by looking ahead at the subheadings, diagrams, and captions. Ask students to predict what they might learn in each subsection. After reading, students can compare their predictions with what they did learn.
- ELL Preview the meanings of the Key Terms. Students often find it difficult to distinguish among *meteor, meteoroid,* and *meteorite.* A diagram may be helpful.

During Reading

- Help students summarize the material in each subsection. They must reduce each passage to just 20 words that capture the gist of the text.
- ELL English language learners can make point-form notes, complete cloze passages, or label diagrams to show the key ideas in each section. A cloze-type format benefits English language learners by providing a model of the language structures, and it encourages them to use contextual cueing when selecting words to fill in the blanks.
- This section includes two tables: the Kuiper Belt characteristics table on page 298, and Table 7.3, Examples of Periodic Comets, on page 300. Have students examine each one with a partner, and then invite pairs to share with the class the interesting information that each table shows. Students should be able to explain where the information they select appears on the table.

After Reading

- Students can make study notes by writing in point form the most important information about each type of object in our solar system. Some students may choose to make these notes in a table or place them on diagrams. Have students compare their study notes with a classmate's to check for completeness and brevity.
- **BLM 7-15 Other Objects in the Solar System** can also be used to summarize this section.

Using the Images

- Have students examine Figures 7.26 to 7.34, on pages 297 to 303, and write one or two sentences to summarize what they learned in each figure. By sharing with the class, students will model for others the process of interpreting and learning from a diagram.
- Have students look at Figure 7.27, on page 298, and ask them why objects in the Kuiper Belt (including Pluto) may be considered dwarf planets instead of planets.
- Have students refer to Figures 7.33 and 7.34, on pages 302 and 303, and discuss the possible consequences of a large asteroid hitting Earth.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Discussion/Learning Check questions, page 301	Students provide correct descriptions of trans-Neptunian objects, comets, and asteroids.	Have students work with a partner to review the relevant subsections of the textbook and to find the information to build a correct answer.
Discussion/ Section 7.5 Review questions, page 306	Students include accurate descriptions of all solar system objects and of the effects of asteroids hitting Earth.	Have students complete **BLM 7-15 Other Objects in the Solar System** to demonstrate their learning in a more structured format.
BLM 7-15 Other Objects in the Solar System	Students correctly summarize characteristics of solar system objects.	Have students work with a partner to find the information they need in the textbook.
Activity 7-4, Making Craters, page 303	Students describe results that show the relationship between the velocity or height of the marble and the resulting craters.	Repeat the activity as a demonstration and have students observe carefully. Stop after every step and invite students to describe patterns that they see and to predict what these patterns tell us about how craters form.

Instructional Strategies

- ELL There is a lot of new vocabulary in this section. Create a word wall, with definitions and diagrams if possible, for students to refer to as they work.
- If you have access to a meteorite, bring it to class and pass it around. Invite students to guess what it is, and to comment on what they observe about it, including colour, hardness, and mass. If no meteorite is available, consider bringing in a colour photograph of a large meteorite or a cross section of a meteorite to show students.
- Some students may have observed meteors or meteor showers in the sky. If so, ask them to describe their experience to others.

- Have students recall the size of the solar system model they created in Activity 7-3, Modelling the Solar System (student textbook page 293), as they learn about the Kuiper Belt and the Oort Cloud. Ask students to calculate where these areas would appear on their model of the solar system (far beyond Neptune; the Oort Cloud would probably need to be outside the school). If you have posted a model, students could add trans-Neptunian objects (or at least an arrow showing in what direction and how far away one would look to find them) and the asteroid belt to it.
- Enrichment—The Case Study, Can We Prevent the Next Big Impact? (student textbook pages 304 and 305), will provide an interesting opportunity for students who are interested in current areas of research.

Activity 7-4 Making Craters (Student textbook page 303)

Pedagogical Purpose

In this hands-on activity, students will develop an understanding of how craters formed and why they look the way they do.

Planning		
Materials	Newspaper 2–3 L sand 50 mL cocoa powder Metric ruler or metre stick	Shallow, rectangular pan 100 mL flour 3 marbles, each a different size
Time	20–30 min	
Safety	Flour or cocoa on the floor can be slippery. Caution students to immediately sweep up any flour or cocoa they spill. Students should not throw the marbles, but drop them gently.	

Background

For many years, it was thought that the craters on the Moon were the result of volcanic activity. It was only in the 1960s that it was determined that asteroid bombardment caused the craters on the Moon and on Earth.

Students should notice that dropping marbles from a greater height will cause a larger crater, dropping larger marbles will cause a larger crater, and dropping marbles from an angle will cause a crater with flour and cocoa ejected to one side.

Activity Notes and Troubleshooting

- Inexpensive aluminum pans from a dollar store work well.
- Any throwing or tossing of marbles may create a flour mess. Ensure that students immediately tidy up any flour that is spilled. Have extra cloths, newspapers, and brooms on hand to facilitate a quick clean-up.
- Pictures of large craters on the Moon show secondary craters—smaller craters created by materials thrown up and out by the first impact—nearby. Have students examine their pans after dropping each set of marbles. Do they see any secondary craters in the flour?
- If one group obtains an interesting pattern (for example, secondary craters) that other groups do not, call others over to observe that group's results.

Additional Support

- **DI** If possible, include both bodily-kinesthetic learners and spatial learners in each group to ensure success in carrying out the activity and in observing patterns in the results.
- **ELL** English language learners should be able to participate fully if they are placed in groups with more fluent English readers.

Answers

1. If the size of the crater varies, and the marbles were all dropped from the same height, then you will know the variation was not because of height but because of mass.
2. Two things affected the size of the crater: the size of the object making the crater and the height from which the object was dropped. (The larger the object is, the larger the crater is. The greater the height is, the larger the crater is.)
3. The cocoa and flour are ejected on one side of the crater.

Learning Check Answers (Student textbook page 301)

1. Trans-Neptunian objects are objects that orbit the Sun beyond the orbit of Neptune.
2. The gas tail is also called an ion tail because the Sun's radiation charges, or ionizes, the gas particles.
3. An asteroid is a small, non-spherical object thought to have been a remnant from the formation of the solar system.
4. Comets come from the Oort Cloud and the Kuiper Belt, which are thought to have formed when the solar system formed. Astronomers who study comet samples are studying material from the early solar system, so these astronomers can learn more about how the solar system formed.

Section 7.5 Review Answers (Student textbook page 306)

Please see also **BLM 7-16 Section 7.5 Review (Alternative Format).**

1. As a comet approaches the Sun, the Sun's radiation causes the process of sublimation. Sublimation releases gas and particles, and two tails form: a gas tail and a dust tail.
2. One of the terms in the definition of a planet given by the International Astronomical Union (IAU) is that the planet cannot share its orbit with another object. Sometimes Pluto's orbit crosses Neptune's orbit, so Pluto can no longer be considered a planet under the new definition.
3. Shooting stars are bits of rock, called meteoroids, which have broken off of asteroids or planets. When meteoroids hit the atmosphere, they burn up and form streaks of light called meteors.
4.

Object	Definition
Asteroid	Small, non-spherical object, usually found in asteroid belt
Meteoroid	Chunk of rock and/or metal in space
Meteor	A streak in the night sky
Meteorite	The leftover matter when a meteoroid hits Earth's surface

5. Most comets originate in the outer reaches of the solar system, in the Oort Cloud and Kuiper Belt; most asteroids originate in the asteroid belt, between Mars and Jupiter.
6. A large asteroid hit Earth with so much force that tonnes of debris were ejected into the atmosphere; the sky stayed dark for a long time because of the debris; not enough sunlight could get through; plants could not grow; plant-eating animals starved to death; animal-eating animals starved to death.
7. Comets leave debris in their orbits around the Sun. When Earth's orbit intersects a comet's orbit, the debris enters Earth's atmosphere, creating a meteor shower.
8. Asteroids are not spherical in shape.

Inquiry Investigation 7-A Modelling the Moon's Movement

(Student textbook page 307)

Pedagogical Purpose

This activity provides students with a three-dimensional interactive model of the Moon's motion to discover what causes it to exhibit phases.

Planning	
Materials	Flashlight or overhead projector Baseball Wide-point, water-soluble black marker Volleyball String, about 0.5 m Large sheet of white paper **BLM 7-17 Inquiry Investigation 7-A, Modelling the Moon's Movement** (optional)
Time	15–20 min to take the measurements and answer questions
Safety	• Ensure students do not look directly into the projector light. • Ensure students do not touch the projector light. It can get very hot. • Ensure students do not pull on the cord of the projector when they unplug it. They should pull on the plug instead.

Background

Earth and the Moon always have a day side and a night side. When we see a crescent Moon, we see part of the Moon that is receiving sunlight (the crescent) while most of the Moon facing Earth is not receiving sunlight.

The Moon orbits on a slightly different plane than Earth does. For that reason, we do not see a lunar eclipse every month. Lunar eclipses appear approximately twice a year when the Moon's orbit is crossing the plane of Earth's orbit (at the node) as the full Moon occurs.

An excellent way to demonstrate the phases of the Moon is to observe it during the day. An 18- or 19-day-old Moon is in between full Moon and last quarter. It is visible in the morning in the southwestern sky after sunrise. If you are looking at the Moon and standing in sunlight, and you hold a ball in your outstretched arm "beside" the Moon, the phase of the ball and the Moon will be the same since the angle they make with respect to the Sun will be the same.

Activity Notes and Troubleshooting

- To provide a clear simulation of the Moon's phases, ensure that all the lights are off and that there is only one light source (the Sun).
- Demonstrate for students how to draw a circle using string as a compass.

Additional Support

- DI Spatial and bodily-kinesthetic learners may better understand the phases if they hold the Moon and move it in an orbit around their head, thus seeing the phases. A classmate could also move the Moon around a student's head, with the student observing the phases.
- ELL For English language learners who may need further assistance after reading the instructions, demonstrate what to do, without illuminating the "Sun" before they begin. Then students can follow your model. This investigation, as well as Data Analysis Investigation 7-C, Gravity on Other Planets (student textbook page 310), may be more accessible for English language learners than Inquiry Investigation 7-B, The Changing View of the Night Sky (student textbook pages 308 and 309).

- This activity can easily be done as a demonstration, especially if an overhead projector is available. If manageability is an issue, consider this option.

Answers

Analyze and Interpret

1. No, the full Moon is visible only between sunset and sunrise. In order for us to see the entire lit-up side of the Moon, the Sun must be behind us (that is, it must be night).
2. A new Moon is in-between Earth and the Sun, so the Moon's dark side is toward Earth and the Moon is invisible except during a solar eclipse.

Conclude and Communicate

3. full
4. new
5. The 5° tilt of the Moon's orbit to Earth's orbit means that the Moon usually passes above or below the Sun at new Moon, and above or below Earth's shadow at full Moon.

Extend Your Inquiry and Research Skills

6. Students should find that the Moon's phases are visible in the way this investigation predicts, unless the Moon is obscured by clouds.

Inquiry Investigation 7-B The Changing View of the Night Sky (Student textbook pages 308 and 309)

Pedagogical Purpose

In this activity, students will apply what they have learned about observing stars, constellations, and planets to demonstrate and observe the motions of different stars in the night sky and relate them to the motion of Earth.

Planning	
Materials	A list of the visible planets Coloured pencils Flashlight with a red filter, such as red cellophane (Red light does not interfere with night vision.) A clipboard or hard surface to use under the star maps **BLM 7-18 Inquiry Investigation 7-B, The Changing View of the Night Sky** (optional) **BLM G-42 Star Maps for Fall, Winter, and Spring** (or Appendix B, Using Star Maps, on page 570 of the student textbook) **BLM G-23 Data Table** (optional)
Time	• 20 min in class to prepare the data table and preview the instructions • 30 min in the evening to observe and record observations
Safety	• Precautions must be taken to be safe when observing at night. Students must be accompanied by an adult. Encourage students to observe together. • Students should dress appropriately for the weather.

Background

This activity provides an opportunity for students to observe the sky themselves. There are always challenges with this activity—the weather for one. Also, it is sometimes difficult for students to know if they are looking in the right direction or if they actually see the constellation or planet. For these reasons, it is beneficial if the class can meet in the evening at school to observe together.

Invite a local astronomy club to attend and to bring their telescopes. Then students can confirm accurate sightings of the stars on their list.

There are regional star maps and planet-information blackline masters for this activity. Photocopy the information that is appropriate for the date that students will be observing. Simulation software, such as *Starry Night,* is also a good way for students to develop hypotheses and prepare for gathering observations.

Activity Notes and Troubleshooting

- Review the star charts and how to read them with students beforehand. Have students practise facing north and pointing to where stars marked on the chart would be in the sky. Refer students to Appendix B, Using Star Maps, on page 570 of the student textbook.
- Assign this investigation when there is no full Moon.
- If possible, use a planetarium software package to display the night sky on the wall so students can become familiar with the night sky beforehand.
- Have students create the data table in class before observing. Encourage them to answer the questions in the investigation immediately after observing.

- The entire activity is available on **BLM 7-18 Inquiry Investigation 7-B, The Changing View of the Night Sky** (student textbook pages 308 and 309). If you wish, make copies of it so that students do not have to carry their textbooks home and outside with them.
- Read through all the instructions and questions with students before they observe to be sure everyone understands what to do.
- Encourage students to enlist their parents' help.

Additional Support

- ELL If possible, try to arrange viewing groups so that English language learners are observing with more fluent readers. It would be useful for all students to observe in groups of two or three.

Answers

Analyze and Interpret

1. **a.** Polaris remains in the same position throughout the night. The other bright star (Vega or Regulus, for example) can be seen slowly moving from east to west as the night progresses.
   b. Stars not near Polaris (that is, near the axis of Earth) can be seen only at certain times of the year (and are called seasonal stars or constellations). At times, due to the movement of Earth, the star or constellation appears in the direction of the Sun and is invisible.
2. Orion is visible in the winter. Leo is visible in the spring. Scorpius is visible in the summer. Pegasus is visible in the autumn.
3. **a.** Students will have observed Venus either just after sunset once it gets dark or just before it gets light in the morning. Venus' position will dictate if it is observable in the morning or evening.
   b. The positions of Jupiter and Saturn will vary. Jupiter stays in a constellation for about one year. Saturn stays in a constellation for about two and a half years.
4. The planets at first glance look like bright stars. (Mercury, Venus, Mars, Jupiter, and Saturn are bright enough to be seen without optical aid.) On closer observation, the planets do not twinkle but the stars do.

Conclude and Communicate

5. The planets follow a path through the sky, through the zodiacal constellations. Planets are never seen in the other constellations.
6. Venus' orbit is inside Earth's so we never see Venus too far from the Sun. Jupiter and Saturn are in orbits outside Earth so if the positions are right, we can look away from the Sun to see these planets and they are visible all night long.
7. As Earth revolves around the Sun, some constellations (the zodiacal constellations, for example) are sometimes behind the Sun and are invisible. The constellations near Earth's axis (near Polaris) are visible all night long, every night.

Extend Your Inquiry and Research Skills

8. Students may list questions such as, "For how long will the star maps we use today be accurate?", "How far can you travel on the surface of the Earth and use the same star map?", or others.
9. Students should find that star maps are very old. Accurate maps were made by Tycho Brahe (1546–1601), and by Chinese astronomers possibly around 600 C.E.

Data Analysis Investigation 7-C Gravity on Other Planets

(Student textbook page 310)

Pedagogical Purpose

In this activity, students will investigate the relationship between the mass of planets and the amount of gravity that the planets have.

Planning	
Materials	Library or computers with Internet access **BLM 7-19 Data Analysis Investigation 7-C, Gravity on Other Planets** (optional) **BLM G-23 Data Table** (optional) **BLM A-29 Data Analysis Investigation Rubric** (optional)
Time	30–60 min to conduct the research, make the data table, and answer the questions

Background

A planet's gravity depends on its mass. Some asteroids have very low gravity fields, which makes it conceivable that if you took a running jump, you could send yourself into orbit!

Activity Notes and Troubleshooting

- You could assign the data collection for homework, and allow students to answer the questions in class. That way, there would be help available for students who have trouble with some of the calculations.
- Ensure that students write their hypotheses before doing the research.
- Several websites include calculators to find a person's weight on other planets. Alternatively, you could have students calculate their weight on each planet by multiplying their weight on Earth by the gravity on the other planet as a decimal. Point out that while someone's mass does not change, weight will change depending on how strong the force of gravity is. Weight is measured in Newtons (N). If a person has a mass of 40 kg, their weight on Earth will be 40 N, since gravity is approximately 1.0 m/s^2. Since Venus's gravity is 0.9 × Earth's gravity, the person's weight on Venus would be 40 × 0.9 = 36 N.
  - To avoid embarrassing students who are sensitive about their weight, you could ask all students to calculate the weight of an animal or an object ("My dog weighs…" "This textbook weighs…").
  - You can guide and assess students' analyses using **BLM A-29 Data Analysis Investigation Rubric.** Provide students with the rubric before they begin.

Additional Support

- DI This activity will appeal to logical-mathematical thinkers.
- Many sources will give gravity for each planet as a decimal of Earth's gravity. If students find gravity only as a percent of Earth's gravity, encourage them to use what they know about decimals and percents to convert to a decimal (50% is 0.50).
- DI Logical-mathematical learners and spatial learners may benefit from drawing a graph to show the relationship between planets' masses and their gravity before answering question 3.
- ELL If you work with them to create a data table, English language learners should be able to gather information relatively independently. You may wish to have them answer questions 3 and 4 orally in a group with verbal prompts as needed.

Answers

Analyze and Interpret

1.

Planet	Gravity (Earth = 1.00)	Atmosphere (yes or no)	Mass (relative to Earth)	Orbital Radius (AU)
Mercury	0.38	no	0.05	0.39
Venus	0.91	yes	0.82	0.72
Earth	1.00	yes	1.00	1.00
Mars	0.38	yes	0.11	1.52
Jupiter	2.54	yes	317.8	5.20
Saturn	1.08	yes	95.2	9.54
Uranus	0.91	yes	14.5	19.18
Neptune	1.19	yes	17.1	30.06

Analyze and Interpret, Conclude and Communicate

2. and **3.** A planet's gravity depends on its mass. As the mass of a planet increases, so does its gravity. Atmosphere and orbital radius are not related to a planet's gravity.

Extend Your Inquiry and Research Skills

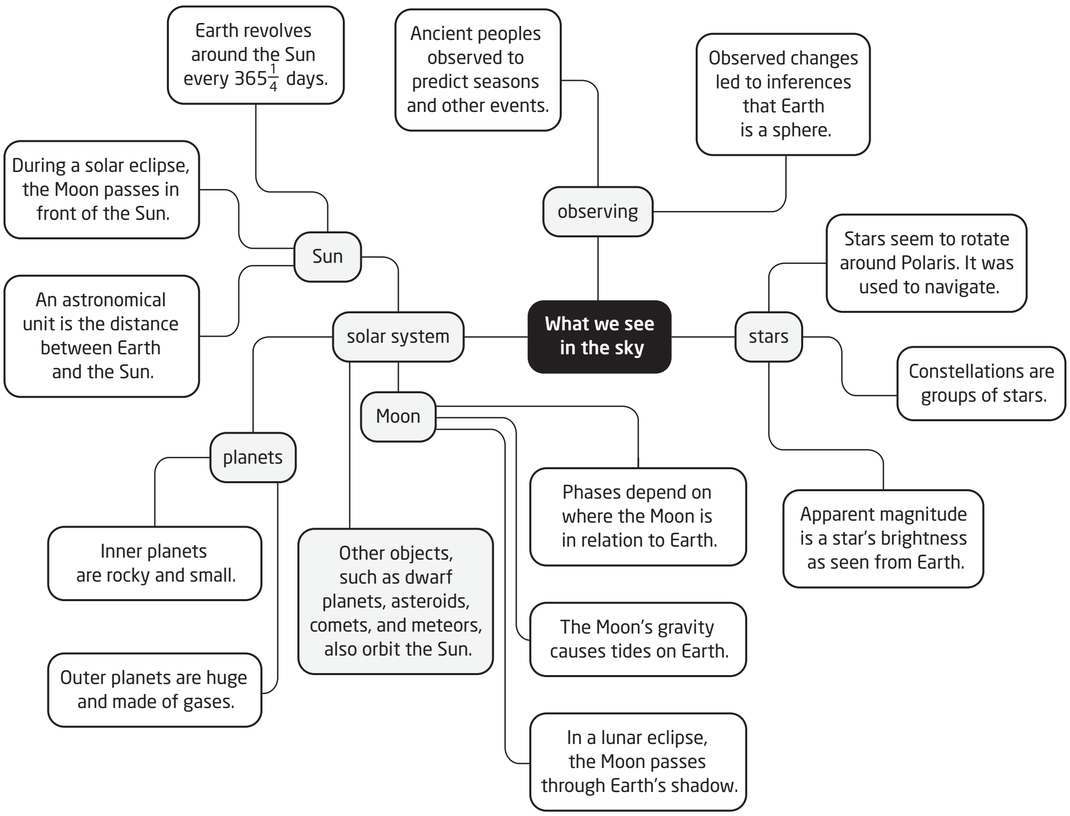
4. Answers will vary, but students should express their weight on Earth in Newtons (N). Their weight on each of the other planets should be their weight on Earth × the gravity on that planet.

Chapter Review Answers (Student textbook pages 312 to 313)

Please see also **BLM 7-20 Chapter 7 Review (Alternative Format).**

- ELL Consider asking English language learners to group the review questions. Have the students pick the questions that they feel they can answer independently. Then have them select the questions for which they are not sure of what they are being asked. Clarify these questions by restating them. Let students select the questions for which they may need some language support, and finally, those questions for which they need peer support or reteaching.

Make Your Own Summary

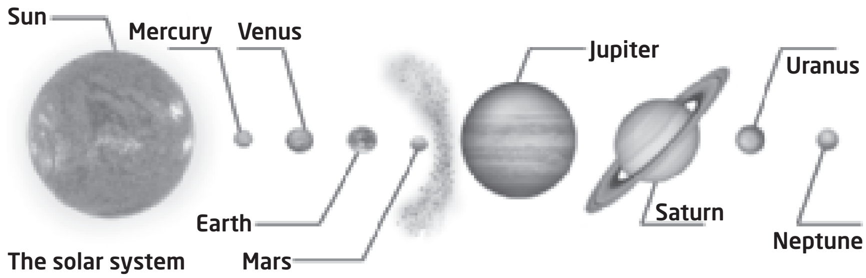


Reviewing Key Terms

1. astronomers
2. rotates/revolves
3. constellations
4. total solar eclipse
5. planet
6. retrograde motion
7. meteoroid/meteorite

Knowledge and Understanding

8. Early sky watchers depended on regular, predictable motions to predict floods, seasons for farming, and the best times for hunting.
9. The Moon is always half-lit by the Sun. The relative positions of the Sun, Earth, and the Moon show different amounts of lighting from Earth.
10. A: full; B: waning crescent; C: waxing gibbous
11. The new Moon is between us and the Sun; the side being lit by the Sun is away from us and the side toward Earth is not receiving (or reflecting) any light from the Sun.
12. During a total eclipse of the Sun (as seen from Earth), an observer on the Moon would see a full Earth in the sky and he or she would see the Moon's shadow slowly move across Earth's surface.

13. 

14. It is more meaningful to measure the distances between objects in the solar system using astronomical units because light-years are larger than any distance within the solar system. Light-years are used for really distant objects like stars.

15. astronomical unit (150 000 000 km)

16. The classification of inner and outer planets is based on composition and distance from the Sun. The inner planets are closest to the Sun (inner part of the solar system) and have rocky compositions, so they should be classified together. The outer planets are much farther away from the Sun (outer part of the solar system) and have gaseous compositions, so they should be classified together.

17. large, mainly gas composition; have lots of moons, ring systems; cold temperatures

18. Pluto is neither a gas giant nor a terrestrial planet. It is far beyond Neptune, the farthest planet. It is small, icy, and has three known moons.

19. Shooting stars are meteoroids, or small bits of debris entering Earth's atmosphere. They burn up as they enter the atmosphere, releasing light.

20. Both asteroids and meteoroids are objects in space. Asteroids are usually larger than meteoroids. Asteroids are usually found in the asteroid belt but some are found near Earth. Meteoroids become meteors when they collide with Earth's atmosphere; if they reach Earth's surface, then they are meteorites.

21. Comets are rocky and icy objects, containing some gas. They originate in the Kuiper Belt and the Oort Cloud. When a comet approaches the Sun, the wind from the Sun forces the gases and particles to be released and pushes them away, forming two tails. The whitish tail is reflected sunlight off the particles that have been released. The blue tail is ionized gas. Students' diagrams should resemble Figure 7.29 (on page 300), or Figure 7.28 (on page 299), but should show two tails as in Figure 7.29.

Thinking and Investigation

22. Yes, a person living in a lunar colony would experience day and night because the Moon rotates, like Earth rotates; the Moon just rotates a lot slower. Day and night each last two weeks on the Moon.

23. A solar eclipse needs a new Moon; a lunar eclipse needs a full Moon. These two phases of the Moon are about two weeks apart.

Communication

24. Students' tables should include information from pages 294 and 295 of the student textbook. Their brochures should address some of the challenges and benefits of visiting some of the planets.

25. Astronomers can study asteroids and comets, which are found in the Kuiper Belt and the Oort Cloud, to understand the solar system because these objects are very old and can explain how the solar system formed.

26. Students' answers will vary, but they should mention the cost ($12 million); the valuable recognition for Canada; the potential for future discoveries and technological development; and the safety benefits.

27. Students' diagrams should show that a celestial object, such as a planet, rotates on its own axis but revolves around another celestial object. Their diagrams may be similar to Figure 7.15, on page 283.

28. Earth rotates so everything rises and sets; and as Earth orbits the Sun, different constellations become visible at different times of the year.

29. Earth experiences seasons because of the tilt of Earth's axis. When the northern hemisphere is tilted toward the Sun, that hemisphere experiences summer. Sunshine hits the northern hemisphere at a higher angle so there is more energy per square area. The opposite is true when the northern hemisphere points away from the Sun. At that time, the northern hemisphere experiences winter. Students' diagrams should be similar to Figure 7.16, on page 284.

Application

30. The halo that appears around the Moon is actually caused by ice crystals in Earth's atmosphere.

31. **a.** find circumference: $C = 2\pi r$ = 942 477 796 km; divide by time = 31.4 km/s
    b. The object would appear to be approaching at 2×31.4 km/s = 62.8 km/s.
    c. 400 000 km ÷ 62.8 km/s = 6369.4 s = 106 min = 1 h 46 min

Chapter 8 Exploring Our Stellar Neighbourhood

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-35 for a summary of the materials required in this chapter and other chapters.

Advance Preparation

- Read newspapers and watch other sources for stories about space exploration (for example, the International Space Station, satellite launches). Gather recent news clippings about space exploration, and post them for students to read. Encourage students to bring in items that they find.
- Determine when the International Space Station will make a visible pass in the evening. Observe the pass as a class, or give students the information they will need to observe it at home.
- Have students talk to their parents and grandparents about space exploration and what they remember from the early missions to the Moon.
- Students can review the Key Terms in Chapter 8 using **BLM 8-1 Chapter 8 Key Terms.**

In this chapter, students will learn how we have explored the universe from Earth's surface with different types of telescopes, why we have explored the solar system with uncrewed space probes, and why Canadian astronauts have travelled into space in the American Space Shuttle. Students will be asked to consider the costs, risks, and ethics of space exploration. The origins of stars and the solar system will also be examined.

Using the Chapter Opener (Student textbook pages 314 and 315)

- The image of an astronaut driving a car on the Moon may cause students to ask about when humans will travel to the Moon again. Discuss with students what they know about the space program and the challenges of going into space.
- Ask students what part of space they might be interested in exploring. What would they like to learn? What would they need in order to travel there?

Activity 8-1 Preparing for a Trip to the Moon (Student textbook page 315)

Pedagogical Purpose

This activity will get students thinking about spaceflight and the challenges involved in making a safe and successful trip to the Moon.

Planning	
Materials	Large sheets of paper (11 × 17) Markers
Time	20–40 min for each group to plan 10 min to discuss the questions

Background

Several nations are considering returning to the Moon. Unlike the Apollo missions of the 1960s, the astronauts on these new missions will stay for weeks, not days. Ultimately, a lunar base may be permanently crewed, like the International Space Station is.

Living for weeks or months on the Moon requires planning. It is critical that the astronauts are kept safe and that the essentials to sustain life are made available. The crew will have to handle unexpected problems, since (in this activity) it will take three days before they can return to Earth. Carrying 1 kg from Earth to the Moon is very expensive, so there will be weight restrictions and the crew size will be limited.

It is possible that some resources may be found on the Moon's surface. Visit **www.scienceontario.ca** to find websites that students can use to learn more about conditions on the Moon.

Activity Notes and Troubleshooting

- Discuss different presentation formats with the class. Encourage students to try something new to display their group's plans and to present them to the class. Also encourage students to discuss their ideas before beginning to record.

Additional Support

- ELL English language learners should be in groups with students who have strong language skills. English language learners will be able to contribute ideas and may be interested in drawing or designing the presentation. They should also be given ample time to practise prior to presenting any information orally.
- DI This activity will provide opportunities for students with spatial, interpersonal, and logical-mathematical intelligences to use their skills. Try to distribute students with these learning styles among all the groups.

Answers

1. For example technological problems:
   - food and water: Can you grow food on the Moon, extract water from the natural resources, or find water at the lunar poles? Otherwise, food and water have to come from Earth. Water will be recycled (humidity in the air, personal exhalation, urine—this is currently being done on the International Space Station).
   - oxygen: Oxygen can be obtained from water if water ice is found on the Moon. It can possibly be found and extracted from rocks, but otherwise it has to come from Earth.
   - radiation: The Moon has no magnetic field to protect the lunar inhabitants. Solar storms can unleash deadly radiation.
   - two-week days and two-week nights: How will the expedition store energy during the day (solar energy) and use it during the long cold night?
   - safety, medical issues: How would the crew handle a heart attack or burst appendix? A doctor (or doctors) will need to be part of the crew.
   - activity: What would you do there? For geologic research and astronomy, scientists will need to be part of the crew.
   - maintenance: The crew will need to include engineers and people who are able repair the base and the machinery, and spare parts will need to be available.
   - supply shuttles from Earth: Crew members may need automatic robotic shuttles to ferry supplies to the lunar base.
2. Possible answer: Yes, there should be a limit to how many people can live on the lunar base at one time. There are limited resources (air, food, water, space) so people will have to have multiple skill sets and fill multiple roles.
3. Families present several problems, including limited resources and risks to children. It will not be a place for vacationers or sight seers. It is very expensive to send one person to the Moon, so the cost of sending a family would be quite high.

Study Toolkit		
Strategy	**Page Reference**	**Additional Support**
Making Study Notes	As well as the pages suggested in the student textbook, have students read Studying Objects in Different Wavelengths on page 322. They can then arrange their notes about the main idea and supporting details in a T-chart.	Some students may wish to make study notes using a main idea web. They can find out more about this type of graphic organizer in Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on student textbook page 566. To help English language learners practise this skill, make sentence strips stating main ideas and details, and have students organize them in a T-chart.
Interpreting Diagrams	As well as interpreting the telescope diagram on page 316, have students interpret Figure 8.5 (page 320); 8.20 (page 336), as suggested in the student textbook; and 8.28 (page 345).	
Compound Words	Have students identify the two smaller words that make up the compound word *sunspot* before they look at the text on page 337, and use the meanings of these two smaller words to figure out the meaning of sunspot. Remind students to be sure that their definition of sunspot makes sense in a scientific context, and then to check against the definition on page 337 of the student textbook.	Tell English language learners that you can find the meanings of many English words if you know the meaning of their parts. Have them keep a list of other compound words and their meanings that they encounter in this chapter, for example, humankind, spacecraft, and starlight.

Section 8.1 Exploring Space (Student textbook pages 317 to 332)

Specific Expectations

- **D1.1** assess, on the basis of research, and report on the contributions of Canadian governments, organizations, businesses, and/or individuals to space technology, research, and/or exploration
- **D1.2** assess some of the costs, hazards, and benefits of space exploration, taking into account the benefits of technologies that were developed for the space program but that can be used to address environmental and other practical challenges on Earth

In this section, students will look at how we have explored space by using telescopes, using unpiloted satellites and space probes, and, finally, sending men and women into space.

Common Misconceptions

- **Students may think that astronomers spend most of their time looking through telescopes.** Explain to students that astronomers use sensitive detectors to measure the light being collected and spend much of their time analyzing the patterns in those data.
- **Students may say, "There is no gravity in space."** This statement is not true—gravity keeps the planets in orbit around the Sun, and the Moon and space station in orbit around Earth. Astronauts appear to be "weightless" because the space station, while in orbit about Earth, is in fact falling around Earth. As the space station falls to Earth due to gravity, its horizontal speed (8 km/s) prevents it from hitting Earth, resulting in a curved trajectory.
- **Students may think that the space shuttle goes to the Moon;** however, it does not. Humans have not travelled to the Moon since 1972.
- **Students may assume that humans have known for a long time what the Sun and planets in our solar system look like.** In fact, each of these celestial bodies has been explored using probes only in recent years, within students' lifetimes. In the case of the Moon, it is possible that there will be people living on its surface within this textbook's lifetime.
- **Many students presume that technology exists because they have seen it in popular media, so they will equate space travel with the ease of commuter air travel.** In fact, long preparation and training, and sophisticated equipment, are needed for space travel. Students acquire some appreciation of the preparations involved by carrying out Activity 8-1, on page 315 of the student textbook, and by reading section 8.1.

Background Knowledge

Our ability to explore and investigate space has been greatly aided by the development of better tools. Space technology is progressing at an amazing rate, enabling us and our instruments to travel farther and farther from Earth. In 1961, the first human was sent into space (followed since then by more than 400 people). In the years following, a permanent laboratory has been established in space, and robotic probes have landed on the Moon, Venus, Mars, an asteroid, and a moon of Saturn.

Sending probes to the planets is much cheaper and safer than sending humans. These robots can take pictures and send them back digitally. Orbiters can map the surface and determine the components of the atmosphere. Landers and rovers can explore the surface of a planet like Mars for months, receiving instructions from Earth and exploring interesting-looking rocks. Instruments on the rovers can actually determine the components of a rock and return the data to Earth via radio.

Sophisticated telescopes have enabled us to see close-up images of every planet, and the Hubble Space Telescope has sent back images that reveal the most distant regions of the universe. In the future, some students may have the opportunity to fly into space just for fun.

The International Space Station is visible in the sky from time to time—just as it gets dark after sunset. Visit **www.scienceontario.ca** to find out when it will be visible from your area. If the space station is visible in the morning when you look, wait four to six weeks and it will be visible in the evening.

Astronomers use several different types of telescopes to study the same galaxy, star cluster, or nebula. Each telescope has its own purpose. By using telescopes that can "see" in different wavelengths, scientists get a better idea about the components of the object they are studying. The frequency of light emitted from an object can tell the astronomers if the object is hot or cold and if tremendous energies are being generated. Telescopes that use radio or infrared frequencies of light can see through the dust in between the stars, revealing things we cannot see with optical telescopes. Telescopes in Earth orbit can detect radiation that never reaches Earth because it is blocked by Earth's atmosphere.

Reflecting telescopes that collect visible light must be made from highly polished, smooth, reflective mirrors. The wavelength of light is very small (400 to 700 nanometres), so any bumps in the mirror must be much smaller than the light wavelength so that the mirror will reflect properly. Since radio waves are much longer, a simple metal mesh structure is sufficient to reflect the longer waves in a radio telescope.

Literacy Support

Using the Text

Before Reading

- Have students connect their prior knowledge with the three main parts of this section: telescopes; probes, landers, and satellites; and human space exploration. Have them predict some advantages and disadvantages of each space exploration method.

During Reading

- ELL There is a lot of reading in this section. Read the first subsection aloud and model how to identify words and phrases that a reader may not understand and what he or she might do to understand them. Have English language learners do the same with other subsections, using sticky notes to mark words and phrases that they do not understand, and work in pairs to consult glossaries, dictionaries, other students, and you to find their meanings.
- Have students monitor comprehension by answering the Learning Check questions on pages 322 and 327. The last questions in each set require students to use inference. They can learn more about making inferences by using **BLM G-4 Making Observations and Inferences.** If necessary, refer students to Study Toolkit 2, Reading Effectively: Monitoring Comprehension, on student textbook page 564.

After Reading

- Have students make study notes by recording the main idea and supporting details of each subsection in a table or a main idea web, as shown on page 316.
- Students can summarize what they have learned about technologies for exploring space on **BLM 8-3 Advantages and Disadvantages of Space Exploration,** or on **BLM 8-4 Advantages and Disadvantages of Space Exploration (Alternative Format).**

Using the Images

- Figure 8.7, on page 322, shows the planet Saturn photographed in different wavelengths. Have students observe each image carefully and describe the differences. Then have them read the paragraph about what each view of Saturn shows.
- Figures 8.11 and 8.12, on page 325, show different ways that satellite technology helps us. Discuss other ways in students' own lives in which satellite technology plays a role. Some examples may include watching television, making phone calls to other countries, and watching weather reports.
- Discuss the two images in Figure 8.13, on page 326. Have students provide examples of other ways that satellite photography of Earth can help scientists. (If necessary, suggest these areas of study: crops, deforestation, natural resources, and lake water levels.)

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Discussion/Learning Check questions, page 322	Students answer the questions, explaining the distinctive characteristics and contributions of different types of telescopes.	Provide students with a table or Venn Diagram to use to compare types of telescopes. Consider filling in some data to give students a starting point to which they can compare other data. See **BLM G-39 Venn Diagram.**
Discussion/Learning Check questions, page 327 Section 8.1 Review questions, page 332	Students • compare the purposes of different types of satellites • describe the advantages and disadvantages of landers, orbiters, and human exploration of space	Allow students to answer orally, or to look through the textbook to find information that helps them develop each answer. Suggest that students use a graphic organizer, for example a T-chart, for their answers to Learning Check questions 5 and 7, and Review question 2.
BLM 8-2 Reflecting and Refracting Telescopes	Students accurately label parts and light paths in both telescopes.	Have students trace the light path on Figure 8.3, on page 319, as they name the parts of the telescope with which the light comes into contact.

Instructional Strategies

- Before students open the textbook, ask them what tools doctors have available to learn about the human body (balances, metre sticks, microscopes, magnifiers, X rays, ultrasounds, thermometers). Point out that astronomers have a similar array of tools at their disposal, and they choose the tool that is best suited to the observations they want to make.
- This is a long section. Consider breaking up the reading into three subsections (telescopes, orbiters and landers, and human exploration) and discussing what students have read after each subsection, including surprises and confusions.
- Set up small refracting and reflecting telescopes in the classroom for students to examine to help them visualize the light path and understand how a telescope works. Use the telescopes to observe distant objects outside the classroom window.
- DI Students may need help understanding the difference in wavelength between long and short frequencies. You can give students a length of string and work with them to model the longest wavelengths. Challenge logical-mathematical thinkers to calculate how many gamma-ray wavelengths there would be in 1 mm, and to report to the class (Answer: at least 10 million).
- ELL If English language learners need support to write in paragraph format, supply them with sentence starters for some of the Learning Check questions. For example, for question 7 on page 327, you could write, "An advantage of using ________________ is ________________."
- ELL Some of the questions in Table 8.3, Issues Related to Space Exploration, on page 331, are quite abstract and far from students' own experiences. Take the time to talk about these issues with English language learners. Word each one as simply as possible and ensure that they understand why each question is important to consider.
- Making a Difference, on student textbook page 328, provides some background information about Roberta Bondar. Her studies and career provide students with an example of how much work can be involved in fulfilling a dream, and also of how rewarding the work can be.
- The Case Study on student textbook pages 330 and 331 provides an opportunity to learn more about one of the negative effects of space exploration and the serious consequences it can have.

- Enrichment—Some students might be interested in learning more about a Canadian contribution to space exploration technology and preparing a display or presentation about it for the class. They can use **BLM 8-5 Canadian Contributions to Space Exploration,** to organize their research.
- Astronauts fascinate students. Some students may want to write up a biography of a favourite astronaut or research what skills and education a potential astronaut must have.
- There are other Canadian companies involved with space research and technology: Optech Incorporated; Dynacon; COM DEV International Ltd.; Neptec Design Group; MacDonald, Dettwiler and Associates Ltd. (MDA), for example. All these companies have websites that students can use to research the companies' development of space research and technology.

Activity 8-2 An Astronomer's View (Student textbook page 318)

Pedagogical Purpose

This activity will show students the problems that astronomers have when using telescopes to observe objects in the night sky, and help them understand the need for additional tools to make further observations.

Planning	
Materials	Piece of plastic wrap, about 15 cm long
Time	15 min to take the observations and answer questions

Background

Astronomers have always had to endure the effects of the atmosphere when using ground-based telescopes. The moving air tends to distort the view. Astronomers have built larger and larger telescopes to see more clearly.

There is a limit to the size of a telescope that we can build. Telescopes with mirrors greater than 5 m sag under their own weight, making them useless. The largest telescopes today are built of multiple small mirrors to create one 10 m mirror. Telescopes larger than this are very expensive and are limited by the turbulent atmosphere anyhow—a 15 m telescope will not see much better than a 10 m telescope. Recently, astronomers developed a technique called adaptive optics to adjust the mirrors to remove the effect of this distortion. Telescopes as large as 30 m are planned to be built, using this technique.

When the space program started, and satellites were being sent into space, astronomers started to plan to send telescopes into Earth orbit, above all the air. Although this height would give the telescopes an undistorted view of the surroundings, it introduced other problems. Since the telescope would be floating instead of firmly planted on the ground, how would astronomers point the floating telescope at the object they wished to observe? How would they keep it pointing in that direction? How would they send the results of the observation to the ground?

The result of this planning was the Large Space Telescope, conceived and designed in the 1970s, built in the 1980s, and launched in 1990. It was renamed the Hubble Space Telescope after American astronomer Edwin Hubble. It has vastly improved what we can see, because it observes from outside of Earth's atmosphere. Other orbiting telescopes have followed.

Activity Notes and Troubleshooting

- Students could fold their plastic wrap, and combine their folded wrap with other groups' to check their predictions in question 2.
- Students could also investigate the following question:

How does distance affect the clarity of the text you observe with plastic sheets in front of your eyes?

Additional Support

- Students with vision difficulties could work with a partner to achieve reasonable team results.
- ELL This is a simple activity to demonstrate before students complete it. A quick demonstration of what to do will help English language learners participate fully.
- Enrichment—Challenge students to find out why Earth's atmosphere distorts light rays and to report back to the class. Astronauts use a technique called adaptive optics to correct this distortion. Students could also find out how this technique works and report back.

Answers

1. Looking through the plastic wrap gives a distorted view, similar to the view an astronomer gets when looking through the atmosphere.
2. Answers will vary, but will probably be close to four or five times.
3. The more layers of plastic wrap there are, the closer you have to be to the text to read it.

Learning Check Answers (Student textbook page 322)

1. Travelling in space requires travelling for long times, which requires enough food and air, and enduring a harsh environment (vacuum, radiation, extreme cold).
2. Space telescopes are placed above Earth's atmosphere so they can detect parts of the electromagnetic spectrum that do not reach Earth's surface. These telescopes are expensive and difficult to service. Earth-based telescopes are limited to the parts of the electromagnetic spectrum that reach Earth's surface: mostly visible light and radio waves.
3. Studying objects in different types of radiation provides more varied information about the objects.
4. Neil Armstrong physically took one small step on the Moon. The act of getting to the Moon was a huge accomplishment for humans.

Learning Check Answers (Student textbook page 327)

5. Remote-sensing satellites are usually less than 700 km above Earth's surface and are used to monitor Earth. GPS satellites are 20 200 km above Earth's surface and are used for search and rescue, and mapping. Geosynchronous satellites are 35 800 km above Earth and are used to broadcast television and satellite radio.
6. planetary orbiters, landers, telescopes
7. A lander can sample the surface as well as the local atmosphere but it cannot move around, while an orbiter can study the entire planet and atmosphere by orbiting around it. If calculations are not exact, the orbiter will not orbit the planet, and will be useless.

8. Students' answers will vary. Some students may feel that the investment was worth it because if humans will be exploring Mars, then we have to understand the planet as much as possible in order to live there. Also, understanding the weather on Mars might help us to understand more about the solar system. Some students may feel that the investment was not worth it because of the huge amount of money spent just to get the weather from Mars. They may feel that there must be other ways of studying the weather on Mars that are less expensive.

Section 8.1 Review Answers (Student textbook page 332)

Please see also **BLM 8-6 Section 8.1 Review (Alternative Format).**

1. Objects in space are very far away so it would take a very long time to get there, and astronomers can gather different types of information using different portions of the electromagnetic spectrum from telescopes in space.
2. Advantages: Robots and satellites can survive in environments that humans cannot live in. Robots and satellites do not require the environmental conditions and food that humans must have. Sending robots and satellites into space is also less expensive than sending humans. If something happens to the robots and satellites while in space, the loss is not as great as it would be for humans. Disadvantages: Satellites contribute to space junk, and they are difficult to service.
3. human safety; space junk; the risk that a spacecraft may not make it to its destination; the spacecraft itself could be lost
4. **a.** Canadarm, Canadarm2, Dextre, MOST, contributions to ENVISAT
   b. Chris Hadfield, Julie Payette, Robert Thirsk, Steve MacLean, Roberta Bondar, Marc Garneau, Bjarni Tryggvason, Dave Williams
5. Canadian companies have participated in the funding, design, and construction of the ENVISAT satellite, which is used for remote sensing. ENVISAT monitors changes in Earth's surface features, such as ice shelves and heights of land features. The MOST satellite is another Canadian contribution. MOST stands for Microvariability and Oscillations of STars and is Canada's first space telescope. It is used to study stars that are similar to the Sun.
6. The image is showing a number of fires and which way the wind is blowing. This satellite image will help firefighters assess the damage; and know how big the fires are, how many there are, where exactly they are, and how they are spreading. This information will help firefighters track the fires so they can put them out and/or control them.
7. The word *geostationary* suggests that the satellites are not moving; however, the satellites are moving. They just appear to be stationary because of the combined rotation of Earth and the orbital motion of the satellite.
8. There is a very thin atmosphere on Mars, so all the radiation would reach Mars's surface. A space suit would have to protect the astronaut from all forms of electromagnetic radiation.
9. Students' answers will vary; for example, students might feel that it is difficult to answer the question of whether humans have the right to explore other environments around the solar system because humans do not own this area, although no one else owns it either. Ensure students include explanations in their answers.

Section 8.2 Exploring the Sun (Student textbook pages 333 to 340)

Specific Expectations

- **D3.2** describe observational and theoretical evidence relating to the formation of the solar system
- **D3.4** describe the Sun's composition and energy source, and explain how its energy warms Earth and supports life on the planet

In this section, students will learn about the closest star to Earth, the Sun. The components and features of the Sun will be explored as well as its effect on Earth. The evidence that supports current theories about the formation of the solar system and the Sun some five billion years ago will also be presented.

Common Misconceptions

- **Students may have heard that "The Sun is an average star."** This statement is not true; the majority of stars are smaller, less massive, and fainter than the Sun.
- **Students may infer that the Sun is made of gas and does not have a solid surface.** It is difficult to imagine what the surface of the Sun is like. It is so different to what we are used to on Earth.
- **Students may not understand the extremely violent reaction that occurs when the Sun converts hydrogen into helium.** They are more familiar with a fuel being burned. Point out that the combustion reactions we see on Earth, like fuel burning in a car, break molecules apart, and reorganize the atoms that are in a molecule into different molecules. This chemical reaction releases energy, but the atoms themselves do not change. They still have the same number of protons and neutrons that they had originally. The nucleus of an atom is held together very tightly. In a nuclear fusion reaction, like hydrogen being converted to helium, the nuclei of individual atoms are fused together to make larger atoms. For this to happen, tremendous amounts of pressure and heat are required—the amounts found in the centre of stars. This reaction creates almost unimaginable amounts of energy, and is the main reaction that occurs on the Sun.

Background Knowledge

The solar system formation theory (solar nebula theory) has been supported by pictures taken with the Hubble Space Telescope. Solar discs and protostars have been photographed in nebulae such as the Great Nebula in Orion.

In just the past few years, over 300 planets outside of our own solar system have been detected. These are all the size of Neptune or larger. A spacecraft called *Kepler* was launched in 2009 to search for Earth-sized planets orbiting other stars. The *Kepler* spacecraft is a large telescope in space that will constantly watch over 100 000 stars, looking for evidence that planets have passed between Earth and the stars. The spacecraft should be able to detect planets that are Earth-sized or larger.

The Sun is a very active celestial body, with magnetic storms, flares, sunspots, and coronal mass ejections in which the Sun spews off great amounts of charged particles from its corona. These ejections can result in great aurora displays if the particles collide with Earth. There are many websites that students can use to monitor the Sun's activity as well as the effects it has on Earth, for example, auroral displays and radio outages.

Although activity on the Sun varies from year to year, the Sun is undergoing a rare period of inactivity (2008 to early 2009) which may be unprecedented for the past 100+ years. The Sun has been empty of sunspots since early 2008 and may remain this way for several years. Scientists do not completely understand why this is happening.

Literacy Support

Using the Text

Before Reading

- Invite students to share what they already know about the Sun and the origin of the solar system, and to ask questions to which they would like to find the answers.

* ELL Introduce new vocabulary in the section by writing the Key Terms on the chalkboard. Have students use what they know about compound words and the definitions in the student textbook to state the meaning of each Key Term in their own words. Write the definitions on which they agree on the board, and have students refer to these definitions as they read.

During Reading

* Allow students to read the text silently, writing a brief summary of each of the subsections. Have them write answers to each question that they posed before reading, if possible.

After Reading

* Have students create a flowchart to show the events in the formation of the Sun and the solar system. They could create the flowchart on poster paper as a group, and display it in the classroom. Students can review flowcharts in Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on page 566 of the student textbook. See also **BLM G-35 Flowchart.**
* Students can summarize what they have learned about the features of the Sun on **BLM 8-7 The Features of the Sun.**

Using the Images

* Before reading the text, have students scan Figures 8.18 to 8.23, on pages 334 to 339, reading only the captions, to predict what they will learn in this section. Have students write one or two sentences to summarize what they learned in each figure. By sharing with the class, students will model for others the process of interpreting and learning from a diagram.
* ELL To introduce and reinforce material presented visually, project it for the class, and use a pointer and gestures to focus students' attention on important aspects of the illustration. Encourage students to come forward and use the projected version to ask and respond to questions.
* Looking at Figure 8.22B, on page 338, ask students to relate any experiences they have had observing the northern lights (aurora borealis).
* Have students refer to Figure 8.23, on page 339, and comment on the importance of the Sun and its effects on Earth.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Discussion/Learning Check questions, pages 336 and 338	Students • name and describe the process that fuels the Sun • explain the solar nebula theory and the evidence that supports it • describe features of the Sun	With a partner, have students look through this section of their textbook, looking for information that they can use in their answers. Encourage English language learners to use labelled diagrams as much as possible in their answers.
Discussion/Section 8.2 Review questions, page 340	Students describe the effects of the Sun on Earth, including the radiation that is absorbed and reflected, the effects of solar flares, and the reasons why energy from the Sun is important.	Provide a pie chart divided into five tenths, three tenths, and two tenths for students to label. Provide a drawing like Figure 8.23, on page 339, for students to label.
BLM 8-7 The Features of the Sun	Students label the parts of the Sun.	Provide label names for students to choose from.

Instructional Strategies

- Begin by showing students a plastic bottle of water with some sand in it. Walk around the room so that students can see that when you shake the bottle, the sand makes a cloud in the water. Then swirl the bottle gently and let everyone see how the sand circulates (or orbits) around the centre. You could pass the bottle around for students to manipulate and observe. Ask students to describe what they observe
  1. when the bottle is still;
  2. when the bottle is swirled.

  Explain that scientists believe spinning like this was a major factor in the formation of the solar system.
- Have students read the section, using before-, during-, and after-reading strategies as outlined above.
- There are some dramatic photographs of solar activity on the Internet. Assemble a slide show to show the class. See **www.scienceontario.ca** for some examples. Better yet, ask an interested student to assemble a slide show and present it.

Learning Check Answers (Student textbook page 336)

1. **a.** It is called the solar nebula theory because the star forms from a nebula, which is a cloud of dust and gas.
2. Cratered surfaces of the planets are evidence of the collisions among dust and rocky materials. The planets are more or less in the same plane. All the planets revolve around the Sun in the same direction, and most planets rotate in the same direction. There are also flattening dust clouds around young stars that are beyond our solar system. (Planets are a by-product of star formation.)
3. A protostar is the young, hot, condensed object at the centre of a star-forming nebula.
4. The process that fuels the Sun is called nuclear fusion. During nuclear fusion, hydrogen atoms combine to form helium atoms.

Learning Check Answers (Student textbook page 338)

5. The Sun is composed of hydrogen and helium. There is a higher proportion of hydrogen than helium.
6. A solar flare is an event in which magnetic fields explosively eject intense streams of charged particles into space. The solar wind is one of these streams.
7. The temperature of the surface of the Sun is not the same as the temperature of sunspots. The photosphere is about 6000°C, and sunspots are about 4500°C. The contrast in temperature makes the sunspots look dark.
8. Possible answer: Yes, I would be concerned. Solar storms can eject huge amounts of charged particles into space, which can disrupt electronics aboard spacecraft. I might be stranded in space. The radiation from a solar storm can also be harmful to astronauts.

Section 8.2 Review Answers (Student textbook page 340)

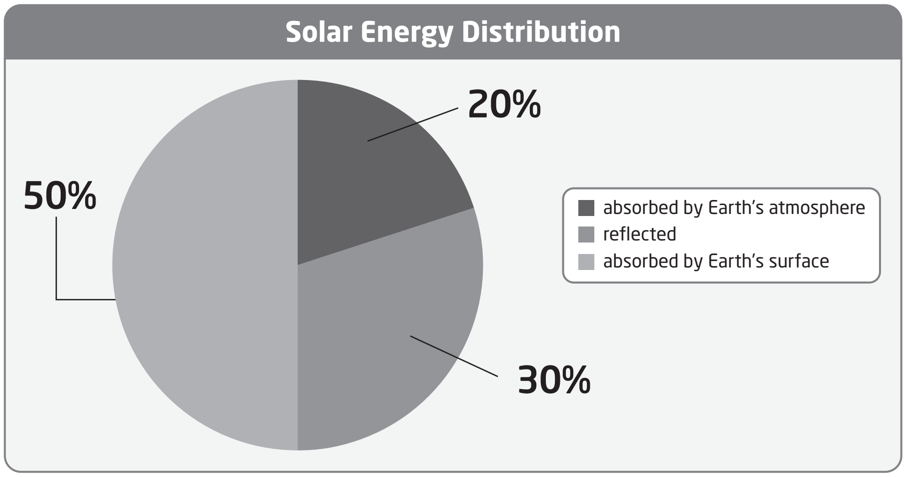
Please see also **BLM 8-8 Section 8.2 Review (Alternative Format).**

1. Students' drawings should be similar to Figure 8.18, on page 334.
2. microwaves, radio waves, light waves, X rays, gamma rays, infrared, ultraviolet, (that is, all forms of electromagnetic radiation)
3. The hydrogen portion will get smaller, and the helium portion will get larger.

4. The Sun's energy drives wind and ocean currents, is responsible for photosynthesis, drives weather systems, and provides light and heat.

5. An example of the Sun's energy interacting with Earth's atmosphere is the aurora borealis or the aurora australis.

6.



7. About 50 percent of the incoming solar energy is absorbed by Earth's surface. While absorbing the solar energy, Earth's surface also emits infrared radiation to the atmosphere. In turn, the atmosphere emits radiation back to Earth. The reflection and absorption of energy heats Earth's surface and keeps it warm.

8. Solar flares can interfere with telecommunications, damage electronic equipment on spacecraft, cause substantial power blackouts, and emit harmful radiation to astronauts. They can, however, also produce beautiful auroras.

9. 2012 or 2013

Section 8.3 Exploring Other Stars (Student textbook pages 341 to 349)

Specific Expectations

- **D3.3** describe the major components of the solar system and the universe using appropriate scientific terminology and units

In this section, students will learn about stars: the composition and mass of stars, their brightness, how they live out their lives, and how they eventually die.

Common Misconceptions

- **Students may believe that stars are all the same size.** However, stars are of different mass, different temperature, and different size. Some stars are much brighter than our Sun. The star Rigel in the constellation Orion, at a distance of 775 light-years from Earth, is 17 times more massive than our Sun and is 40 000 times brighter.
- **Students may think that stars have always been around and always will be.** Stars do not live forever. They use hydrogen as a fuel to create heat and light. The hydrogen is converted into helium in a process called fusion. When the fuel is used up, the star will die.
- **Students may have heard, seen, or read in science fiction that you can travel through a black hole to another universe, to a different dimension, or to a different time.** A black hole is what is left over from a star after it has undergone a supernova explosion. It is an extremely dense object and is not likely an entrance to a wormhole or a door to another place or time.

Background Knowledge

Stars are born, they live, and then they die. They are different sizes, different temperatures, and therefore, they differ in colour. A star's life depends on its mass. Stars that are more massive than our Sun are very hot—white or blue in colour—and burn up their hydrogen quickly, perhaps in a few hundred million years. They can end their lives in a massive explosion like a nova or supernova. Stars like our Sun burn the hydrogen more slowly and can last 10 billion years. Ultimately the hydrogen will be used up and the Sun will enter the red giant stage, swelling until it is larger than the orbits of Mercury, Venus, and Earth. It will not explode but will ultimately cool and shrink to become a white dwarf.

More than 50 percent of all stars are in a double or multiple star system. In this type of system, two or more stars are in orbit about each other.

Literacy Support

Using the Text

- ELL The list of Key Terms looks long, but it can be divided into three parts. Before reading, preview the meanings of the first four words with English language learners to help them understand pages 341 and 342. Preview the next two terms while viewing Figure 8.26, on page 343. Tell students that the final three terms are types of stars, and challenge them to find their definitions as they read about the evolution of stars on pages 394 to 397. Reinforce Key Terms by allowing students to participate in "What Am I?" activities. One student chooses a Key Term and offers one clue at a time until a classmate guesses which Key Term it is. For example, "I am made of gas. Neither stars nor planets could exist without me."

Before Reading

- Have students examine Figure 8.28, on page 345, showing the life cycle of stars of different masses. Ask students to relate what they already know and what they see in this diagram to predict some characteristics of the different stars. Invite a volunteer to trace a life cycle of one type of star with their finger, and describe to the class how the star changes. Referring to Figure 8.26, on page 343, students should be able to make predictions about the stars' temperature and luminosity. Have them compare the life cycles of the different stars. As they read the section, they can confirm or revise these predictions.

During Reading

- Students can summarize each subsection, stating the main idea and a few important supporting details about brightness, colour, luminosity, temperature, mass, and life cycle.

After Reading

- Have students complete a flowchart describing the lives of low-, intermediate-, and high-mass stars. Students should include information about each step of the flowchart based on the summaries they prepared. If you wish, distribute copies of **BLM G-35 Flowchart.**

Using the Images

- Have students look at the H-R diagram in Figure 8.26, on page 343. Students can work in groups and categorize the different stars by size, temperature, luminosity, and colour. What patterns can they detect? Ask, "Are all large stars hot?", "Are high-mass stars cool?" Have groups share with the class the patterns they found, and invite other groups to add to, or suggest changes to, the descriptions of the pattern.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Discussion/Learning Check questions, pages 342 and 347	Students describe the four properties of stars and the life cycles of stars including our Sun.	Have students look back at the section in the textbook with a partner and find information to help them complete a T-chart showing the name of each property of stars, and a description of each property. They can also create a flowchart showing the life cycle of our Sun in the same way. See **BLM G-38 T-chart,** and **BLM G-35 Flowchart.**
Discussion/Section 8.3 Review questions, page 349	Students describe how the H-R diagram is used to predict star properties and the different life cycles of low-, intermediate-, and high-mass stars.	Name a type of star, and ask students to tell you, orally, what the H-R diagram tells us about that type. Have students review the material in the textbook and create flowcharts for each type of star's life cycle.

Instructional Strategies

- Invite students to speculate about what conditions on Earth would be different if our Sun were larger, brighter, closer, or heavier than it is. Point out that stars vary in all these ways.
- Read the section with the class. Stop after each subsection to discuss what students learned, what they found surprising, and any questions they have.
- Inquiry Investigation 8-B, Using Spectral Analysis to Identify Star Composition (on pages 352 and 353), gives students the opportunity to analyze the spectra of our own Sun and three other stars, to determine their composition.
- Data Analysis Investigation 8-C, Building an H-R Diagram (on page 354), allows students to investigate patterns in stars' spectral types and absolute magnitudes.
- DI Bodily-kinesthetic learners could build a model showing the stages of a star's life cycle.
- Some students may be confused by the idea that some things can be both small and heavy. Bring in a small piece of iron or lead and a large piece of plastic foam to demonstrate that small objects are not always lighter than large ones.
- ELL As a summary activity, have teams of students write a factual statement from this chapter on index cards, one word per card, and then place the cards face down in order. Another team will attempt to guess the sentence by flipping one card over at a time. Teams earn the right to flip over one card by correctly answering a question posed by you or a student.

Learning Check Answers (Student textbook page 342)

1. Luminosity is the measure of a star's energy output per second.
2. No, a star's brightness also depends on its luminosity. A bright star is not necessarily closer to Earth; it could just be large and more luminous.
3. Four properties of stars are brightness, colour, temperature, and composition.
4. By looking at a star's spectrum, you can learn what its photosphere is made of.

Learning Check Answers (Student textbook page 347)

5. In about 5 billion years, the Sun will become a red giant, then collapse to become a white dwarf.
6. No, stars have to be more than 12 times the mass of the Sun before they can become a supernova.
7. A neutron star is an extremely dense star that is made only of neutrons.
8. Possible answer: I am made of stardust. Heavier elements released through supernova explosions are ejected throughout the universe, eventually showing up in stars, planets, and other bodies, including humans.

Section 8.3 Review Answers (Student textbook page 349)

Please see also **BLM 8-9 Section 8.3 Review (Alternative Format).**

1. The star is yellow-white in colour.
2. The H-R diagram is a graphical comparison of many stellar properties by star type.
3. B. nebula; A. star; C. red giant; D. white dwarf
4. The heavy elements come from supernovae; only more massive stars become supernovae.
5. Students' stories will vary. Ensure they accurately describe features of the star at different stages of its life cycle as they tell their story.
6.

Star	Colour	Approximate Surface Temperature (°C)	Bright or Dim
Aldebaran	red	3 300	bright
Arcturus	orange	4 700	bright
Betelgeuse	red	3 300	bright
Polaris	yellow-white	7 500	bright
Proxima Centauri	red	3 300	dim
Rigel	blue-white	21 000	bright
Sirius	white	10 000	bright

7. Students might mention the Canadian astronomer Ian Shelton who discovered a supernova in 1987. Studying supernovae helps us understand the lives and deaths of stars, which is important because the Sun is a star. We should understand the Sun because we depend on it for life. Students might also mention Canadian astronomer Tom Bolton who identified the first black hole, called Cygnus X-1. Black holes were theoretical until this discovery. Because of this discovery, astronomers now know that black holes are everywhere.
8. They were probably observing the sky regularly and knew the star patterns. When the supernova happened, it must have seemed like there was a new star all of a sudden. But over time the bright supernova went away, just like a guest would.

Plan Your Own Investigation 8-A The Brightness of Stars

(Student textbook pages 350 and 351)

Pedagogical Purpose

In this activity, students will study the relationship between brightness of a light source, such as a star, and its distance from Earth.

Planning	
Materials	Six 1.5 V C or D battery cells, set up with one, then two, and then three in series (that is, 1.5 V, 3.0 V, and 4.5 V); see the illustration on page 350 of the student textbook 6 hook-up wires with clips three 5 V (4.8 V) incandescent flashlight bulbs 3 base sockets for bulbs 3 battery holders Sufficient connecting wires with connecting clips for 3 lamps Metric tape measure **BLM 8-10 Plan Your Own Investigation 8-A The Brightness of Stars** (optional) **BLM G-23 Data Table** (optional) **BLM A-27 Plan Your Own Investigation Rubric** (optional)
Time	15 min to plan and set up the display 20 min to collect and record data and answer the questions
Safety	Caution students against short circuiting the batteries. Short circuiting them will make them hot and shorten their lifespan. Use only incandescent bulbs. Ensure students do not exceed 4.5 V when hooking up the bulbs. If students perform this investigation in a dark room, remind them to work carefully so that they do not knock bulbs or other equipment off tables.

Background

The apparent brightness of a star depends on its luminosity and its distance from the observer. Just because one star appears brighter than another does not mean it is brighter; it may be dimmer but a lot closer.

Activity Notes and Troubleshooting

- The brightness of each light with respect to the other will be qualitative. Students will not be able to measure the differences in brightness.
- Students may find it easier just to tape the wires to the batteries instead of using clips.
- Approve each group's predictions and plan before students begin to build their display. Ensure that all group members understand and agree with the plan.
- The Analyze and Interpret question is best answered by students individually, and the Conclude and Communicate questions are most effective if discussed and answered by the group together.
- You can guide and assess students' work using **BLM A-27 Plan Your Own Investigation Rubric.**

Additional Example

- **DI** This activity requires bodily-kinesthetic, logical-mathematical, and linguistic skills. Try to ensure that each group includes students with strengths in each area.
- **ELL** Group English language learners with fluent English speakers. Consider providing English language learners with websites and print resources appropriate to their level of English comprehension. See **www.scienceontario.ca** for some suggestions.
- **ELL** If the Conclude and Communicate questions are discussed as a group, and one person records the group's answers, English language learners will find fewer barriers to participation.

Answers

Analyze and Interpret

1. The light with one battery will be closest. The light with two batteries will be farther away, and the light with three batteries will be farthest away.

Conclude and Communicate

2. The apparent and absolute brightnesses of the star must be used to determine the distance.
3. The brightness of the lights is determined by eye and best guess. It would be better to have a tool to accurately measure brightness.
4. The farther away a star is, the dimmer it appears. If a bright star and a dim star are the same distance away, the bright star will appear brighter than the dim star. If the bright star is farther away than the dim star is, the two may appear to be the same brightness. If a star appears bright, it may be because it is a bright star far away, or a dim star close to the observer.
5. The plaque should mention that this is a simulation of star brightness and distance from Earth. It should explain the relative brightness of the three bulbs.

Extend Your Inquiry and Research Skills

6. Answers will vary. Students may mention benefits such as a good scale for people to see and inexpensive materials. They may mention limitations such as short distances and light rooms making it difficult to appreciate the difference in brightness of the bulbs.
7. Answers will vary. Students may mention that simulations make it easier to understand something that you cannot see, but that they also simplify phenomena, so the phenomena are not represented accurately

Inquiry Investigation 8-B Using Spectral Analysis to Identify Star Composition (Student textbook pages 352 and 353)

Pedagogical Purpose

In this investigation, students practise analyzing spectral lines to draw conclusions about a star's composition, in a process similar to spectroscopy used by astronomers.

Planning	
Materials	Ruler **BLM 8-11 Inquiry Investigation 8-B Using Spectral Analysis to Identify Star Composition** (optional)
Time	15–20 min

Background

The dark lines in a star's spectrum show wavelengths of light that are absorbed and help to indicate the elements that are present in a star's atmosphere.

Activity Notes and Troubleshooting

- Once students understand how spectral lines are analyzed, the activity should be relatively simple. In most cases, students can perform the activity individually.
- Students could compare answers to questions 1 to 5 with a classmate.

Additional Support

- ELL Make sure English language learners understand what to do, and read the Analyze and Interpret questions to them. Encourage them to indicate what they may not understand, and have them describe how they will find the answer.
- DI Spatial learners may wish to answer question 6 by drawing a flowchart. Demonstrate as needed.

Answers

Analyze and Interpret

1. Hydrogen, helium, and sodium are present in the Sun's spectrum.
2. Calcium is present in mystery stars 1 and 3.
3. Mystery star 3 contains sodium.
4. Mystery star 3 contains mercury.
5. Mystery star 3 is least like the Sun in some ways. Students may point out that Mystery star 1 is also very unlike the Sun.

Conclude and Communicate

6. Students' paragraphs should include an explanation of how a star's spectrum shows dark lines across the colours, indicating that some wavelengths have been absorbed by gases in the star's atmosphere. Each element has a unique pattern of dark lines on a spectrum, enabling scientists to determine which elements are present.

Extend Your Inquiry and Research Skills

7. The spectra from the full Moon should be very similar to the spectra from the Sun, since the Moon simply reflects the Sun's light. There may be parts of the spectra that the Moon absorbs that is not reflected.
8. Students should include using spectroscopy to study the characteristics of celestial objects by analyzing particular wavelengths of the electromagnetic spectrum, including wavelengths that are not visible to the human eye.

Data Analysis Investigation 8-C Building an H-R Diagram

(Student textbook page 354)

Pedagogical Purpose

In this activity, students will use a Hertzsprung-Russell (H-R) Diagram to predict the relationship between the spectral type of stars and their absolute magnitude.

Planning	
Materials	**BLM G-41 Build an H-R Diagram** **BLM 8-12 Data Analysis Investigation 8-C Building an H-R Diagram** (optional)
Time	15–20 min to plot the points and answer questions

Background

The surface temperature of a star has an influence on its spectral type. Stars with spectral types earlier in the sequence (Os and Bs) are hotter. (Brighter stars have lower absolute magnitudes. A star with an absolute magnitude of −5.7 is brighter than a star with an absolute magnitude of +12.3.)

Activity Notes and Troubleshooting

- Prepare copies of **BLM G-41 Build an H-R Diagram,** for students to graph points on.
- Explain to students that stars with spectral types nearer the top of the table are hotter and stars with spectral types nearer the bottom are cooler.

Additional Support

- Remind students how to plot points on a graph. If necessary, have students use a ruler to guide them. You can refer students to Math Skills Toolkit 3, Organizing and Communicating Scientific Results with Graphs, on student textbook page 557. Students can also use **BLM G-25 Constructing a Line Graph,** and **BLM G-26 Interpreting Line Graphs,** to review how to build and use graphs.
- Enrichment—Some students may wish to predict the spectral type for stars whose absolute magnitudes they know (or can look up); then research to check.
- Although students are not required to memorize the order of spectral types, some students may wish to develop a phrase to help them remember the order.

Answers

Analyze and Interpret

1. Graphs should show a direct linear relationship between spectral type and absolute magnitude.
2. +4.7
3. +0.65
4. −1.2

Conclude and Communicate

5. You can find the spectral type on the horizontal axis, then trace a line up to the graph and then across to find the corresponding magnitude on the vertical axis.
6. The hypothesis is supported by the data. Students may use data from their graph to support this conclusion.

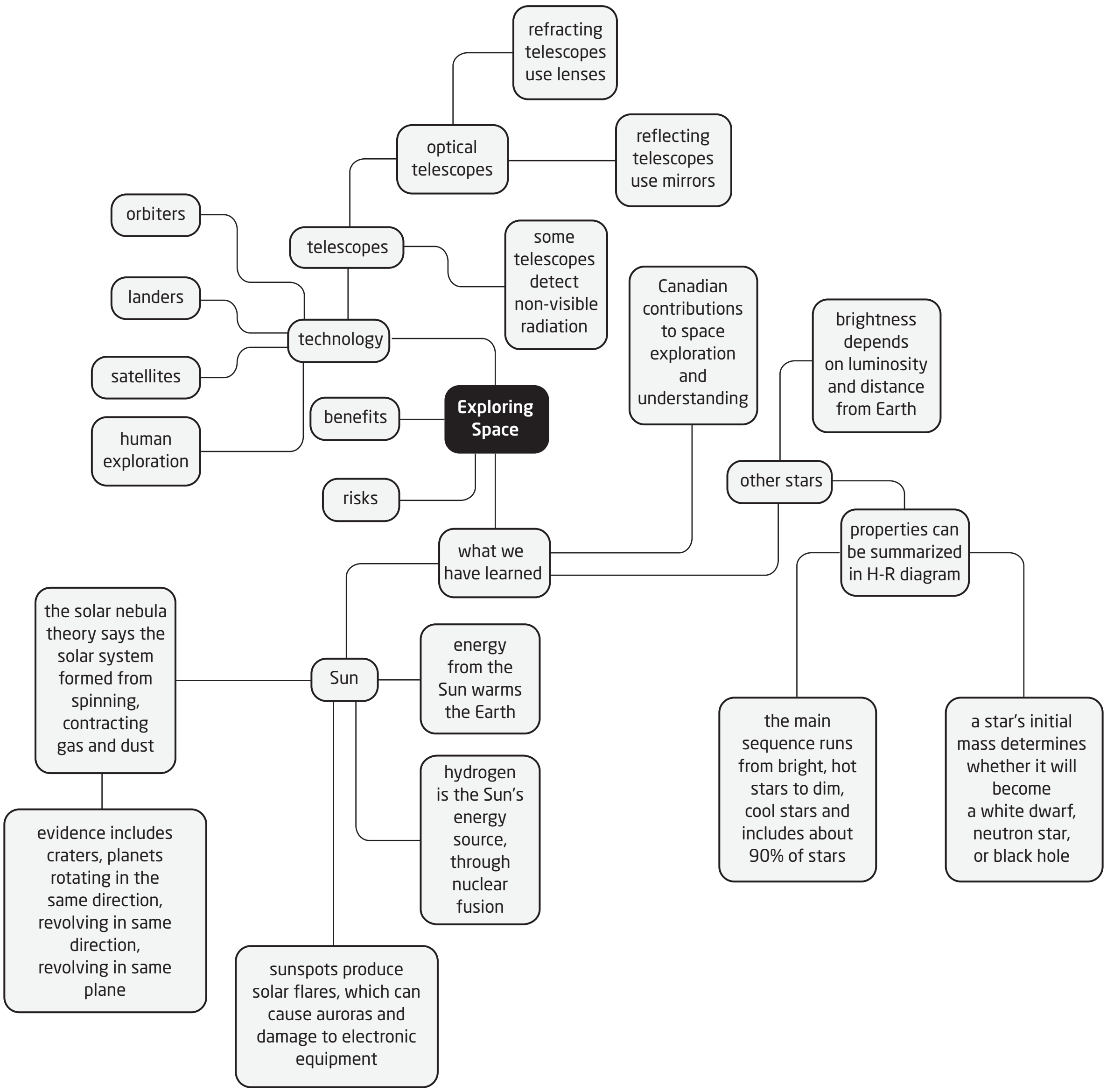
Extend Your Inquiry and Research Skills

7. Since apparent magnitude is partly related to a star's distance from Earth, it is not directly related to characteristics of the star itself.

Chapter Review Answers (Student textbook pages 356 and 357)

Please see also **BLM 8-13 Chapter 8 Review (Alternative Format).**

Make Your Own Summary



Reviewing Key Terms

1. electromagnetic radiation
2. reflecting, refracting
3. protostar, nuclear fusion
4. sunspots
5. main sequence, Hertzsprung-Russell
6. white dwarf
7. neutron star, black hole

Knowledge and Understanding

8. The partnerships have resulted in innovative technologies, such as the microsatellite MOST, which allow researchers to learn about stars and the Sun. The partnerships have also resulted in the development of robotic fixtures that were designed and built in Canada, such as the Canadarm, Canadarm2, and Dextre.
9. Magnetic fields on the Sun send streams of charged particles into space. These streams are solar wind. If solar wind hits Earth, telecommunications can be interrupted, electronic equipment on spacecraft can be damaged, and the electrical power network can be overloaded. The charged particles are normally carried past Earth's magnetic field, generating electric currents that flow toward Earth's poles. These electric currents charge gases in Earth's upper atmosphere, producing the auroras.

10. **a.** There could be problems with the spacecraft in which humans are travelling, such as what happened with the space shuttle *Columbia*. The crew were killed, and the spacecraft was destroyed, when returning to Earth.

b. The Canadian government and Canadian businesses designed the Canadarm2 and an attachment to the Canadarm2, called Dextre, which allows the astronauts to scan the whole space shuttle for potential problems before returning to Earth.

11. The Sun provides heat and light, which we need to live. The Sun is necessary for photosynthesis, which helps plants grow, which we eat.

12. Solar radiation reflected by clouds, the atmosphere, and Earth's surface: 30%
Solar radiation absorbed by Earth's atmosphere: 20%
Solar radiation absorbed by Earth's surface: 50%

13. As nuclear fusion occurs, the Sun's helium core grows larger. The temperature of the core rises, causing the core to expand, so the Sun as a whole grows larger. Students may also mention that gravity pulls matter toward the centre of the Sun, reducing growth.

14. sunspots

15. Sunspots move across the Sun's surface as the Sun rotates.

16. The spectrum provides information about the composition of a star.

17.

Evidence for the Solar Nebula Theory

Solar Nebula Theory	Evidence
The Sun and planets formed in a spinning disk.	The Sun and planets all rotate, most in the same direction, and they all revolve around the Sun in the same direction. The planets are more or less on the same plane.
The early solar system was active, with a lot of collisions.	There are a lot of craters on the Moon, Mercury, and Earth.
Theory predicts that planets are a by-product of the formation of stars.	Over 300 planets have been found orbiting other stars.

18.

	HST	MOST
Cost and year of launch	$10 billion; 1990	$10 million; 2003
Dimensions and mass	13.2 m × 4.2 m (about the size of a large school bus); 11 110 kg	65 × 65 × 30 cm (about the size of a suitcase); 60 kg
Instruments	Seven science instruments; diameter of the primary optical mirror: 2.4 m	Telescope mirror diameter: 15 cm
Altitude above Earth	600 km	820 km
Power	Solar energy	Solar energy

19. Students' diagrams should be similar to Figure 8.26, on page 343 of the student textbook.

Thinking and Investigation

20. Humans need an area to prepare food, a bathroom, air, storage space for food, a place to sleep, a place to work, and some recreation space if it is a long voyage.

21. White dwarf stars are no longer burning fuel, but it takes a long time for them to cool down. So they are still very hot; they just are not producing energy anymore to shine.

22. The only thing that changes when a black hole forms is its volume. The black hole has no volume but it does have mass, so its gravitational influence on nearby objects does not change. If you moved near a newly formed black hole, and got too close, however, you would be devoured!

23. Canada's MOST satellite is being compared to the Hubble Space Telescope, which is much bigger and costs much more. But MOST is performing far better than expected and producing valuable data, so it is still useful, even though it is tiny.

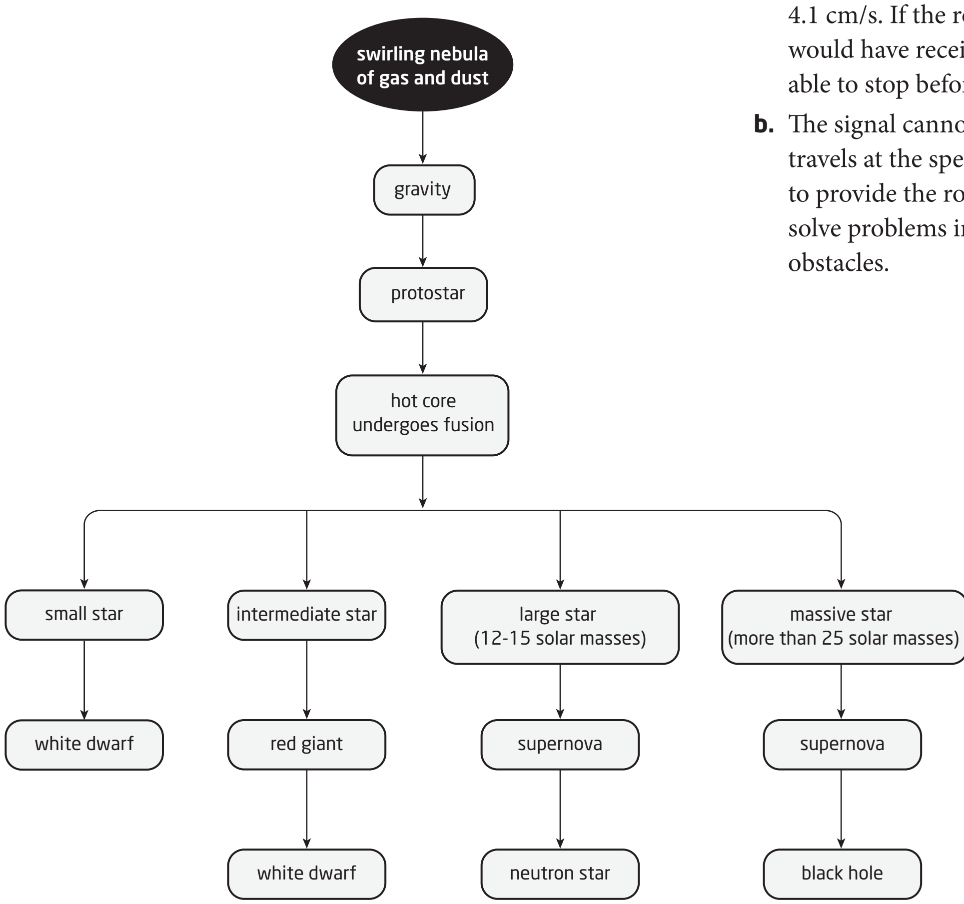
Communication

24. Astronomers observed many similarities among bodies in the solar system, such as craters, the direction of rotation and revolution around the Sun, and celestial bodies being more or less in the same plane. They develop theories that explain these similarities, for example, the solar nebula theory.

25. Students' e-mails should state an opinion about the merits of space exploration and should include reference to some of the discoveries that space exploration has led to, as well as some of the huge costs, both monetary and in terms of human life.

26. Students should state whether they do or do not think it is ethical to send people to Mars, and should support their opinion with their own answers to some of the questions in Table 8.3, Issues Related to Space Exploration, on student textbook page 331.

27. For example, low-mass stars (red dwarfs) consume their hydrogen very slowly and end up white dwarfs; they eventually become black dwarfs. Intermediate-mass stars, like the Sun, eventually swell out to become red giants, and then shrink to become white dwarfs. High-mass stars will turn into supernovae and either become neutron stars or black holes.



Application

28. GPS technology helps find locations and give directions, remote-sensing satellites monitor Earth, and communications satellites allow us to use cell phones and the Internet.

29. For example, the technology used to develop Canadarm has helped to develop techniques to perform surgery remotely using robotic technology. The medical advantages include greater accuracy, efficiency, and care of patients.

30. a. $v = d/t$

10 cm/s = d/2400 s (because the signal must travel to Earth and back to Mars)

d = 24 000 cm or 240 m

The rover will not get the signal from Earth in time to stop before the hole. The rover will travel 240 m before it gets the signal, and the hole is 100 m away.

$v = d/t$

v = 100 m ÷ 20 min

v = 10 000 cm ÷ 2400 s

v = 4.1 cm/s

The maximum safe speed for the rover to travel at is 4.1 cm/s. If the rover was travelling at this speed, it would have received the signal from Earth and been able to stop before it reached the hole.

b. The signal cannot travel any faster, since it already travels at the speed of light. A better option would be to provide the rover with the ability to recognize and solve problems in its path, specifically holes or other obstacles.

Chapter 9 The Mysterious Universe

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-35 for a summary of the materials required in this chapter and other chapters.

Advance Preparation

- Watch newspapers and other sources for stories about astronomical research and discoveries. Post them for students to read. Encourage students to bring in items that they find to share with the class.
- Students can review the Key Terms in Chapter 9 using **BLM 9-1 Chapter 9 Key Terms.**

In this chapter, students will learn about the formation of galaxies and the theory of the big bang—the beginnings of the universe—as well as the evidence we have to support this theory.

Using the Chapter Opener

- Engage students in a discussion about what they know about the objects in the universe. These objects could include galaxies, black holes, and exploding stars.
  - Using student input, make a list of where one would come across these objects in their daily life (for example, movies or science fiction books).
  - How many commercial brands or company names include names of astronomical objects (for example, star, galaxy, nova)? Ask students why they think companies use these names.
- After looking at the photograph on page 358, ask students whether they think there might be other planets circling these stars and how we might be able to tell if life exists on these other planets. Ask students what they could infer if astronomers confirmed that radio signals had been received from a planet circling a star in a different galaxy.
- As an alternative, 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.

Activity 9-1 Matter in Motion (Student textbook page 359)

Pedagogical Purpose

This activity will help students understand more about galaxies and the effects of their rotation. The swirling water in the bowl simulates the rotation of the galaxy and the motions of the stars in the galaxies' spiral arms.

Planning	
Materials	600 mL beaker or plastic cup Warm water Medicine dropper Small samples of food colouring, cocoa powder, and powdered milk
Time	30–40 min to make the observations and answer questions
Safety	Ensure students are careful when they are handling the glass beaker. Have students wipe up any spills immediately. Ensure students wear safety goggles and a lab apron.

Background

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.

In this activity, students simulate the rotational motion of galaxies—specifically elliptical and spiral galaxies. The focus of the activity is for students to recognize patterns of the spinning materials, and to observe how the different materials interact.

Activity Notes and Troubleshooting

- You may wish to have students read The Shapes of Galaxies section, on page 362 of the textbook, before they complete this activity. After reading, students will have better vocabulary with which to describe the various shapes they will observe in the activity.

- If students are careful, they can fill the beakers three quarters full of water. A deeper amount of water creates greater visibility for the "vortex" effect.
- If you substitute any of the materials, try to avoid using materials that float on the surface. The best effects are achieved by materials that partly submerge in the spinning water.
- Instruct students to observe the motion of the materials not only from above, but from the side of the beaker as well.
- After students have completed the activity and recorded their observations, allow them to experiment with mixing the different materials. The effects of combining the materials will reinforce the concept that galaxies are three-dimensional objects.

Additional Support

- ELL Partner English language learners with students who have stronger language skills.
- If students find it difficult to swirl the water by moving the flask, have them use the medicine dropper (or a stirring rod) to move the water.
- Enrichment—Have students use fluids of different viscosities to see how the results change.
- Enrichment—Have students use a digital camera or a video camera to record their observations instead of sketching. By recording the observations using a camera, students will have a much better way to compare what they have seen with one another's results, and with images of galaxies. Students can organize the pictures in a table format, or set up a simple computer slide show presentation that shows all related images on one page.

Answers

1. Answers will vary but should include references to the way the materials clump together, how the materials seem to spread out from the centre of the beaker, and the motion of the materials below the water surface. The materials will behave differently due to the way they float. In addition, the cohesiveness of each material will play a role in how the material radiates from the centre.
2. Increasing the speed of rotation increases the rate at which the material is pushed to the side of the beaker. In addition, increasing the rate of rotation increases the depth of penetration of the material into the water.
3. The activity simulates the rotational motion of galaxies. The different materials are analogous to stars in a galaxy. A galaxy, however, has gravity to keep its material together. In this activity, the beaker helps keep the material together.

Study Toolkit		
Strategy	**Page Reference**	**Additional Support**
Skim, Scan, or Study	Page 363 Section 9.3, pages 377 and 378	Model for students and give them specific tasks to practise, for example, "Scan the caption for Figure 9.14B to find out what the dark blue ring in the image is."
Using Graphic Organizers	Page 363	Begin by creating a shared graphic organizer, then have students create their own for another chunk of text. See the Study Toolkit, pages 566 and 567. Have students compare the different organizers that they chose to use and explain why they chose the one they did.
Base Words	Page 368 (cosmology) Page 362 (galaxy)	Use this strategy as an opportunity to review metric units for English language learners or other students. You can understand any unit by knowing the meaning of the base unit and of the prefix.

Section 9.1 Galaxies (Student textbook pages 361 to 367)

Specific Expectations

- **D3.3** describe the major components of the solar system and the universe using appropriate scientific terminology and units

In this section, students will learn about galaxies—how they were discovered, their shapes, and about our own Milky Way galaxy and its place in the universe.

Common Misconceptions

- **When shown a picture of a galaxy, students often think it is our galaxy, the Milky Way.** Since we are inside the Milky Way galaxy, we cannot take a complete picture of it. We see the Milky Way as a band of light stretching across the sky. It is best seen in a dark sky on a clear night, as shown on page 361 of the student textbook.
- **Students often incorrectly associate our solar system with the Milky Way galaxy. They may interchange the terms *galaxy* and *solar system*, rather than realizing that our solar system is a small part of the Milky Way galaxy.** Review what students learned about the Sun and our solar system in Chapter 8. Consider using an analogy to help students understand and remember; for example, the solar system is like our city or town, the galaxy is like Canada, and the universe is like planet Earth.
- **Students may have a difficult time processing such concepts as the number of stars in a galaxy as well as the vast expanses of empty space.** The important concept is that these distances and numbers are virtually unimaginable.

Background Knowledge

The universe is believed to have formed in an instant, about 13.7 billion years ago. Once stars began to populate the universe, it was not long before their gravity was pulling them together into galaxies. A galaxy forms when gravity causes a large, slowly spinning cloud of stars, gas, and dust to contract. All the stars in the universe are contained in galaxies that are separated by millions of light-years of empty space. Although in section 9.3 we will find that it may not be empty after all.

The Milky Way is the name of the galaxy in which Earth is located. There are 40 times more stars in the Milky Way than there are humans on Earth! When you look up at the sky on a very clear night, away from city lights, every star you see is part of the Milky Way. Because there is so much dust in our Milky Way, we can see only the nearby stars in our area of the Milky Way. The light from the millions of other stars is blocked by all the dust.

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 Support

Using the Images

- Have students examine Figure 9.1, on page 361, and read the caption. Have them describe their own experience seeing the Milky Way, and encourage them to watch for the Milky Way when they are out at night. Have students suggest what they are seeing when they see the Milky Way. Ask, "What effect do city lights have on our ability to see the Milky Way?"
- Invite English language learners, and other students, to share how ancient astronomers from their culture interpreted the Milky Way and other celestial phenomena.
- Have students compare Figure 9.1 with Figures 9.4 and 9.5, on page 364. Ask students how the images in Figures 9.4 and 9.5 can help to understand what we are seeing when we see the Milky Way from Earth.
- Ask students why we cannot see the Milky Way as a spiral galaxy as shown in Figure 9.2A, on page 362.

Using the Text

Before Reading

- ELL Preview the Key Terms with English language learners. Talk about the meaning of the word *cluster*. Then have students predict the meanings of the Key Terms *star cluster, open cluster, globular cluster,* and *supercluster.* Ask students to suggest other words they would like to discuss. Suggest that they use context to first predict what they think the words might mean.
- Have students preview the text features in the section, especially the subheads, Key Terms, and captions for the figures. Ask students to predict what each subsection might be about, based on these features.
- Refer to Study Toolkit 1, Preparing for Reading: Previewing Text Features, on page 563 of the student textbook.

During Reading

- Students can summarize each subsection, stating the main idea and a few important supporting details about galaxy shape, the Milky Way, and the Local Group.
  - ELL Encourage English language learners to use sketches where possible.

After Reading

- Have students identify the three or four main ideas of the section from their notes, and then work with a classmate to agree on three main ideas for the section.
- Students can summarize what they have learned using **BLM 9-2 Galaxies,** or **BLM 9-3 Galaxies (Alternative Version).**
- ELL Have groups of students create graphic organizers to summarize the content of this section. These can be left on display as visual aids for English language learners and other students.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Discussion, Learning Check questions, page 366	Students interpret diagrams to describe galaxy types and locations.	Have students answer these questions orally, while they refer to the diagrams in the textbook and scan the text to help them explain.
Activity 9-2, How Big Is the Milky Way Galaxy? and Activity 9-3, Counting Galaxies by Sampling	Students manipulate common astronomical measurements and exponential notation to accurately estimate size and number of galaxies.	Review how to multiply and divide using scientific notation. Use **BLM 9-4 Calculating with Scientific Notation.** Have students say what steps they would use to answer each question before they begin calculating.
Section 9.1 Review questions, question 8, page 367	Students label a diagram to show the features of, and our Sun's location in, the Milky Way.	Have students work in pairs to scan pages 363 and 364 of the student textbook for information about each label. Then have them place the labels on their diagram.

Instructional Strategies

- Begin by using the images in this section to start a discussion about our own galaxy—what we see, what it really looks like, and who are our neighbours.
- When discussing shapes of galaxies, help English language learners, as well as spatial and bodily-kinesthetic learners, make connections by referring to the swirling matter in Activity 9-1 (and to students' photographs of it, if photographs were taken).
- Scientists use very, very large numbers to estimate the numbers of galaxies in the universe or in the Milky Way. To help students understand the size of these numbers, have them perform the activity on **BLM 9-5 The Universe in a Spoonful of Sand.**

Activity 9-2 How Big Is the Milky Way Galaxy? (Student textbook page 365)

Pedagogical Purpose

This activity provides students with an opportunity to make calculations using common astronomical units and to appreciate the scale of the Milky Way galaxy. Just as in Activity 7-3 where students modelled the size of the solar system, this activity shows the immense size of the Milky Way.

Planning	
Materials	Calculator
Time	20–30 min

Background

The scale of the solar system and the distances involved are overwhelming. But these aspects are tiny compared to the size of galaxies and the distances between them. If you were to build a model of the solar system, a reasonable scale would leave the planets nearly invisible. Similarly, if you were to build a model of a galaxy, the entire solar system would be almost microscopic. As a result, the distances within a galaxy are measured in astronomical units and light-years.

Activity Notes and Troubleshooting

- Students may need to be reminded of how to do scale calculation. Remind students that the numbers they calculate are supposed to be large. Students should not be surprised by getting a large number.
- Review scientific notation. See Math Skills Toolkit 1, The Metric System and Scientific Notation, on page 554 of the student textbook. Show students how to multiply and divide using scientific notation by adding or subtracting the exponents. If students have derived the exponent laws from mathematics, help them to draw connections between those laws, and how we calculate using scientific notation.
- Provide pairs or small groups of students with copies of a local map. Have them use the scale they used in Procedure step 3 to sketch the Milky Way galaxy on the map, with their school at its centre. They should label the location of the solar system on the map as well.

Additional Support

- If students require further practice with scientific notation, have them complete **BLM 9-4 Calculating with Scientific Notation.**
- ELL Consider pairing English language learners with students who have strong language and interpersonal skills.
- DI Logical-mathematical, as well as spatial, skills are required for this activity. Ensure that as many groups as possible include students with these skills.
- This activity requires accurate calculations, but students also need to decide which calculations are required. Allow students who have trouble making decisions to work with a classmate. Both students must agree on what calculation to perform in each step before they calculate. Pairs can also check each other's answers.

Answers

Procedure

1. 100 014 light-years
2. 7.9×10^{-4} light-years
3. 100 014 mm $\doteq$ 100.0 m
4. 28 000 mm = 28 m
5. 7.9×10^{-4} mm = 7.9×10^{-7} m

Questions

1. The model would be quite large; I would have to go outside to the school parking lot or football field. I would need help counting off the metres.
2. The solar system would be too small to show in this model.
3. I would not use millimetres; I would use maybe metres or kilometres.

Activity 9-3 Counting Galaxies by Sampling (Student textbook page 366)

Pedagogical Purpose

This activity will give students an opportunity to count the total number of galaxies in the universe. Students will use sampling techniques to count the number of galaxies visible in a picture taken by the Hubble Space Telescope (HST), determine what area of the sky the picture covers, and then (assuming equal distribution) they will estimate the total number of galaxies.

Planning	
Materials	Image of galaxies taken by HST **BLM 9-6 Hubble Deep Field View** (optional)
Time	20–30 min

Background

The image of galaxies in the student textbook and on **BLM 9-6 Hubble Deep Field View,** was taken by the Hubble Space Telescope in December 1995. It shows an area in the sky in the constellation of Ursa Major. The image covers a speck of the sky that is only about the width of a dime 23 m away. Though the field is a very small sample of the sky, it is considered representative of the typical distribution of galaxies in space, because the universe, statistically, looks largely the same in all directions. Gazing into this small field, the Hubble Space Telescope uncovered a bewildering assortment of at least 1500 galaxies at various stages of evolution.

Most of the galaxies are so faint (four billion times fainter than can be seen by the human eye) that they have never before been seen by even the largest telescopes. Some fraction of the galaxies shown in this image probably formed at nearly the beginning of the universe.

Activity Notes and Troubleshooting

- Students should be reminded that this is an estimation exercise, and that they should do their best to count the smudges but that they might not be able to count every one.
- Quickly review calculating with scientific notation.

Additional Support

- Some students who lean toward being perfectionists may become frustrated because there are many subtle smudges that may or may not be galaxies. Remind these students to do their best but to not worry about counting every galaxy.
- ELL Consider pairing English language learners with students who have strong language and interpersonal skills. If the English language learners have strong logical-mathematical skills, have them coach others. This will enhance self-esteem and allow them to assume a positive role among their peers.
- This is an excellent activity for students who have strong logical-mathematical intelligence as well as those who are spatial learners. Pair them with students who may have difficulty.
- To help students better understand the idea of sampling, talk about other instances where sampling is done and why the whole population is not surveyed. For example, polls before elections, surveys, tests of new medications, and TV show ratings.

Answers

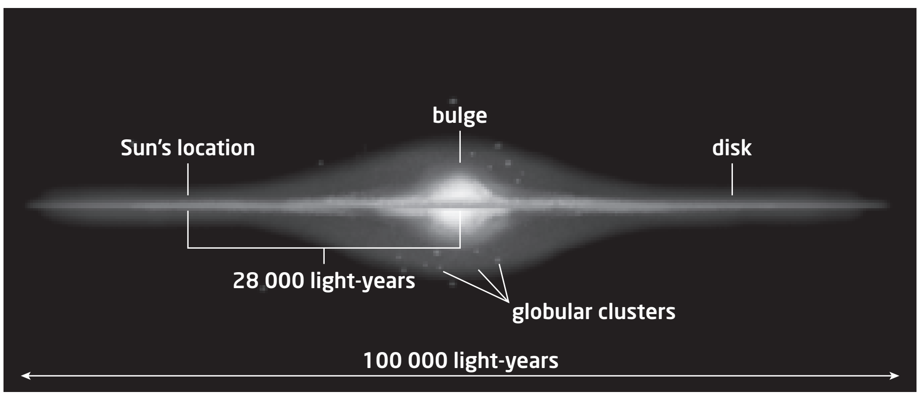
1. Typical results yield between 10 billion and 30 billion galaxies.
2. If a single section is low in number or unusually high in number, the results will be biased and therefore unreliable. Averaging helps avoid this problem.
3. Samples are much faster. There are millions of sections of this size in the sky, so it would take too long to count the galaxies in every one.

Learning Check Answers (Student textbook page 366)

1. A spiral galaxy is roundish but flat with a bulge in the centre. It has major and minor spiral arms that come from the centre. An elliptical galaxy is oval or cigar shaped with no visible arm structure. An irregular galaxy does not have a regular shape.
2. Galaxies form when gravity causes a large, slowly spinning cloud of gases, dust, and stars to contract.
3. By using radio telescopes, astronomers were able to map the Milky Way galaxy and determine its diameter and shape. By mapping the position of globular clusters, astronomers were able to determine that these clusters surround the bulge at the centre of the galaxy.
4. The two closest galaxies are the Large and Small Magellanic Cloud galaxies. The two farthest galaxies are the Pinwheel and Andromeda galaxies. (Note: these galaxies are the farthest galaxies in the Local Group. Many other galaxies are farther away from the Milky Way galaxy.)

Section 9.1 Review Answers (Student textbook page 367)

Please see also **BLM 9-7 Section 9.1 Review (Alternative Format).**

1. Image A is a spiral galaxy; Image B is a globular cluster.
2. The Local Group is a system of about 40 or so nearby galaxies, which includes the Milky Way galaxy (the second largest) and the Andromeda galaxy (the largest). The galaxies are all bound by gravity.
3. A galaxy cluster is a group of galaxies held together by gravity. A supercluster of galaxies is made up of 4 to 25 galaxy clusters.
4. No, the Sun is about 28 000 light-years from the centre of the Milky Way.
5. open star clusters: 10 to 1000 stars; appear along the main band of the Milky Way;
   globular star clusters: 100 000 to 1 million stars; spherical shape; not along the main band of the Milky Way;
   shared: organization of stars held together by gravity
6. Diagram should show the Milky Way galaxy as seen from above, as in Figure 9.2A, on page 362.
7. Globular clusters are spherical and contain thousands of stars held in the cluster by gravity. A galaxy also contains many stars held together by gravity, but a galaxy is much larger, and it contains more stars. Some galaxies are flat (pinwheel), and some are elliptical.
8. 

Section 9.2 The Universe (Student textbook pages 368 to 376)

Specific Expectations

- **D3.1** describe observational and theoretical evidence relating to the origin and evolution of the universe

In this section, students will study the theory that the universe began with a big bang. First, the universe is observed to be expanding—everything is moving away from everything else. This expansion is detected by observing the light (and spectra) from galaxies and by measuring the redshift. Second, modern satellites allow us to observe the background radiation left over from the big bang. By using powerful telescopes and looking at objects very far away, we are looking back in time, toward the beginning of the universe.

Common Misconceptions

- **Students will most likely have a difficult time grasping the concept of a universe that was born in a single event.** Cultural perspectives notwithstanding, the idea of "nothingness" is difficult for most people to reconcile. It is important to stress that the big bang theory has arisen as a "best explanation" for the observed data. This concept will be addressed as you progress through the section.
- **Students may confuse the origin of the solar system (~4.5 billion years ago) with the origin of the universe (~13.7 billion years ago).** You might use the analogy of the birth of a mother (40 years ago) with the birth of her child (13 years ago).

Background Knowledge

One hundredth of one second is less time than it takes to blink your eye. In one hundredth of one second, a lightning bolt can hit the ground, a baseball can fly across home plate, or a sound wave can travel 3 m. Scientists believe that one hundredth of one second was all the time needed to form the particles that would become the atoms that are the basic building blocks of everything we find today in our universe. To talk about the history of the universe, we have to go back very far in time because the universe is believed to have started approximately 13.7 billion years ago. The instant the universe formed, an unimaginably tiny volume of space suddenly and rapidly expanded to immense size. That catastrophic event, first described by Georges Lemaître in 1927, came to be referred to as the *big bang*.

According to the big bang theory, for the first few milliseconds, the newborn universe was a rapidly changing hot soup of matter and particles of light energy called photons. Since the initial expansion in these early moments was incredibly hot and dense, all the photon energy dominated the other matter, pushing it around in an unorganized mass. According to some estimates, at one second old, the temperature of the universe was 10 billion degrees Celsius. The matter in the hot soup was made up almost entirely of subatomic particles called quarks (indivisible particles) and electrons. As the universe continued to expand, its temperature decreased and the quarks formed into protons and neutrons.

By the time the universe was 300 000 years old, it had expanded to trillions and trillions of kilometres. Although its temperature had cooled from what it was in the beginning, it was still extremely hot. Some structures started to take shape as the energy spread out.

Literacy Support

Using the Text

Before Reading

- ELL Preview Key Terms by creating a concept web with English language learners. Make use of the concept map during reading and after reading to review concepts. Consider having English language learners complete a similar concept map as part of their assessment.
- This section is very long. Consider breaking up the reading into three subsections (Edwin Hubble and The Expanding Universe, The Big Bang Theory, Looking Back in Time) and discussing what students have read after they finish reading each subsection, including surprises and confusions.
- Invite students to share what they already know about each subtopic and to ask questions to which they would like to find the answers in the textbook. They could complete a K-W-L chart or could share their ideas orally.

During Reading

- Ask students to read each subsection of text independently, and then to pair up with another student to check comprehension, by discussing the main ideas of what they have read. Tell students to include the causes of each phenomenon in their notes. Students can compare notes with a classmate, and revise their own notes as necessary.

After Reading

- Divide students into small groups. Assign each group one of the three subsections of text. Have the group members agree on the main idea of their subsection, and record it, as well as supporting points, on a large sheet of paper. If two groups work on each section, the groups can exchange summaries and revise them as necessary.
  - ELL If these summaries are presented and posted in the classroom, they can help English language learners to understand the content of this lengthy, technical section. Allow time to review and rehearse concepts presented in these summaries.
- ELL To encourage English language learners to review key vocabulary, provide Key Terms and their definitions on separate strips of paper. Two students can play a game of tic-tac-toe, matching one term to its definition before placing each X or O.

Using the Images

- Figure 9.7, on page 368, shows galaxies billions of light-years away. Discuss why the galaxies might not all look the same. (shape, distance)
- Figure 9.12, on page 374, provides a useful illustration of the big bang time line. You can use it to preview or review the big bang.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Discussion/Learning Check questions, page 371	Students explain what a star's spectral lines tell us about its movement.	With a partner, have students look through this section of their textbook, finding information that they can use in their answers.
Inquiry Investigation 9-A, Estimating the Age of the Universe	Students graph data and calculate to estimate the age of the universe.	Students who have trouble graphing can refer to Math Skills Toolkit 3, on page 557, or use data from the graph on page 383.
Section 9.2 Review questions, page 376	Students explain and present evidence for aspects of the big bang theory.	Have students refer to the main idea and supporting summaries created by groups in After Reading to obtain the information they need. Students can work individually or in pairs to complete **BLM 9-8 The Universe: A Time Line.**

Section 9.2 Review Answers (Student textbook page 376)

Please see also **BLM 9-9 Section 9.2 Review (Alternative Format).**

1. Hubble discovered that the spectra are redshifted.
2. Redshifted galaxies are moving away from us.
3. The main idea of the big bang theory is that about 14 billion years ago, an unimaginably tiny volume of space suddenly and rapidly expanded to an immense size.
4. George Gamow predicted that the background radiation in the universe should have cooled to about −269°C. The cosmic background radiation detected by Robert Wilson and Arno Penzias and later confirmed by the COBE and WMAP satellites corresponds to a temperature of about −270°C, which is very close to the predicted value.
5. Different colours in the pattern represent different temperatures. The CMB radiation is represented mostly in green. The other colours indicate differences in temperature. Blue is colder, and yellow-red is warmer. The colour differences indicate that microwave radiation is not the same everywhere.
6. The universe began expanding quickly when it suddenly expanded from about 10^{-48} cm to about 10^{3} cm at about 10^{-35} s before returning to its original rate of expansion; overall, it increased in size about 10^{75} times (10^{20} cm/10^{-55} cm) from 10^{-45} s to 10^{-5} s.
7. The distance-redshift relationship discovered by Hubble and Humason confirms the expansion of the universe because of observations of very large distances and, therefore, a very early time in the history of the universe.
8. Answers will vary. The World Wide Web is now so commonplace that it is difficult to imagine life without it. Students would likely use the library a lot more; they would not be able to communicate using e-mail or on-line communication websites, so they might have more face-to-face communication.

Section 9.3 Unsolved Mysteries (Student textbook pages 377 to 381)

Specific Expectations

- **D3.1** describe observational and theoretical evidence relating to the origin and evolution of the universe
- **D3.3** describe the major components of the solar system and the universe

In this section, students will study some of the mysteries of the universe that are currently keeping professional astronomers busy. The idea that most of the mass in the universe is invisible is currently a major area of study in astronomy. The recent discovery that the expansion of the universe is not decelerating as was expected, but is accelerating due to dark energy, sounds like it is science fiction, but it is an area of serious study.

Background Knowledge

Galaxies are incredibly large systems of millions, billions, or even trillions of stars; gas; dust; and dark matter. The stars are held in place by a common gravity that cannot be explained using only the matter visible through telescopes. Our present understanding of physics indicates that rotating galaxies should not have sufficient gravity to maintain a hold on the stars. However, new discoveries suggest that there is a lot more going on than meets the eye. With data collected by the Wilkinson Microwave Anisotropy Probe, for example, astronomers have estimated that what we can view (including all those billions of galaxies) accounts for a mere 4 percent of the universe's total matter. Only 0.5 percent of the visible 4 percent is estimated to be star matter.

So, what is the content of 96 percent of the universe? About 22 percent is now believed to be dark matter. Dark matter refers to particles that cannot be seen directly but whose existence can be detected because of their gravitational effect on galaxies and stars. Unlike the atoms of the visible matter, whatever makes up dark matter neither radiates nor absorbs light. The other 74 percent of the universe is called dark energy.

Literacy Support

Using the Text

Before Reading

- Invite students to write questions about dark matter and dark energy to which they would like to find the answers in the textbook. Encourage them to use the words *who, what, when, where, why,* and *how.*

During Reading

- Allow students to read the section silently, writing a brief summary of each of the subsections. Have them write answers to each question they posed before reading, if possible.
- ELL The content of this section is very abstract. Have students place sticky notes beside difficult passages as they read. Then meet as a group after reading each subsection to deal with any difficulties, and summarize together. Alternatively, have English language learners work in pairs. One student reads a chunk of text and summarizes it orally for their partner while the partner asks questions to clarify.

After Reading

- Have students make study notes by recording the main idea and supporting details of each topic.

Assessment FOR Learning

Tool	Evidence of Student Understanding	Supporting Learners
Discussion/Learning Check questions, page 379	Students describe characteristics of dark matter.	Discuss these questions as a class, and have the students who provide each answer model the process by indicating where in the textbook they found the information they needed.

Instructional Strategies

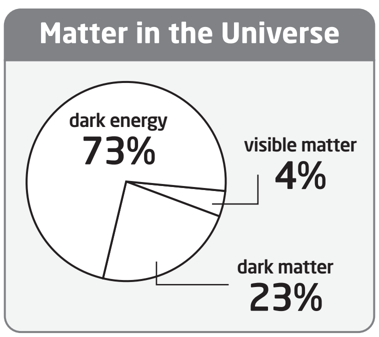
- Remind students of the evolution of the model of our solar system. Each time something was discovered that did not fit with an existing theory, the theory had to be modified. New observations are causing us to continue to modify the model we use.
- DI If students have trouble imagining how something that cannot be detected can exist, list with them some things that we cannot see, but that we know exist, for example, air, microwaves, and cell phone signals.
- Making a Difference introduces students to someone who has made it his life's work to try to answer the biggest of cosmological questions.

Learning Check Answers (Student textbook page 379)

1. Dark matter is the most abundant form of matter in the universe, but is not seen.
2. The Andromeda galaxy is similar to the Milky Way galaxy, so by learning more about Andromeda, we can learn more about the Milky Way galaxy.
3. The blue-coloured material is a computer-generated model that shows where the mysterious dark matter must be.
4. Astronomers' models work only when dark matter is included. Models help astronomers understand the nature and composition of the universe.

Section 9.3 Review Answers (Student textbook page 381)

Please see also **BLM 9-10 Section 9.3 Review (Alternative Format).**

1. 

2. The motions of stars in galaxies and the motions of galaxies within groups of galaxies do not make sense unless there is more mass in the universe.
3. To account for the motions of stars within galaxies, astronomers must assume that there exists a huge amount of matter that cannot be seen. Similarly, the motions of galaxies can only be explained when huge amounts of unseen mass are assumed.
4. There is nearly six times more dark matter than visible matter; or 23 percent of the universe is dark matter and 4 percent of the universe is visible matter.
5. **a.** Dark matter is invisible, and it does not emit radiation so telescopes cannot detect it.
   b. The interaction of dark matter is weak, and dark matter does not conform to the shape of a galaxy. It seems to form a spherical halo around the galaxy.
6. The distances to Type Ia supernovae, determined from their absolute magnitudes, were larger than their redshift predicted. Astronomers can account for the increased distances if the expansion of the universe is increasing. But astronomers do not know what is causing the increase in expansion, so they called the cause dark energy.
7. Without dark energy, the expansion of the universe would not be increasing. Therefore, the supernovae would have been brighter.
8. We cannot see dark energy or detect it with any type of telescope.

Inquiry Investigation 9-A Estimating the Age of the Universe

(Student textbook pages 382 and 383)

Pedagogical Purpose

This activity allows students to process real data to determine the Hubble constant and estimate the age of the universe.

Planning	
Materials	Ruler Calculator **BLM 9-11 Inquiry Investigation 9-A Estimating the Age of the Universe** (optional) **BLM G-23 Data Table** (optional) **BLM 9-12 Finding the Slope of a Line** (optional)
Time	30 min

Background

Edwin Hubble showed that except for the Andromeda galaxy and a few other close galaxies in the Local Group, all the galaxies are redshifted. In other words everywhere we look, the galaxies are all moving away from us. The universe is expanding.

The Hubble Constant expresses the rate at which the universe is expanding. It can be used to calculate the distance of galaxies from Earth if their redshift is known $\left(\text{distance} = \frac{\text{velocity}}{\text{Hubble constant}}\right)$. According to this law, known as the Hubble law, the greater the distance of a galaxy, the faster it recedes. Modern estimates, using measurements of the cosmic microwave background radiation left over from the big bang, place the value of this constant between 21.5 km and 23.4 km per second per 1 000 000 light-years. The reciprocal of Hubble's constant lies between 13 billion and 14 billion years, and this cosmic time scale serves as an approximate measure of the age of the universe.

Calculating Slope

The slope of a straight line is defined as the *rise* over the *run*. To find this ratio, pick any two points on the line. (Note: they must be points on the line and not data points through which the best fit line has been drawn.)

$$\text{Slope} = \frac{\text{rise}}{\text{run}}$$
$$= \frac{\text{difference in } y\text{-coordinates}}{\text{difference in } x\text{-coordinates}}$$

This concept is illustrated in the graph at the bottom of page 383.

Activity Notes and Troubleshooting

- Students should be familiar with the prefix mega (1×10^6).
- The unit of Hubble constant (H) is kilometres per second per megaparsec. (km/s/Mpc). Students should know this unit to avoid confusion in this activity.
- To ensure students are able to calculate slope, demonstrate at the chalkboard before students begin. Plot a set of simple coordinates, draw a line of best fit, and calculate the slope of the line using the equation in Background. Leave the model on display so that students can refer to it.

Additional Support

- ELL Consider pairing English language learners with students who have strong language and interpersonal skills.
- DI This is an excellent activity for students with strong logical-mathematical intelligence as well as those who are spatial learners. Pair these students with other students who have different dominant learning styles for this investigation.
- If students experience difficulties calculating slope, have them complete the step-by-step process on **BLM 9-12 Finding the Slope of a Line.**

Answers

Analyze and Interpret

1. Students should get an answer close to 14 billion years.

Conclude and Communicate

2. The currently accepted age of the universe should be about the same as the age that students calculated.

Extend Your Inquiry and Research Skills

3. It would be the same since the slope of the line of best fit would not change, just the *y*-intercept.
4. The value of the Hubble constant varies because of the difficulty in measuring astronomical distances accurately. Hubble originally calculated the constant as 500 km/s/Mpc. In 1968, Allan Sandage estimated the value as 75 km/s/Mpc. There have been debates about the value of Hubble's constant and the value is thought to be around 70 km/s/Mpc.

Inquiry Investigation 9-B Modelling the Expanding Universe

(Student textbook page 384)

Pedagogical Purpose

In this activity, students will model the current theory about the expansion of the universe using a balloon. Some students may believe that if all other galaxies are moving away from us, we must be at the centre of the universe. In this investigation, students discover that every galaxy in an expanding universe becomes farther from every other galaxy, regardless of their position.

Planning	
Materials	Marker, black or blue Balloon (light colours only and with no marks on it) Clothespin String Ruler **BLM 9-13 Inquiry Investigation 9-B Modelling the Expanding Universe** (optional) **BLM G-23 Data Table** (optional)
Time	30 min

Background

In 1925, Edwin Hubble discovered that objects formerly thought to be nebulae near Earth were actually galaxies made up of millions of stars, very far away. The immediate significance of his discovery was to cause astronomers to realize that the universe was much larger and much older than they had previously thought.

The closest galaxy to Earth is the Andromeda galaxy, which was once called the Andromeda Nebula. It is about the same size as the Milky Way galaxy and is over 2 million light-years away from the Milky Way galaxy. This calculation means that the light we see coming from Andromeda left the galaxy over 2 million years ago.

Hubble showed that except for Andromeda and a few other close galaxies in the Local Group, all the galaxies are redshifted. In other words, everywhere we look, the galaxies are all moving away from us. The universe is expanding.

Measurements of the speed of this recession can be made from the redshifting of the galaxies' spectra. Hubble found that there is a linear relationship between the speeds of recession and the galaxy's distances. Galaxies twice as far away from us are receding twice as fast. By extrapolating galaxy speeds and distances back in time, we can get an estimate for the age of the universe. Early estimates were from 15 to 22 billion years. Observations made with the Hubble Space Telescope give us a more accurate value today of 13.7 billion years.

Activity Notes and Troubleshooting

- Students will be measuring distances along a curved surface (the balloon). If they have only an inflexible ruler, suggest that they drape the string between the two dots and measure the string length using the ruler.
- Have one student in the group inflate the balloon, but tell groups to ensure that other roles are shared so that everyone has a chance to measure and to record.

Additional Support

- ELL Pair English language learners with students who have strong language and interpersonal skills.
- DI This is an excellent activity for students with strong logical-mathematical intelligence as well as those who are spatial learners. Try to place one student with these skills in each group.
- DI A similar bodily-kinesthetic activity can be carried out by having all students stand in a cluster. Have them identify the student in the centre. Then ask all students (except for the student in the centre) to move away from one another. Ask "What happened to the size of the cluster?" Ask the student in the centre, as well as a couple of students near the outer edge, to describe what happened to the distances between themselves and their neighbours when the cluster expanded.

Answers

Analyze and Interpret

1. As you look across a row on the table, each measurement is increasing.
2. Yes. With each measurement, the dots are moving farther away from the centre of the balloon. The dots are also moving farther away from each other, so the Milky Way galaxy may not be at the centre of the universe just because all the galaxies around it are moving away.

Conclude and Communicate

3. As the universe expands, the spaces between the clusters of galaxies increase. *Clusters* is mentioned here because within a cluster, some galaxies may be approaching each other due to their mutual gravitational forces.

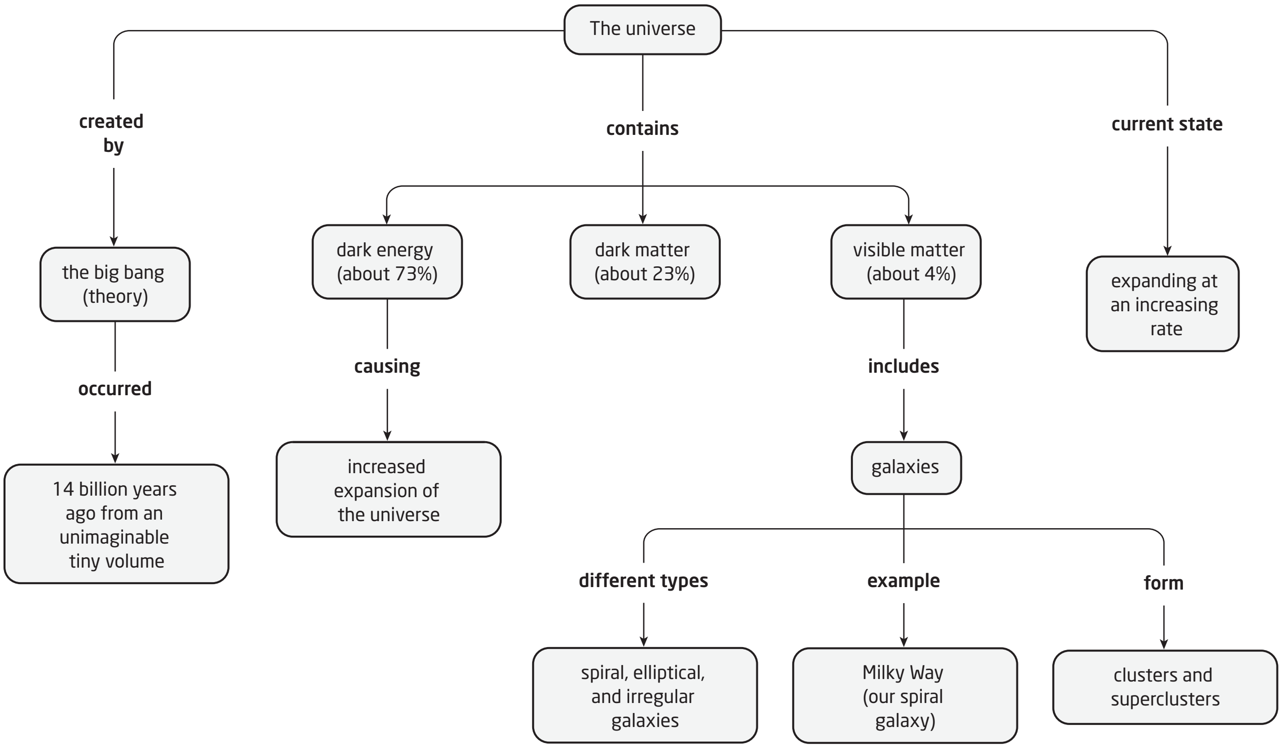
Extend Your Inquiry and Research Skills

4. In 1998, astronomers were shocked to find evidence that the universe was expanding at an increasing rate instead of slowing down due to gravity as expected. The best explanation for this result was the concept of dark energy. Dark energy pushes matter away instead of attracting it like gravity, which is why the expansion of the universe is not slowing down.

Chapter Review Answers (Student textbook pages 386 and 387)

Please see also **BLM 9-14 Chapter 9 Review (Alternative Format).**

Make Your Own Summary



Reviewing Key Terms

1. **f.** galaxy
2. **g.** Milky Way galaxy
3. **c.** cosmology
4. **a.** big bang
5. **b.** cosmic microwave background
6. **e.** dark matter
7. **d.** dark energy

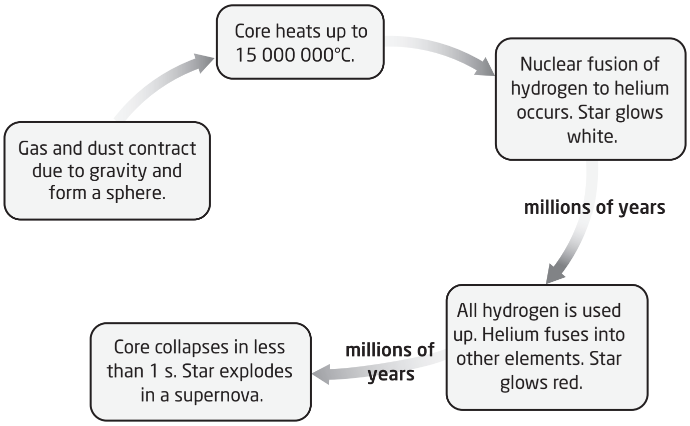
Knowledge and Understanding

8. star, globular cluster, galaxy, galaxy cluster, universe
9. Using one of his best telescopes, Herschel was able to break up the fuzzy regions of the Milky Way into individual stars.
10. A: spiral galaxy, B: elliptical galaxy, C: irregular galaxy, D: globular cluster
11. elliptical
12. The spectra from galaxies are redshifted; the galaxies are moving away from us.
13. In the past, the universe must have been very small and unimaginably dense.
14. eye-controlled wheelchair, cooling suits for race car mechanics, means of detecting breast tumours
15. Gamow predicted that the cosmic microwave background radiation in the universe had cooled to about −269°C, and it was accidentally verified by Wilson and Penzias.
16. **e.** The big bang happened.
    d. The earliest stars form.
    c. The Milky Way galaxy formed.
    a. The Sun and solar system formed.
    b. The cosmic microwave background radiation cooled to −270°C.
17. Scientists can observe its effects on the stars in our galaxy and on the stars in other galaxies.
18. It seems to be in spherical halos around galaxies.
19. The universe is expanding so it must have started from something. It must have been compact and dense to contain the matter required for the universe.

Thinking and Investigation

20. If the stars in the sphere around a galaxy are old, then that part of the galaxy must have formed first.
21. around 72 km/s/Mpc
22. The spectra of galaxy A will be blueshifted. The spectra of galaxy B will be redshifted. The spectra of galaxy C will not be shifted at all.

23.



Communication

24. By studying globular clusters, astronomers learned that they appear only around the centre of the galaxy, so astronomers learned that the centre of the Milky Way is surrounded by globular clusters. Globular clusters are old, so that part of the Milky Way likely formed first.

25. Astronomers theorized that the leftover radiation from the big bang should exist and should be around 269°C; Arnos and Penzias accidentally found the evidence to confirm the theory. Also, thanks to Hubble and Humason's discovery of the distance-redshift relationship, astronomers know that the universe is expanding.

26. Electric tools that did not need to be plugged in were first developed for the first moon landing (1969) for drilling into the moon to collect samples.

27. Charts may vary but should include information such as the cost of a single shuttle launch (approximately $450 000 000 US), the cost of a replacement space shuttle (approximately $2 000 000 000 US), and the risk to those aboard the shuttle—seven astronauts died during the Challenger launch disaster and another seven astronauts died when Columbia broke up on re-entry.

28. Hubble and Humason's distance-redshift relationship: the universe's expansion has been confirmed by observations at very large distances and, therefore, a very early time in the history of the universe. The cosmic microwave background radiation cooled to –270°C, which was the expected temperature for this time after the big bang.

Application

29. astronomer, cosmologist, astronaut, technical artist

30. Objects that are farther away look young because it takes light so long to travel from them to Earth that we are actually seeing them as they were millions or billions of years ago.

31. **a.** warp 9.9 = 3000 × 300 000 km/s = 9×10^8 km/s; 11.68 h

b. Using the distance 28 000 in years gives 9.34 years.

c. Using a diameter of 100 000 light-years gives 33.33 years.

d. Circumference ~176 000 light-years yields 58.67 years.

Unit 3 Projects

Inquiry Investigation
Simulating a Cosmic Event (Student textbook page 390)

Pedagogical Purpose

This investigation allows students to research and simulate a cosmic event. They will determine the conditions before, during, and after the event, and how it might affect Earth if it occurred nearby.

This project is an opportunity for students to demonstrate the understandings and skills they have developed in this unit about the solar system, galaxies, and stars. It also provides an opportunity for students to assess their work.

Planning	
Materials	Internet access Book the computer lab for research. A month before the assignment, collect newspaper articles or magazines on recent astronomy events. **BLM 9-14 Inquiry Investigation Simulating a Cosmic Event** (optional) **BLM A-48 Unit 3 Inquiry Investigation Rubric** (optional)
Time	• 1–2 weeks (in and out of class) for research • 1–2 h to write, practise, and deliver presentations

Background

The universe is dynamic and full of events happening every day. Some events discussed in the textbook are eclipses, tides, asteroid/comet impacts (on Earth and Jupiter), a bright comet passing through the inner solar system visible from Earth, solar flares, aurora borealis, supernova explosions, and the big bang. Some of these events are easily observed and not dangerous. Other events, if they occur near Earth (such as a supernova), could cause great damage to people (for example, severe radiation).

Activity Notes and Troubleshooting

- Talk with students about simulations they have observed. One example is in Activity 7-4, on page 303 of the student textbook, where students dropped marbles into flour to simulate crater formation. Other examples may include the predator-prey simulation described in Instructional Strategies for section 2.2 or a special effect that they created or observed during a drama presentation.
- Tell students that a simulation shows a process or an event. Students will need to show before, during, and after the event, as they are directed in the student textbook.
- Tell students how you would like them to list references. Provide examples.
- Encourage students to have a classmate observe their completed simulation to ensure that they have met all of the assessment criteria.
- You can guide and assess students' simulations using **BLM A-48 Unit 3 Inquiry Investigation Rubric.** Make this rubric available to students before they begin their work.

Additional Support

- ELL This project may be more accessible for English language learners than An Issue to Analyze.

• DI Some groups may produce a more visual presentation (a skit or song) while other groups may use computer software to "simulate" the event and present their work using computer slide-show presentation software. Encourage all creative solutions, but remind students that the primary objective of their simulation is to convey information about the cosmic event that they have chosen.

Rubric

ACHIEVEMENT CHART CATEGORY	Level 1	Level 2	Level 3	Level 4
Knowledge & Understanding	A list of cosmic events is developed with limited accuracy.	A list of cosmic events is developed with some accuracy.	A list of cosmic events is developed with considerable accuracy.	A highly accurate list of cosmic events is developed.
Thinking & Investigation	The hypothesis is written with limited accuracy and clarity. The simulation of the cosmic event has limited effectiveness. Student presents an analysis of possible observations of cosmic events with limited effectiveness. Student evaluates the accuracy of the simulation and proposes possible improvements to the design with limited effectiveness.	The hypothesis is written with some accuracy and clarity. The simulation of the cosmic event has some effectiveness. Student presents an analysis of possible observations of cosmic events with some effectiveness. Student evaluates the accuracy of the simulation and proposes possible improvements to the design with some effectiveness.	The hypothesis is written with considerable accuracy and clarity. The simulation of the cosmic event has considerable effectiveness. Student presents an analysis of possible observations of cosmic events with considerable effectiveness. Student evaluates the accuracy of the simulation and proposes possible improvements to the design with considerable effectiveness.	The hypothesis is written with a high degree of accuracy and clarity. The simulation of the cosmic event has a high degree of effectiveness. Student presents an analysis of possible observations of cosmic events with a high degree of effectiveness. Student evaluates the accuracy of the simulation and proposes possible improvements to the design with a high degree of effectiveness.
Communication	Information is organized with limited effectiveness. Student communicates information verbally and graphically for selected audience and purpose with limited effectiveness.	Information is organized with some effectiveness Student communicates information verbally and graphically for selected audience and purpose with some effectiveness.	Information is organized with considerable effectiveness. Student communicates information verbally and graphically for selected audience and purpose with considerable effectiveness.	Information is organized with a high degree of effectiveness. Student communicates information verbally and graphically for selected audience and purpose with a high degree of effectiveness.

An Issue to Analyze
Canadian Space Missions: To Go or Not to Go? (Student textbook page 391)

Pedagogical Purpose

The purpose of the project is to provide students with an opportunity to consider the extent to which money spent by the Canadian government and Canadian Space Agency is worthwhile. Ask, "Should Canada be performing research in space, or sending astronauts into space?" "Is the risk of doing this research acceptable?"

Planning	
Materials	Internet access, Canadian Space Agency materials Book the computer lab for research. A month before the assignment, contact the Canadian Space Agency and NASA for materials on their various programs **BLM 9-15 An Issue to Analyze Canadian Space Missions: To Go or Not to Go?** (optional) **BLM A-49 Unit 3 An Issue to Analyze Rubric** (optional) **BLM G-16 Tips for Investigating Many-Sided Issues** (optional) **BLM G-17 Worksheet for Investigating Issues** (optional)
Time	• 1–2 weeks (in and out of class) for research • 1–2 h to prepare report and presentation

Background

Spending money on space exploration has always been a debated issue. Crewed and uncrewed space exploration is a well-known topic, and the costs always get media attention. For example, NASA's annual budget is approximately $15 billion, which is for space- and non-space-related research, such as aerospace research. However, Americans spend twice this amount on their pets and 40 times this amount on gambling. Other similar comparisons can be made.

Most of the money that NASA spends is for payroll—salaries for very technical, smart people. Their research results in new discoveries that could help us tremendously here on Earth. For example, developing energy systems for outposts on the Moon or Mars may open new energy resources we can use on Earth.

The picture of Earth rising over the Moon taken by the *Apollo 8* astronauts in 1968 has been given credit for creating the wave of interest in protecting Earth and for creating Earth Day, which we celebrate every April 22nd. Space exploration is also a refreshing example of humans working together to learn things and explore, and not fight with one another. Humans have always been a curious species, eager to explore and learn new things. Space exploration is truly the "final frontier" when it comes to this exploration. How do you put a cost or value on this?

However, an argument against spending money on space exploration is that the money could be better spent here on Earth, making sure everyone is properly fed, clothed, and sheltered. Should money for space research be diverted to these causes? If it were, what might the outcome be? It is possible that discoveries made through space research will one day help to solve many of the problems we have here on Earth.

Activity Notes and Troubleshooting

- If possible, have students listen to a simple speech, and then analyze the main parts of the speech with them. Ensure that students understand the importance and structure of these parts, and build them into their project:
  1. Introduction (getting the audience's attention, stating your point of view)
  2. Points supporting the point of view (with evidence)
  3. Conclusion (summarizing the weight of evidence, restating your point of view)

- Refer students to Study Toolkit 4, Organizing Your Learning: Using Graphic Organizers, on page 566 of the student textbook.
- Encourage students to have a classmate read their report to ensure they have met the assessment criteria.

Additional Support

- Students can use **BLM G-16 Tips for Investigating Many-Sided Issues,** to help them express support for their opinion, or **BLM G-17 Worksheet for Investigating Issues,** to help them explore several points of view.
- ELL Some students, including some English language learners, may wish to present their project in an alternative format. Ensure that their chosen format allows them to clearly state and support a point of view.

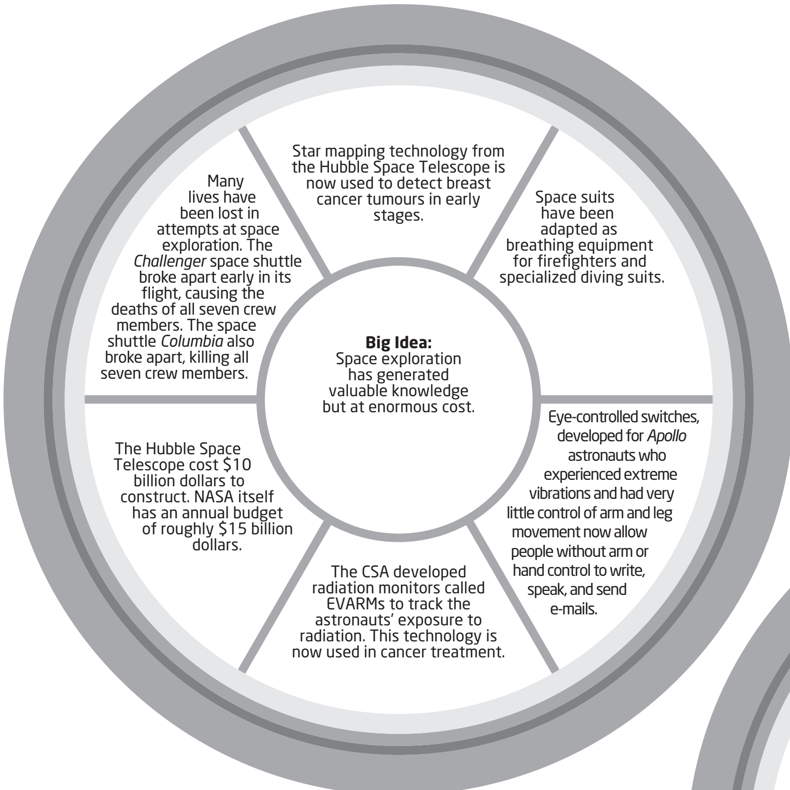
Rubric

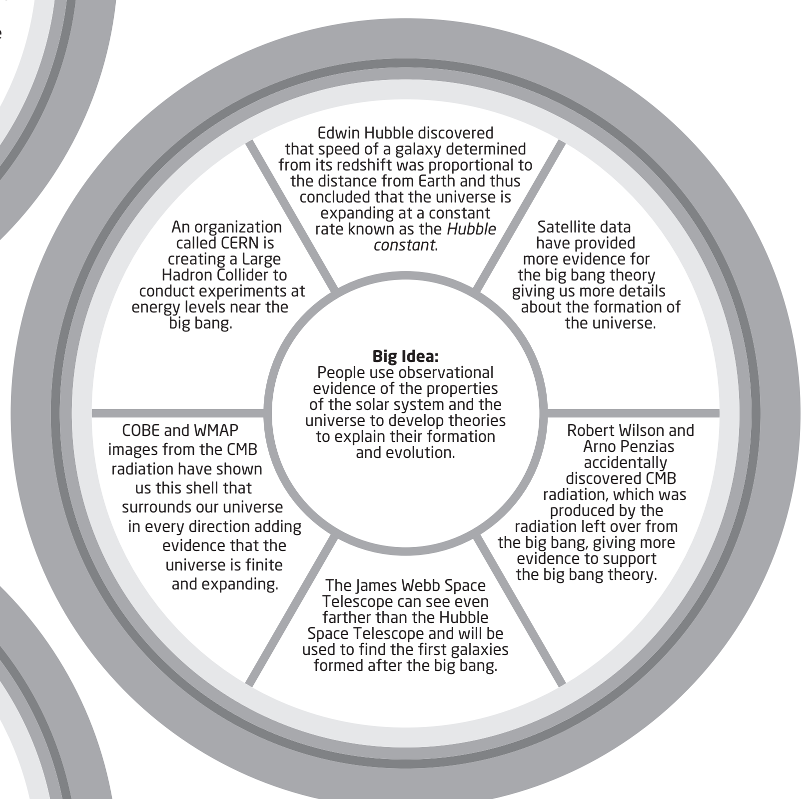
ACHIEVEMENT CHART CATEGORY	Level 1	Level 2	Level 3	Level 4
Application	Student describes the risks from multiple perspectives with limited effectiveness. Student describes supporting evidence from varying perspectives with limited effectiveness.	Student describes the risks from multiple perspectives with some effectiveness. Student describes supporting evidence from varying perspectives with some effectiveness.	Student describes the risks from multiple perspectives with considerable effectiveness. Student describes supporting evidence from varying perspectives with considerable effectiveness.	Student describes the risks from multiple perspectives with a high degree of effectiveness. Student describes supporting evidence from varying perspectives with a high degree of effectiveness.

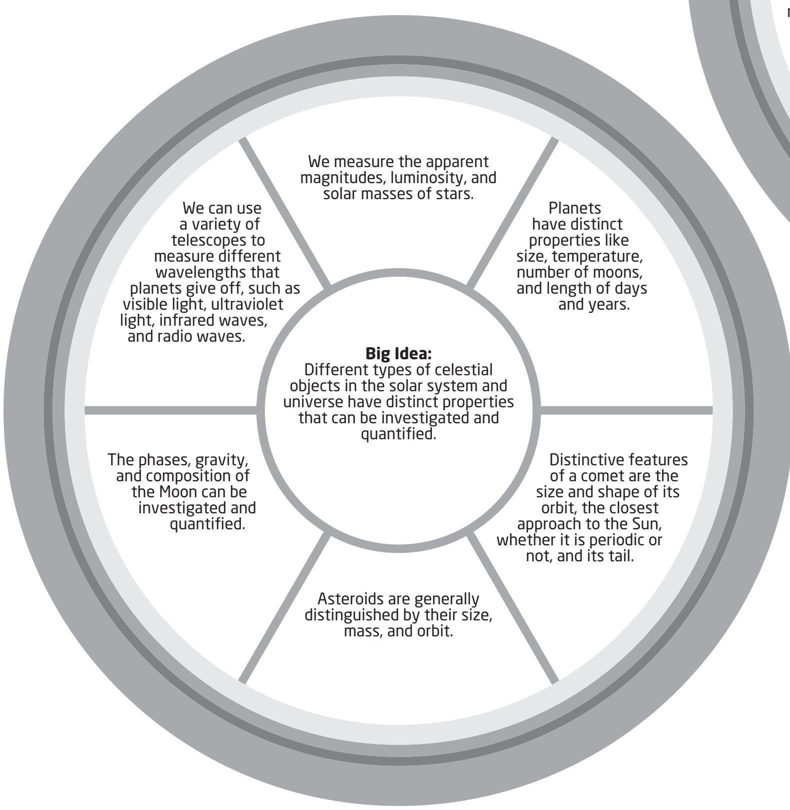
Unit 3 Review Answers (Student textbook pages 392 to 395)

Connect to the Big Ideas

Connect to the Big Ideas answers are also available as a Blackline master on the accompanying CD.







Knowledge and Understanding

1. **c.** heliocentric
2. **d.** spectroscope
3. **b.** 10 billion years
4. **a.** elliptical
5. **b.** 23 percent and 73 percent
6. **a.** C
   b. A
   c. D
   d. B
7. Stars form from a star-forming nebula, which collapses and contracts. The gas compresses and the temperature increases. When the temperature reaches 10 000 000°C, nuclear fusion begins. Students' diagrams should be similar to Figure 8.18, on page 334 of the student textbook.
8. solar sebula theory: gas and dust in a nebula collapse due to gravity → create protostar → nebula begins to spin and contract → rocky lumps called planetesimals form → planets form
9. A radio telescope can be used 24 hours a day, day or night, in clear or cloudy weather.
10. **a.** the Sun
    b. sirius
    c. rigel (greatest absolute magnitude)
    d. No. Rigel is the farthest away but has the greatest absolute magnitude.
11. The Sun is not massive enough to become a supernova, and then a black hole.
12. mass
13. low-mass stars: form out of a nebula → collapse into a protostar → form red dwarf star → exist for up to 100 billion years → lose mass, become a white dwarf → cool into black dwarfs

    intermediate-mass stars: form out of a nebula → collapse into a medium protostar → exist on main sequence for 10 billion years → core collapses when hydrogen is used up → temperature increases, outer layers expand into a red giant star → outer layers disappear forming a white dwarf

    high-mass star: form out of a nebula → collapse into a large protostar → exist on main sequence for less than 10 billion years → higher temperatures form heavier elements by fusion → become supergiants → core collapses, explode as a supernova → become a neutron star or a black hole
14. Observations show galaxies are redshifted, which means that they are all moving away from each other. The universe is expanding, resulting from an initial explosion that we call the big bang. Theoretical evidence has caused scientists to include dark energy in their model of the expanding universe to account for the continued acceleration of matter away from the origin.
15. **a.** The terms *dark matter* and *dark energy* were created by astronomers to explain the missing mass in the galaxy.
    b. Their existence would explain what is observed. The dark matter would make up for missing mass and the dark energy would explain the acceleration of the universe's expansion.

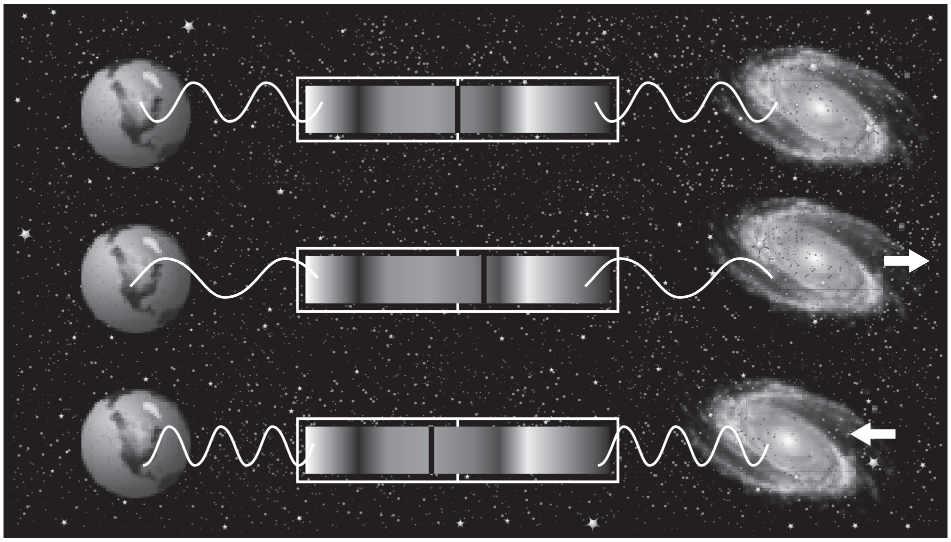
Thinking and Investigation

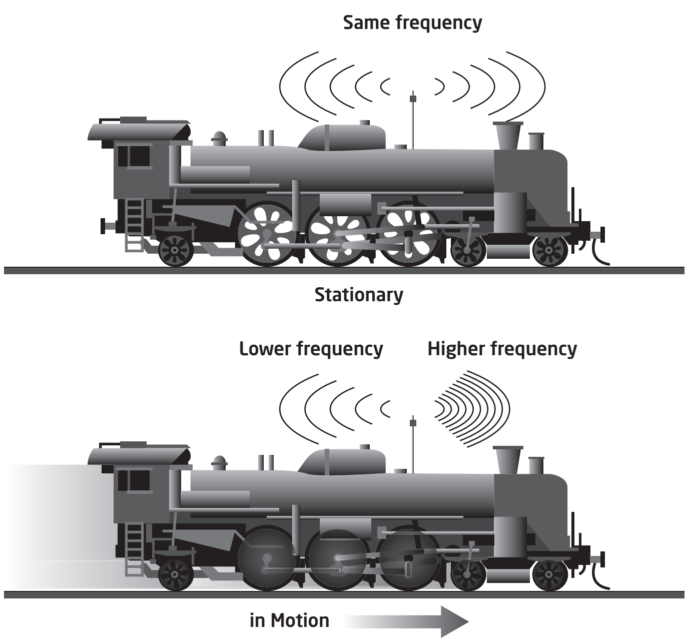
16. Since Earth is in an elliptical orbit, its distance to the Sun varies so an average is taken as the astronomical unit.
17. Earth has weather which erodes craters over time. Mars' thin atmosphere slowly erodes craters over time (dust storms), and Mercury has no atmosphere so the craters are only eroded by other impacts which make more craters.
18. Beyond Mars, the light from the Sun is too weak to power a spacecraft using solar panels. These spacecraft use nuclear energy to supply electricity.
19. colour, temperature
20. They move objects which are "weightless," meaning they do not have weight in the space environment. They do have mass and the arms have to be careful as they push these objects around. Since the Canadarm and Canadarm2 do not have to lift the weight of the objects in space, they can be made lighter.
21. The universe was very hot, and as it expanded, the wavelengths of the gamma rays stretched. As they stretched, the radiation changed from gamma rays to visible light, and as the universe continued to expand, the wavelengths stretched farther until they slipped into other parts of the electromagnetic spectrum. Waves in these parts of the spectrum have longer wavelengths and carry less energy.
22. **a.** There are always three satellites above the horizon at any one time, to provide accurate readings of positions on Earth.
    b. Students may suggest that spare satellites could be used if one breaks down.

Communication

23. Some students might say that the cost of building and maintaining the International Space Station, as well as sending a crewed mission to Mars, would be spread across many countries, and these projects are important for space travel and research. However, they might also point out that the money should be spent on solving problems on Earth, such as providing food, shelter, and clothing for people who need it.

24. The Doppler effect can be shown by either of the following diagrams:





25. All planets provide an opportunity for further study of the planet's surface, atmosphere, and natural moons. Surface study of the gas giants is not possible, however.

26. eject → intense streams of charged particles → damage → electronic equipment aboard spacecraft → cause large-scale blackouts → charge → gasses in Earth's atmosphere → generate → electric currents that flow toward Earth's poles → produce aurora borealis

27. Shapley observed globular star clusters only in the direction of the constellations Hercules, Scorpius, Ophiuchus, and Sagittarius (in a sphere about the centre of the Milky Way galaxy). Since they always appeared in that position in the sky, he concluded that Earth must be far away from them. Since Earth is close to the Sun, he then concluded that the Sun must be nowhere near the globular clusters.

28. The rate of expansion is greater for two points that are a greater distance apart on the surface of an expanding balloon. In Hubble's law, the expanding velocity between two galaxies is greater when there is a great distance between the two galaxies.

Application

29. If a planet's polar axis is tilted, it could experience seasons (for example, Mars experiences seasons).

30. The North Star can be used for navigation as it is always due north. Southern constellations can be used for rough navigation. Rising constellations are roughly in the east and setting constellations are roughly in the west.

31. A calendar provides a schedule for farming, such as when to sow and harvest crops, which can then feed many people and allow a civilization to grow.

32. For: These projects can inspire young people to study science and technology, which is critical for our future. We can learn new things, and benefit from the knowledge obtained from Canadian satellites.
Against: The money could be better spent on Earth.

33. Students' graphic organizers will vary. Ensure they support their opinion with facts and present their ideas clearly.

Literacy Test Prep

Multiple Choice

34. c

35. b

36. d

37. a

Written Answer

38. Students' summaries will vary. Possible answer: Just as vibrations cause the ringing sound made by a bell, vibrations cause stars to "ring" as well. In the Sun's core, energy is transferred to the photosphere where it escapes, producing bubbles on the photosphere, and causing movement that we can see using special cameras.