CHAPTER 12 OPENER, pp. 426–427

USING THE PHOTO AND TEXT

After reading the text on page 426, have students examine the photograph of the field of galaxies taken by the Hubble Space Telescope.

This telescope has changed astronomy—its discoveries in just under 20 years have forced astronomers to change the way they understand the universe. Ask students to predict why scientists would go to the trouble and expense to place a telescope in Earth orbit (above the atmosphere).

Almost all of the smudges in the photograph on page 426 are galaxies, and this photograph is just a part of a larger image that shows 10 000 galaxies! Imagine that every one of these galaxies contains 100 billion stars. We have learned that many stars near us have planets in orbit around them, so it is reasonable to think that many of these billions of stars have billions of planets. The question is whether any of these planets have life forms like us. Visit www.discoverscience9.ca for links to many images of space and the curious and beautiful features it contains. Where possible, take the opportunity to project these images for the class as a catalyst to cultivate students' imaginations.

USING THE WHAT YOU WILL LEARN/WHY IT IS IMPORTANT/SKILLS YOU WILL USE

Ask for student volunteers to read the What You Will Learn points aloud. Ensure that students understand the points and define the terms as required. How do they feel when they see how big the universe is and how many other galaxies and stars there are?

Have students read the Why It Is Important section, and ask them why it is important to understand how the universe and solar system formed. Do students expect to travel into space in their lifetimes? Do they want to go?

Encourage students to read the Skills You Will Use section, and ask them if they have ever looked at stars through a telescope. Did they know that stars are born, live, and die, and that they are different sizes, colours, and temperatures?

USING THE FOLDABLES™ FEATURE

See the Foldables section of this resource.

12.1 EXPLAINING THE EARLY UNIVERSE

BACKGROUND INFORMATION

A good starting point of discussion for this unit may be to ask students, "How far can you see?" The answers will vary depending on the geography surrounding the school, the position of the classroom, and the current weather. Raise the point of the limitations of human vision. From Earth, there may be several thousand stars visible to the naked eye on a clear night. Every star visible from Earth is part of our own galaxy, the Milky Way. The unaided human eye cannot distinguish stars outside our galaxy. To elicit students' background knowledge, ask, "How did ancient people learn about space?" It seems like a simple question, but you can expect a variety of answers and, more than likely, a few misconceptions. The historic progression of understanding was quite logical: observation, data collection, and development of technology, such as telescopes.

One hundredth of a second is less time than it takes to blink your eye. In one hundredth of a 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 a second was all the time needed to form the particles that would later create 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 very far back in time because the universe is believed to have started approximately 13.7 billion years ago. At 10^{-43} seconds, 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. So super-hot and super-dense was the initial expansion that, in these early moments, all the photon energy dominated the other matter, pushing it around in an unorganized mass.

According to some estimates, at 1 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 300 000 years, the universe had expanded to trillions and trillions of kilometres. Although it had cooled from its super-heated beginning, it was still extremely hot. Some structure started to take shape as the light was freed.

COMMON MISCONCEPTIONS

- Students may confuse the terms "astronomical unit" and "light-year." With this confusion may be the misinterpretation that light-years are a unit of time measure within our solar system. As students will see in this section, an astronomical unit is the distance between Earth and the Sun—very useful for distances within the solar system. A light year is much larger. While light takes only a few minutes to travel from the Sun to Earth, a light year is the distance light travels in one year.
- 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 observed data. This issue will be addressed as students 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). An analogy would have a mother and child being born at the same time.
- The red shift of light from receding galaxies is similar to the Doppler shift we hear when cars, emergency vehicles, or trains pass—the pitch of the sound changes as the vehicles approach and then recede. Some students may think that the change in pitch of a passing vehicle is caused by the sound being altered by the vehicle rather than its motion. As the section will describe, wavelengths (either sound or light) are affected by the relative motion of the source.
- Students often interchange the terms "galaxy" and "solar system." Explain that our solar system is one small part of our galaxy.
- When it comes to space tourism and people flying in space, many students will equate space travel with the ease of commuter air travel. Space travel is not so easy yet—maybe in a decade or two.

ADVANCE PREPARATION

- Several activities in this section require the use of balloons. It would be a good idea to buy a couple of bags of good-quality round balloons and some twist-ties.
- Consult the Unit front matter for a list of blackline masters that can be used when teaching this section.

Useful research materials for advance preparation can be found at www.discoveringscience.ca.

INTRODUCING THE SECTION, p. 428

Using the Key Terms and Section Summary

At the beginning of each section in the student textbook are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the Key Terms by scanning the text and using the Glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are important for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, and BLM 4-5, Chapter 12 Key Terms can be used to assist students.

Using the Did You Know, p. 431

Like many major scientific theories over time, the Big Bang theory has its opponents. New theories dealing with dark matter and dark energy as well as string theory attempt to explain weaknesses in the Big Bang theory. These topics are beyond the scope of Grade 9, except for the fact that they reinforce two themes in this unit:

1. Our knowledge of the universe comes in stages with new discoveries and theories, some which stand the test of time for centuries before they are replaced with new ones.
2. These new theories and discoveries come as our technology improves and we can see farther and clearer into the universe.

Using the Did You Know, p. 432

This is an excellent example of scientific serendipity. Students will be surprised after a bit of research how many discoveries happened by accident.

TEACHING THE SECTION, pp. 367–373

Using Reading

Divide the section in to three parts: Hubble's Proposal and the Big Bang Theory, The Origin of Our Solar System, and Technique for Indirectly

Measuring Distance. Discuss each part with students after they have read it, and before they move on to the next part.

Pre-reading— Key Term Concept Map

This section contains Key Terms that may be unfamiliar to many students. Before students begin reading, write "Early Universe" on the chalkboard, and work with students to create a concept map, connecting as many of the Key Terms as they can, as well as other ideas, to the early universe. After students have read the section, you can expand the concept map to include new ideas.

During Reading—Note Taking (Cornell Format)

- Have students take notes as they read through each paragraph. They can use the topic titles to generate questions and then take notes as a means of answering the questions.
- Encourage students to use the Reading Check questions on page 433 to check their understanding of the first chunk of text, and to review the text to find answers to any questions they were not able to answer on their own.

After Reading—Reflect and Evaluate

Have students review their notes and select three facts that they find the most interesting. Then, have them explain in writing why they found the information interesting. Alternatively, have them share their explanations in a class discussion.

Supporting Diverse Student Needs

Some students may wish to include diagrams as a significant part of their notes. Encourage the use of clear diagrams, with neat and thorough labels to convey scientific meaning. Display examples for the class, and review Science Skill 5 Scientific Drawing, on page 488 of the student textbook, with students.

Reading Check Answers, p. 433

1. Hubble noticed that all the galaxies are moving away from each other.
2. Hubble proposed that the universe is expanding in all directions, and that the galaxies have taken the same amount of time to reach their present positions from an original starting point.
3. (a) A spectrum is the pattern of colours seen when white light passes through a prism. The different colours represent light at different wavelengths.
   (b) If a galaxy's spectral lines are red shifted, it means that it is moving away from us.
4. The Oscillating theory states that the universe is closed and that there is enough matter in the universe to, through gravitational force, slow and ultimately stop the expansion of the universe, and even reverse it. According to this theory, all the matter will meet again in a Big Crunch.
5. Cosmic background radiation is the radiation left over from the Big Bang expansion.

Reading Check Answers, p. 439

1. The nebular hypothesis of solar system formation is that the Sun and planets formed when a large nebula condensed and was collected together by gravity.
2. Our solar system formed more than 4.5 billion years ago.
3. Inner or terrestrial planets and outer or Jovian planets
4. The distances are too great to be measured in astronomical units.

USING THE ACTIVITIES

- Activity12-1A, on page 439 of the student textbook, is best used after students have read pages 436 and 437.
- Activity12-1B, on page 440 of the student textbook, can be used any time during this section.

Detailed notes on doing the activities follow.

USING THE ACTIVITIES

Find Out Activity 10-2A

The Light-Year, p. 439

Purpose

- Students find out about the light-year and how long light and radio waves take to traverse the solar system.

Time Required

- 30 min

Science Background

A light-year is a unit of measurement for enormous distances. It is the distance that light travels in one year. Light travels at the speed of 300 000 km/s, and 1 light-year is equal to about 9.5 trillion km. The light from the Moon takes about 1.3 s to reach us, whereas the light from the Alpha Centauri star takes 4.3 light-years to reach us.

Activity Notes

- Students will have very little context to use to decide if their calculations are reasonable. Consider having students stand at appropriate distances from a central object to represent the distances in the activity. You could use a scale of

1 mm = 1 million km. The Sun would be 150 mm, or 15 cm away, Mars at its farthest would be 38 cm away, and Alpha Centauri would be 39 × 150 mm, or 585 cm away.

- Discuss students' answers to the What Did You Find Out? questions to explore the problems with communicating or traveling over these vast distances with them.

Supporting Diverse Student Needs

- Some students may need a reminder of how to calculate distance, when they know speed and time. Review the formula with them, and perform a sample calculation.
- Allow students to work in pairs or groups, with a logical-mathematical learner in each group to support them as they calculate distances and times.
- Students may need additional support with What to Do Step 6. Consider developing a plan to solve the problem as a group, then having students follow the steps you agree on to solve it on their own or with a classmate.

What To Do Answers

1. 300 000 km/s
   18 000 000 km/minute
   1 080 000 000 km/hour
   25 920 000 000 km/day
   9 460 800 000 000 km/year
2. 4 068 144 000 000 000 km
3. 150 000 000 km / 18 000 000 km/min
   = 8.33 min
4. 5.56 min, 21.1 min
5. 5.42 hours
6. 678 024 000 h or 77 400 years

What Did You Find Out? Answers

1. The values are very large.
2. A conversation would take a long time. If you said something to someone on Pluto, you would have to wait 10.8 hours for the round-trip time to hear a response.
3. You would never get there; your descendants would.

Find Out Activity 12-1B

Investigating the Relative Motion of Galaxies in the Expanding Universe, p. 440

Purpose

- Students investigate the relative motion of galaxies in an expanding universe.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Gather materials (prepare 25 cm lengths of string). Optional: Photocopy BLM 4-18, Find Out Activity 12-1B, Investigating the Relative Motion of Galaxies in the Expanding Universe.	For each group: – large, round balloon – twist-tie – felt pen – 25 cm of string – ruler

Time Required

- 30 min

Safety Precautions

- Remind students to watch for protruding wires in the twist-ties.

Science Background

Throughout history, philosophers have discussed the nature and formation of the universe. In 1929, Edwin Hubble made an extraordinary discovery while calculating distances to galaxies from Earth: all the galaxies he observed appeared to be moving away from us. An even more startling revelation suggested that galaxies farther away were moving the fastest. Hubble went on to propose that the universe is expanding in all directions, and that all the galaxies have taken the same amount of time to reach their present positions from an original starting point. The student textbook uses the analogy of a loaf of raisin bread baking in an oven. Think of the dough as space and the raisins as galaxies. As the dough (space) expands, the distance between the raisins (galaxies) increases. The distances between the dots on the balloon in this activity will increase relative to the distance from the M dot. Students should come to the same conclusion as Hubble: galaxies farther away from us are moving faster than those that are closer to us. This is a result that one would expect in an expanding universe.

Activity Notes

- As with any activity involving balloons, clear expectations should be defined. Besides inappropriate sound effects, there is the additional "hazard" of released balloons.
- Clothespins may be substituted for twist-ties. Ensure that students twist the balloon neck sufficiently to prevent loss of air.
- For the best effect, use round balloons.
- A flexible measuring tape may be substituted for the ruler and string.
- You may wish to distribute BLM 4-18, Find Out Activity 12-1B, Investigating the Relative Motion of Galaxies in the Expanding Universe, for students to complete.

Supporting Diverse Student Needs

- Encourage visual learners to use a diagram to explain their observations.
- This is a good hands-on activity for body-kinesthetic and visual-spatial learners. Ensure that each group includes learners with strength in these areas.
- For enrichment, challenge students to measure relative distances using different-shaped balloons. Have students explain how the different shapes provide different results for the expanding universe model.

What Did You Find Out? Answers

1. The galaxies farthest away from M would have their distances increase the most.
2. The galaxies closest to M would have their distances increase the least.
3. (a) This activity confirms what we would expect from an expanding universe: galaxies closer to the Milky Way are moving away at a slower rate than galaxies farther away.
   (b) Galaxies occupy all parts of the universe (in three dimensions), not just the outside of a sphere, like the balloon, which is two-dimensional.
4. Answers will vary, but should include the idea that the distances between points that are farther away from the Milky Way galaxy increase faster than those closer to our galaxy.

USING THE FEATURES

Science Watch: Trying to Simulate the Big Bang, p. 441

This feature is an excellent starting point for a discussion on how scientists theorize about events that happened billions of years ago. By smashing subatomic particles into each other at high speeds, scientists hope to simulate conditions that helped form the universe. Breaking protons into their component parts may enable scientists to determine how matter in the universe was created from the most basic of building blocks.

Science Watch Answers

1. A quark is a subatomic particle hypothesized to make up protons in an atom.
2. A particle accelerator is used to smash protons together to break them into the smaller pieces (quarks) of which they are composed.
3. Understanding quarks (and how they contribute to the structure of protons) will provide physicists with clues about how the very first atoms were formed in the early universe.

National Geographic: Visualizing the Solar System's Formation, p. 442

The formation of the solar system took millions of years. Gas and dust in the nebula began to condense due to a passing star of some other gravitational event. Once started, the gravity of the central mass collected more material until the Sun began to shine as a new star. The planets slowly began to emerge as larger bodies orbiting the Sun.

SECTION 12.1 ASSESSMENT, p. 443

Check Your Understanding Answers

Checking Concepts

1. Edwin Hubble estimated the distance to 46 galaxies and discovered a red shift in the spectra of galaxies, meaning that all galaxies were moving away from each other, and the speed at which they were moving apart varied depending on their distances from one another. He determined that it appeared that the galaxies started moving from the same area in space.
2. Electromagnetic radiation
3. A spectroscope is an optical instrument that acts like a prism to separate light into its basic component colours.
4. The red-shifting of the galaxies' spectra indicates that the distant galaxies are moving away from us. The cosmological red shift suggests that space itself is expanding and is evidence for the Big Bang theory.
5. The Big Bang theory states that the universe began 13.7 billion years ago. The universe started as an unimaginably tiny volume of space suddenly and rapidly expanded to immense size. In a very short time, all the matter and energy in the universe was formed.
6. The cosmic background radiation, which is the radiation left over from the Big Bang expansion
7. The temperature of the Big Bang was over 1 billion degrees Celsius but has cooled since then.
8. A nebula is a cloud of hydrogen gas and dust in-between the stars in a galaxy.
9. The gas and dust in the centre of the proto-planetary disc begin to collect, building up into bigger, rocky lumps called planetesimals. These planetesimals may develop into full-fledged planets.

10. The inner planets are relatively small and have solid cores and rocky crusts. The outer planets have large gaseous bands and cold temperatures.
11. A light year is the distance light travels in one year (9.5 trillion km)
12. (a) 1.3 s (b) 8 min (c) 41 min (d) 4.3 years (e) 2.5 million years
13. Parallax is the apparent change of position of distant objects caused by the change in position of observation.
14. The positions of a star with respect to background stars are observed six months apart, on either side of Earth's orbit. The distance can then be determined using triangulation.

Understanding Key Ideas

15. Hubble noted that the speed at which all galaxies were moving apart varied depending on the galaxies' distance from each other. Since it appeared that they had all started moving from the same area in space, he deuced that the universe was expanding.
16. As the raisin bread bakes, it expands and the raisins move away from each other.
17. (a) The Big Bang theory states that universe will continue to expand forever. This is an open universe.
    (b) The Oscillating Theory states that the universe will go through a series of Big Bangs and Big Crunches in an ongoing cycle. This is a closed universe.
18. It was necessary to get the spacecraft detectors into the cold environment of space to be able to detect this small temperature difference. This would be impossible from Earth which is much warmer than –270°C.
19. The blue areas show the slightly denser regions of the early universe. These areas, many scientists believe, are where galaxies formed as a result of gravity. Red shows the less dense regions that became emptier and emptier as the universe expanded.
20. (a) The cosmic background radiation is the radiation left over from the Big Bang expansion.
    (b) Dark areas of WMAP indicate dense areas of the early universe. Astronomers hypothesize that these patches show where galaxies formed.
21. The distances in space are so great, we cannot travel to measure them directly.
22. The light took 2.5 million years to reach us so this is a picture of what the Andromeda Galaxy looked like 2.5 million years ago.

Pause and Reflect Answer

Answers may include new satellites and telescopes in space seeing farther, in different wavelengths discovering cosmic background radiation, seeing far off galaxies, and seeing objects as they were billions of years ago just after the Big Bang.

Other Assessment Opportunities

Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

12.2 GALAXIES AND STARS

BACKGROUND INFORMATION

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.

The Milky Way is the name of the galaxy in which Earth is located. 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. 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. If we could design a rocket ship 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. This section of the student textbook deals with concepts such as the number of galaxies in the universe. It should be noted that current theory suggests that "dark energy" and a material called "dark matter" comprise about 96 percent of all the matter in the universe. Dark matter is invisible, and it is known only because of its observed effects. Astronomers believe dark matter is the reason stars in a spinning galaxy are not just flung into space but held together in a group by an incredible gravity explained only by unseen matter.

This section also deals with the life cycle and classification of stars. A star begins its life when large clouds of gas and dust collapse. This collapse causes the density and temperature to increase very quickly. A protostar is the infant star that is formed at the centre of the collapsing cloud. Early in its life, a protostar is not visible because the small amount of light it releases is blocked by the dust and gas that surround it. Protostars can be observed using infrared technology, which identifies the immense heat they generate. If the heat is sufficient, the nuclear reaction called fusion will take place. When fusion occurs, lighter elements (such as hydrogen) combine to make a heavier element (helium). The result is the release of an unimaginable amount of energy in the form of radiation. The light and heat we receive from our Sun is a result of fusion reactions. Scientists around the world are working hard to devise a way to harness fusion. Theoretically, if the hydrogen available in a single glass of water underwent fusion, it could produce the same amount of energy obtained from 70 000 boxcar loads of coal or over 2000 Churchill Falls hydroelectric dams. That would be enough electricity to power the lights for an entire city for a year.

After a star has used all its internal fuel of hydrogen, it will begin fusing heavier elements. This is a signal for the end of a star. Eventually, it will collapse on itself and explode in a massive explosion called a nova. Large stars would have a particularly impressive explosion called a supernova. After a star reaches its nova phase, it can take one of several paths depending on its size: small stars will become burnt-out chunks of rock called dwarfs floating through space; massive stars may collapse to become black holes or neutron stars.

Common Misconceptions

- Depending on the clearness of the night sky in the area in which they live, students may assume that all stars are the same colour (that is, white light). This section will illustrate that stars have a variety of colours and are, in fact, classified based on their colour.
- Students who are familiar with the term "black hole" may have been told that black holes trap light. For this to happen, light would have to be matter. It is the gravity of black holes that actually affects the paths of light by warping space itself. To get a better idea of this concept, think of what happens when you throw a ball to someone across a field. The ball stays up in the air for some distance before gravity pulls it to the ground. If you were able to throw the ball fast enough, it would escape Earth's gravitational pull. This is called "escape velocity." On Earth, escape velocity is about 11 000 m/s (about 40 000 km/h). This means you would have to throw the ball at that speed for it to escape Earth's gravity and go into space. In a black hole, the escape velocity for anything to overcome its gravitational pull is even greater than the speed of light. (The speed of light is the fastest velocity we know.) Therefore, because not even light can escape black holes, they are virtually invisible.
- Students may have a difficult time processing such concepts as the number of stars in a galaxy (billions or trillions) as well as the vast expanses of empty space—both within a galaxy and between galaxies. Assure them that many people have difficulty with these concepts.

Advance Preparation

- Gas discharge tubes are used in Activity 12-2B, on page 452 of the student textbook. If your school does not have any, it may be possible to borrow some from another school in your district. Inexpensive spectroscopes are available from any educational supply store or distributor.

Useful research materials for advance preparation can be found at www.discoveringscience.ca.

INTRODUCING THE SECTION, p. 444

Using the Text

After students read page 444 of the student textbook, have them work in pairs to create analogies by completing this sentence in as many ways as they can:

If stars are like ________ then galaxies are like ________ , because ________. You might start by giving them an example, such as, if stars are like fish, then galaxies are like oceans, because they contain lots of fish, and other material. Invite students to share their analogies with the class.

Using the Key Terms and Section Summary

At the beginning of each section in the student textbook are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the Key Terms by scanning the text and using the Glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are important for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, and BLM 4-5, Chapter 12 Key Terms can be used to assist students.

Using the Did You Know, p. 446

See the Pause and Reflect section on page 455 for more information on colliding galaxies.

Using the Did You Know, p. 449

Big numbers like 1 billion or 1 trillion take a long time to get used to. To understand the number 1 trillion (1×10^{12}), have students perform a short numerical experiment: How long would it take to count to 1 trillion if you counted one number per second? In other words, how long is 1 trillion seconds? Answer: Divide 1 trillion by 31 536 000 seconds in 1 year = 31 709 years!

TEACHING THE SECTION, pp. 445–450

Using Reading

Pre-reading—Key Word Concept Map

Clarify the meaning of the following Key Terms with students: "astronomical unit," "axis," "Big Bang theory," "cosmological red shift," "electromagnetic radiation," "galaxy," "light-year," "Oscillating theory," "nebula," "parallax," "planetesimal," "red shift," "revolution," "rotation," "spectroscope," "spectral lines," and "triangulation." Then discuss how these terms are related to the formation of the solar system and the universe. During reading, students can add definitions to the words in this list. After reading, students can identify word concepts that they wish to learn more about.

During Reading—GIST

As students read this section, have them write short summaries for each of the celestial bodies. Encourage students to keep their summaries to 20 words or fewer, highlighting the characteristics of each body.

Supporting Diverse Student Needs

- Remind students who have forgotten that words in boldface in the textbook are Key Terms that are important to know in order to understand the meaning of the text. Each Key Term is defined in the Glossary. Have students who need practice using a glossary work with a classmate and each look up two of this section's Key Terms to share with their partner.
- Have students who have difficulty summarizing text work in a small group and create their summaries as write-arounds. One student writes one key idea about a celestial body from the text, then another student writes about another celestial body. Students can each choose one point from their summary to share with the class, giving every student an opportunity to make a meaningful contribution.

After Reading— Reflect and Evaluate

Have students review their notes and select three facts that they find the most interesting. Then, have them explain (in writing) why they found the information interesting. Alternatively, have them share their explanations in a class discussion. Discuss the characteristics of each galaxy and what is similar and different. Discuss the life cycles and the different masses of stars and what is similar and different.

Reading Check Answers, p. 450

1. Gas (mostly hydrogen) and a small amount of dust
2. The mass of the star
3. The Sun will exist for 10 billion years. After 5 billion years, it expands into a red giant star, sheds much of its material into space, and then shrinks into a small dim white dwarf.
4. An explosion of a high mass star is called a supernova.
5. A black hole is black because it is the remnant of a star that is so massive, light cannot escape its powerful gravitational force.

USING THE ACTIVITIES

- Activity 12-2A, on page 451 of the student textbook, is best used after discussing the section on the sizes of stars (on page 450).
- Activity 12-2B, on page 452 of the student textbook, is best used after discussing the evolution of stars on pages 447 to 449.

Detailed notes on doing the activities follow.

Conduct an Investigation 12-2A

Sizes of Stars, p. 451

Purpose

- Students investigate the differences among the sizes of stars.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Collect research materials. Book time in the computer lab for research. Have students preview the investigation and bring in some materials that they could use to build a model.	Research materials Materials to build models

Time Required

- 60–90 min

Science Background

	DISTANCE FROM EARTH	MAGNITUDE	SIZE	MASS (SUN)	RADIUS (SUN)	COLOUR	LOCATION
VEGA	25 light-years	0.03	Blue giant	2	2	Blue-white	Lyra summer
CANOPUS	310 light-years	–0.72	White supergiant	8	65	White	Carina winter
THE SUN	1 AU			1	1	Yellow	
ARCTURUS	37 light-years	–0.05	Red giant	3.5	25	Red	Boötes spring
BETELGEUSE	520 light-years	0.45	Red giant	20	936	Red	Orion winter
RIGEL	800 light-years	0.18	Blue supergiant	17	78	Blue	Orion winter
DELTA ORIONIS (MINTAKA)	900 light-years	2.23	Blue giant	20	*	Blue	Orion winter

Activity Notes

- Have groups outline their research plans to you, and receive your approval before gathering information.
- Since students will be selecting materials appropriate for their model, schedule this investigation over two periods, with a couple days between them. In the intervening days, have students gather the materials they will need for their models.
- Emphasize that every group member must participate in the presentation and be able to explain the group's conclusions and the group's model.
- If possible, have groups select different stars to research, to avoid repetition in presentations.

Supporting Diverse Student Needs

- Verbal, visual-spatial, and logical-mathematical intelligences will be helpful to successfully complete this activity. Ensure that groups include learners with diverse strengths.
- Encourage groups to involve all members in a meaningful way.

Analyze Answers

1. Betelgeuse is the largest star; the Sun is the smallest star.
2. Red and blue-white stars seem to be larger than yellow stars.
3. Out of this sample, there may not be a true average star.

Conclude and Apply Answers

1. The yellow and red stars seem different; the yellow stars are cooler and smaller while the red giant is cooler but bigger.
2. Our Sun seems to be small compared to these stars. It should be pointed out that there are many other stars like the Sun in size and temperature.
3. Students' hypotheses should relate to the life path of two stars, based on their characteristics and should refer to the information they have learned.

Find Out Activity 12-2B

Spying Spectra, p. 452

Purpose

- Students investigate the spectra of different light sources.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Prepare and practise using the gas discharge tubes. Test a variety of angles for holding the tube so you may instruct students who are having difficulty.	For each group: – spectroscope – 4 different light sources (for example, Sun, fluorescent, incandescent, ultra-violet, energy-saver lamp, frosted light, holiday lights) – gas discharge tubes (for example, mercury, xenon, hydrogen, sodium) – paper – pencil – ruler – pencil crayons
Day of instruction	Assemble spectroscopes. Test all the materials. Optional: Photocopy BLM 4-19, Find Out Activity Spying Spectra.	

Time Required
- 45 min

Safety Precautions
- Remind students never to look directly at the Sun.
- If you are using a gas discharge tube, ensure the tube is safely mounted in a place where it cannot be knocked over.

Science Background
Any student who has seen a rainbow, watched light reflect off a DVD, or observed the sparkle of sunlight off freshly fallen snow has experienced the concept of spectra. A spectrum occurs when a source of light is broken into its constituent parts—the rainbow of colours. The visible spectrum is the light we can see. Astronomers use the spectra produced by stars to analyze a number of characteristics of that star. A star's spectrum is like a fingerprint, which can identify that star. This allows astronomers to tell stars apart, as well as examine similarities between stars. When we see a rainbow, we are observing a continuum spectrum—a spectrum where the colour pattern is continuous. When light comes from a gaseous source (for example, hydrogen, helium, neon), the result is coloured lines, called spectral lines, or emission spectra. The third type of spectrum is an absorption spectrum. This spectrum occurs when light passes through a cold, dilute gas and results in black lines in the spectrum.

In this activity, students will be comparing spectra of different light sources. The purpose is to illustrate that different light sources produce different spectra. If gas discharge tubes are available, students will be able to see how each element has its own signature. By observing a spectrum of a star, astronomers can compare the spectrum with the specific elemental spectra to determine the composition of the star.

Activity Notes
- Much of the success of this activity depends on the quality of the spectroscopes. Even inexpensive spectroscopes can provide students with the data they need.
- It is important that students learn about the nature of spectra and spectral lines prior to this activity. This knowledge will help them know what to look for as they perform the activity.
- If you have trouble obtaining useful spectra using the equipment provided, you can use data you find online. See www.discoveringscience.ca for some links. Consider working with your school's physics teacher on this activity.
- Have interested students create a poster on star composition, which will be an excellent learning tool. After the activity, you should reinforce the idea that spectra are related to the composition of the star.
- You may wish to distribute BLM 4-19, Find Out Activity Spying Spectra, for students to use for their drawings.

Supporting Diverse Student Needs
- Students who are not able to see certain colours will have trouble completing this activity on their own. Have them work with a classmate who can help them distinguish and identify the colours in the spectra.
- This activity is suited to students with visual-spatial, body-kinesthetic, and inter-personal intelligences. If possible, ensure that groups include at least one student with strength in these areas.
- As enrichment, students could try a larger variety of light sources (for example, black light or heat lamps). Note: Extreme caution should be used when observing bright light sources.

What Did You Find Out? Answers

Part 1 Analyzing Light Spectra

1. Answers will vary depending on the spectroscope. If the inexpensive cardboard spectroscopes are used, students will most likely refer to the sides of the tube as the place where the spectrum is visible.
2. The colours of the spectra all appear in the regular order: red, orange, yellow, green, blue, indigo, violet.
3. Changing the angle of the spectroscope elongates the image of the spectra on the inner wall of the tube. If the angle is too acute, it will be difficult to see the spectrum.

Part 2 Analyzing Gas Spectra

4. Answers will vary but should include the position of spectral lines in the spectra from the gas discharge tubes. The different gases will produce different patterns.
5. By analyzing the spectra of a star, and comparing the results with the spectra from known elements, astronomers can determine the elements that make up the star.

USING THE FEATURES

Career Connect: Radio Astronomer, p. 453
This feature illustrates the wide variety of professions associated with astronomy. When visualizing what an astronomer does, students may conjure up an image of a person peering through the small end of a massive refracting telescope. This feature shows the different types of astronomy as well as the varied information that different technology provides.

Career Connect Answers

1. Canada-France-Hawaii Telescope (optical, reflecting) and the Gemini telescopes (optical, reflecting) on the ground; the Spitzer Space Telescope (infrared) and the Hubble Space Telescope (optical, reflecting) in space.
2. Space telescope time is very expensive and hard to get so he would use land-based telescopes for some work. He may need to observe with space-based telescopes to see in a certain wavelength.
3. Computer programming

Science Math Connect: Way Faster Than A Speeding Bullet—the Speed of Light, p. 454

The purpose of this feature is to reinforce the idea that light-years are a unit of distance rather than time. The fastest velocity determined by humans is the speed of light. The feature explains how the actual velocity of light was determined, from the first calculations by Ole Rømer in the late 1600s to today's accepted value of 300 000 km/s. The exercise will illustrate the vast distances in space and the need for a very large unit with which to measure these distances.

Science Math Connect Answers

1. $2 \times 25\,000 = 50\,000$ years
2. 855 trillion ÷ 9.5 trillion = 90 years
3. $(300\,000 - 298\,000) \div 300\,000 \times 100\%$ $= 0.7\%$

SECTION 12.2 ASSESSMENT, p. 455

Check Your Understanding Answers

Checking Concepts

1. Hydrogen gas
2. A galaxy forms when gravity causes a large, slowly spinning cloud of gases, dust, and stars to contract.
3. (a) A: spiral B: elliptical C: spiral
   (b) a spiral galaxy
   (c) an irregular galaxy
   (d) an elliptical galaxy
   (e) a spiral galaxy
4. When two galaxies pass close to each other (one larger than the other), one galaxy can pull the other galaxy apart and eventually pull the pieces into its own structure.
5. A star forms from the materials in a nebula. Gravity pulls chunks of gas and dust together forming a protostar. If the protostar grows large enough, the central temperature will be hot enough to start fusion and the star will give off heat and light.
6. (a) Low mass stars exist as dim, cool red dwarfs. They burn their hydrogen fuel slowly and may last 100 billion years. They change into hot, small, dim white dwarfs and quietly burn out.
   (b) Intermediate mass stars burn the hydrogen fuel faster and last only 10 billion years. After a long period of stability, an intermediate mass star expands into a red giant. It sheds much of its material into space and collapses in on itself, shrinking into a small, dim white dwarf. It ultimately ends up as a dense, black dwarf.
   (c) High mass stars consume their fuel faster, becoming red giants. The life of an average high mass star will last for only 7 billion years and come to a much more violent end. They collapse in on themselves, causing a dramatic, massive explosion called a supernova.

Understanding Key Ideas

7. Radio and infrared telescopes are able to detect and record wavelengths of electromagnetic radiation that we cannot see with our eyes.
8. Hydrogen atoms fuse together to form larger helium atoms, releasing an enormous amount of energy.
9. Eventually, all the stars in the universe will lose their fuel and burn out—some with large explosions; some with small flickers.
10. B. nebula; A. star; C. red giant; D. white dwarf
11. The dying star releases its material into space. Higher mass stars release heavier elements into space.
12. It contains a lot of mass in a very small package.
13. Material pulled toward the black hole emits electromagnetic radiation. The gravity of black holes affects passing stars and galaxies. Observations confirm the computer models that show that super-dense objects distort light from distant stars.
14. Quasars get their energy from the gravitational energy of matter falling into the black hole, which makes them the brightest objects that we know of in the universe.

Pause and Reflect Answer

Answers may include disrupting a galaxy like our Milky Way galaxy if it were to ever collide with another galaxy. Although the risk of stars colliding is small (there is a lot of empty space in a galaxy), it could happen. Also the gravity of a large star could throw our Sun out of the galaxy.

Other Assessment Opportunities

Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

12.3 OUR FUTURE IN SPACE

BACKGROUND INFORMATION

Most students should be aware of telescopes (specifically, optical telescopes) and their uses. Lead students back into the discussion of telescopes by having them imagine using a telescope to observe a star. Ask, "What kind of information can you get from an optical (visual) telescope?" Students' answers may include the following:

- colour of a star (reveals temperature, relative age, and composition)
- size of a star
- type of star (for example, red giant, blue supergiant, white dwarf)

The discussion can progress to information provided by telescopes that is unavailable using only the naked eye. Challenge the notion that everything must be "seen" in order to exist. Ask, "Is all the information we receive from space visible?" If the response is limited, ask students if the only sense they use in their daily lives is sight. Ask, "What other senses are used to gather information?" This discussion should lead students to think about things like touch (heat and infrared) and sound (radio waves transformed into sound on the radio).

The natural progression will be to introduce concepts like invisible forms of radiation such as X rays and ultraviolet rays. All of these concepts help to show that the universe is a far more complex and amazing place than can ever be imagined.

COMMON MISCONCEPTIONS

- Students may not realize that telescopes can be used to observe light in frequencies beyond the visible spectrum. They may have experienced infrared cameras for night vision but telescopes to detect radio, gamma ray, and X ray radiation will likely be new concepts.

ADVANCE PREPARATION

- Assemble resource material for the three activities that are research-oriented.

Useful research materials for advance preparation can be found at www.discoveringscience.ca.

INTRODUCING THE SECTION, p. 456

Using the Text

Based on the title of the section alone, have students predict what the section will be about. Write their ideas on the chalkboard. Then read the summary on page 456 together, and encourage students to refine their predictions. Finally, have students preview the headings and figures in the section and add to their prediction.

You might discuss possible futures in space with students, and ask them to categorize any ideas they have about what those futures may include as short-term or long-term.

Using the Key Terms and Section Summary

At the beginning of each section in the student textbook are the Key Terms and section summary. Both can be used as a pre-reading strategy and a review tool. Before reading the text in the section, students should be able to define the Key Terms by scanning the text and using the Glossary. The Key Terms include terms from the curriculum outcomes and additional terms that are important for students to know and understand.

The section summary provides an overview of the key concepts being covered in the section. Students may not know all the concepts and terms described in the summary, but they can use this information to help guide them through their reading.

After reading the section, students can go back to the Key Terms and section summary to consolidate their understanding and identify areas that require clarification. At the end of the chapter or unit, students can use the Key Terms and section summary for review. BLM 4-2, Unit 4 Key Terms, and BLM 4-5, Chapter 12 Key Terms can be used to assist students.

Using the Did You Know, p. 458

Orbital telescopes require this kind of speed to remain in orbit. Ask students to calculate how long it takes the Hubble Space Telescope to travel from Vancouver to St John's Newfoundland (approximately 7500 km – < 10 min.)

Using the Did You Know, p. 463

NASA had no way of controlling where the Skylab would land. Ask students if they think spacecraft in orbit should be controllable so that when they come down they can be directed into the ocean instead of falling on land. Have students explain their answers.

TEACHING THE SECTION, pp. 456–464

Using Reading

Pre-reading—K-W-L (Know-Want to Know-Learned)

Have students work with a partner to develop answers to the question, "What do I know about the benefits and risks of spaceflight?" Then, have them review their answers and record questions that they have about spaceflight. Have students share their questions as a class, and have them use chart paper to group their questions into categories. For example, Category 1: benefits of spaceflight—spinoffs; Category 2: risks of spaceflight; and Category 3: my future in space. Post the chart paper where it can be referred to easily. As students work through the section, prompt them to return to the chart paper and see if some of the questions they had can now be answered.

During Reading—Note Taking

Encourage students to take notes as they read through each subsection. They can use the topic titles to generate questions and then take notes as a means of answering those questions.

Supporting Diverse Student Needs

- Intrapersonal and Existential learners may be interested in considering some of the questions in Table 12.1 in more detail, perhaps gathering information or preparing a presentation or debate for the class.

After Reading— Reflect and Evaluate

Refer to the chart of questions from the pre-reading activity. Have students identify which of the questions that they wrote about the benefits and risks of spaceflight were answered by reading this section. Ask, "What questions would require a little more research to answer?" "What category or categories of questions were answered most completely?" "How could you find more information about the questions that require more research to answer?"

Reading Check Answers, p. 464

1. Telescopes have provided us with close-up views of celestial bodies to help astronomers make new discoveries.
2. A refracting telescope uses lenses while a reflecting telescope uses mirrors.
3. Infrared telescopes enable astronomers to "see" through the dusty curtains of interstellar matter and into distant nebulas.
4. Equipment failure, being hit by space junk, solar radiation

USING THE ACTIVITIES

- Activity 12-3A, on page 465 of the student textbook, is best used after discussing the different types of space telescopes and their capabilities on pages 457 to 460.
- Activity12-3B, on page 465 of the student textbook, can be used any time in the section.
- Activity12-3C, on page 466 of the student textbook, is best used at the end of the section.

Detailed notes on doing the activities follow.

Think About It Activity 12-3A
Telescope Technology, p. 465

Purpose

- Students investigate how different types of telescopes are used to explore the universe.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Several weeks before	Collect articles from newspapers, magazines, and websites. Book computer lab for research.	Research material

Time Required

- 120 min

Science Background

The graphic on page 460 is a good overview of telescope technology used today. To obtain all the information from an object in space (that is, at all the available frequencies of light) all of these instruments plus land-based optical and radio telescopes may be used.

The different wavelengths of light tell us something different about the object. X rays and gamma rays are more energetic and reveal high energy activity. Infrared light cuts through gas and dust revealing details never seen before.

Spectroscopy was introduced in section 12.1. The use of spectroscopes on the Hubble Space Telescope could also be part of the study.

The groups might be made up to study different telescopes and therefore different areas of the spectrum. They should report on areas of study such as the solar system, star formation, galaxy formation, and formation of the universe. Reports could cover areas of study, what astronomers are trying to understand, problems astronomers are trying to solve, and recent discoveries that have been made.

Groups could present their findings to the class in a computer slide show presentation or a poster presentation.

Activity Notes

- This activity may be done in pairs or groups of three.
- Each telescope project has its own website with pictures and results.
- Ground-based telescopes, such as the Canada-France-Hawaii Telescope, Gemini telescopes, and Subaru telescope could be examined.

Supporting Diverse Student Needs

- While the three topics to choose from are all related, students may find that research related to Topic (a) will result in data that is more accessible to students with a basic understanding of astronomy. Topics (b) and (c) may involve more abstract and theoretical concepts.
- Encourage students to choose a creative presentation format that suits their own interests and abilities.

Think About It Activity 12-3B

A Career In Space Exploration, p. 465

Purpose

- Students research various careers related to space exploration.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Assemble information on space-related careers.	Research material

Time Required

- 60–120 min

Science Background

Astronaut: fly spacecraft, perform experiments, maintain/fix the spacecraft or space station, build the station using robotics, take a space walk

Biologist: design, build, perform experiments; analyze results and modify the experiment

Structural engineer: design spacecraft, space stations, satellites; oversee the construction, testing

Medical doctor: examine astronauts, note change to astronauts' bodies during spaceflight, design ways to help astronauts adapt to spaceflight

Pilot: fly spacecraft

Computer technician: design, assemble, maintain computers for spacecraft; write and repair software

Activity Notes

- Organize students into groups to research and present their findings. If possible, have each group research a different career to avoid repetition in presentations.
- Show students some job advertisements from print or electronic sources, to familiarize them with common styles and contents of these ads.
- Encourage students to find a meaningful role for every group member in the research and the creation of the advertisement.
- Encourage groups to have another group review a draft version of their job advertisement and suggest any improvements that would make it more useful to a job-seeker.

Supporting Diverse Student Needs

- You may wish to let students select a career that interests them, and form groups based on their selections.

Conduct an Investigation 12-3C

The Great Space Debate, p. 466

Purpose

- Students investigate the value of space exploration through debate.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Arrange for your class to have access to research materials.	For each group: – Internet access

Time Required

- 60–120 min

Science Background

The debate over the value of space exploration has raged since the dawn of the space age, back in the late 1950s. The scientific pursuit of knowledge can be an expensive endeavour and requires the support of the general public who, more times than not, fund such work. The fact that space can provide limitless opportunity is undeniable, but the question that is constantly being asked is, "Who will pay?" Space is no longer the realm of scientists and astronauts. It seems every month exposes a new player in the race to commercialize space, take it from the grips of governments and countries, and put the opportunities in the hands of private companies. Already, there have been several private citizens who have paid for the privilege to journey into space.

Space is quickly becoming a commodity: companies are rushing to put hotels in orbit and on the Moon, countries are vying to be the first to send probes to exotic alien worlds, and airlines are already selling tickets for zero-gravity excursions beyond the stratosphere.

The lust for economic gain in space is quickly outpacing and overshadowing the scientific perspective. Space was once a target of scientific discovery—an endeavour with feats that could unite the world with a common sense of awe and wonder. What has quickly become apparent is that funding that once seemed endless is actually very finite. Many people feel we should be looking a lot closer to home in an effort to solve problems we have created for ourselves on our home planet before we go searching for other worlds.

The purpose of this exercise is to get students thinking about all the issues involved in space exploration: scientific, moral, ethical, commercial, and even military. This is a generation that has never known a time when Mars did not have robotic explorers on its surface. It is important that students assess the issues for themselves. A cynic may suggest that, due to the exponential increase of technological advancement, we have lost some of our innocence with respect to space exploration. We once travelled into space to learn more about who we are as inhabitants of this little blue island in the ocean of the universe.

Activity Notes

- This activity may be done in pairs or groups of three.
- The activity works best when students are asked to research information to justify a view that they do not hold, for example, a pro-space-exploration student should research information that opposes space exploration.

Supporting Diverse Student Needs

- This activity is suitable for reflective students and those with strong intrapersonal and interpersonal intelligence. Interpersonal learners will be able to play a vital role by helping to keep the group on track, encouraging all groups members to make meaningful contributions, and helping to plan the presentation.
- As enrichment, students can research information through universities, organizations, or the Canadian Space Agency. They could draft a letter to these agencies soliciting expert opinions.

SECTION 12.3 ASSESSMENT, p. 467

Check Your Understanding Answers

Checking Concepts

1. It has a larger mirror.
2. Adaptive optics are used to improve the views of distant objects. Computers monitor the atmosphere while the telescope is being used, and small mechanisms slightly change the shape of the mirror to compensate for this distortion.
3. Some infrared rays, ultraviolet rays, X rays, and gamma rays are absorbed by the atmosphere and do not reach the surface of Earth.
4. The Hubble Space Telescope has provided images of some of the oldest galaxies ever observed and has helped astronomers solve many problems in astronomy, such as the age of the universe. It has also provided views of galaxies over 10 billion light-years away, showing us how galaxies looked not long after the Big Bang.
5. Astronauts who travel in space experience loss in bone density, they have to be protected from the cold of space, and equipment can break down.
6. Some examples are freeze-dried foods, high-tech running shoes, bicycle helmets, cold weather clothing, light sportswear, sunglasses, insulin pumps, eye examination systems, locator beacons, and self-repairing computers.
7. Terraforming Mars, which would require changing its atmosphere to be like Earth's, would be an enormous project that would be costly and would take many years to accomplish, if it is even possible. Terraforming Mars is unlikely to occur in a student's lifetime because it would take centuries to physically change the planet. An entire atmosphere and water cycle would have to be created.
8. Even small objects in space move at tremendous velocities. A small object could cause devastating damage to a spacecraft.
9. Answers would vary. Students may say that they would experience zero gravity or see the world from space.

Understanding Key Ideas

10. Reflecting telescopes use mirrors, which are lighter than lenses, and large mirrors do not cause as much distortion as large lenses do. Therefore, reflecting telescopes can be made larger than refracting telescopes.
11. Answers will vary but might include that the cost of getting the materials into space is

great; the telescope requires a greater sophistication of technology to keep it operational, and repairing the telescope is incredibly difficult and expensive.

12. (a) Used to explore the universe in visible, ultraviolet and infrared light; gives a clear view of old galaxies because it is above the atmosphere; has solved many problems; determined that the age of the universe is between 13 and 14 billion years.
    (b) New infrared telescope to be launched into Earth orbit in 2013 to help astronomers observe the first galaxies formed after the Big Bang.
    (c) Infrared telescope; detector must be cooled to –273°C; detects heat given off the centres of galaxies and newly forming planetary systems.
    (d) X-ray Observatory in Earth orbit detects exploding stars, black holes, and the centres of galaxies.
    (e) Detects high-energy gamma rays from exploding stars, neutron stars, and galaxies.
13. (a) Space junk is pieces of debris orbiting Earth, left over from artificial satellites.
    (b) As the piece of space junk is lowered, it enters thicker regions of the atmosphere, slowing even more until it burns up due to air friction.
14. Solar radiation, space junk, equipment malfunction, vacuum of space

Pause and Reflect Answer

Students' paragraphs will vary. Ensure that students adequately support their opinions with examples that they have learned in this section.

Other Assessment Opportunities

Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

CHAPTER 12 ASSESSMENT, pp. 468–469

PREPARE YOUR OWN SUMMARY

Students' summaries should incorporate the following main ideas:

1. Technologies to understand and explain stars and galaxies
   - Galaxies are a collection of stars, planets, gas, and dust.
   - Stars are born, they live, and they die.
   - Stars are different sizes and temperatures.
2. Theories to explain the origin and the future of the universe
   - The universe began 13 to 14 billion years ago with the Big Bang.
   - Evidence of the Big Bang is detected as background radiation.
   - The universe is expanding and all of the galaxies are moving away from each other.
3. Measurement of distances in space
   - Parallax and triangulation are used to determine distances in space.
   - The distances between stars and between galaxies are measured in light-years.
4. Exploration of space
   - Travel in space is risky and expensive but returns great rewards of information.
   - Unpiloted spacecraft are used to explore the planets without risk to humans.
   - Different types of telescopes in space explore the universe observing in different wavelengths of light.

CHAPTER REVIEW ANSWERS

Checking Concepts

1. A galaxy is a collection of stars, planets, gas, and dust held together by gravity.
2. The Big Bang theory
3. Between 13 and 14 billion years
4. Hubble noticed that the galaxies are moving away from each other.
5. The light of the galaxies is becoming longer; the spectral lines shifted toward the red end.
6. (a) A star forms from gas and dust in a nebula. Gravity pulls the material together. As the mass grows, the material collapses in on itself and contracts. If enough mass collects, the temperature and pressure in the centre increases until fusion begins and the star shines.
   (b) Leftover material from stellar formation collects as the nebula contracts. The nebula begins to rotate as it contracts and planetesimals form in the protoplanetary disc.
   (c) Planets form from planetesimals as they continue to build up, collecting material from the protoplanetary disc.
7. Terrestrial means that they are similar to Earth (with a solid surface).
8. Distances between the stars are so great that astronomical units are too small to use. Light-years are much larger units and are easier to use to describe the distances.

9. Gravity holds the billions of stars in a galaxy together.
10. The Milky Way is a spiral galaxy.
11. Fusion, where hydrogen atoms combine to make helium atoms, releasing tremendous amounts of energy
12. (a) A low mass star that burns hydrogen slowly, may last for 100 billion years.
    (b) The cool remnant of a red dwarf or red giant.
    (c) An intermediate mass star that has expanded after a long period of instability. The Sun will grow into a red giant near the end of its life.
    (d) The remnants of a white dwarf made mainly of carbon and oxygen.
    (e) An exploding large mass star, creating many of the heavier elements.
    (f) The remnants of an exploded high mass star, very dense and hot.
13. They do not have to look through the turbulent atmosphere, the image is not distorted, there are no weather concerns, they can observe at all times of the day.
14. A telescopes using adaptive optics has a mirror which can change shape slightly to compensate for the distortion caused by the atmosphere. This results in a much better views of distant objects.
15. The Hubble Space telescope has shown us some of the oldest galaxies ever observed, and its clear views of distant objects has helped astronomers to solve many problems in astronomy. Using the Hubble Space Telescope, astronomers have determined that the universe is 13.7 billion years old. It has provided views of galaxies 10 billion light-years away.
16. Infrared telescopes observe a wavelength of light that does not penetrate our atmosphere and reach the ground; it is only visible from space.
17. Unpiloted space probes are smaller than spaceships carrying humans, they do not need to support humans (food, water, air), and they do not have to return to Earth.
    Robotic explorers do not need the same kind of protection from harmful rays as humans do.
18. Answers may include freeze-dried foods, high-tech running shoes, bicycle helmets, cold weather clothing, light sportswear, sunglasses, insulin pumps, eye examination systems, locator beacons, and self-repairing computers.

Understanding Key Ideas

19. Cosmic background radiation may be the remnants of the Big Bang.
20. Hubble detected the cosmological red shift of the galaxies, and he concluded that they were moving away from each other.
21. All points on the balloon are moving away from the other points, just like the galaxies in an expanding universe.
22. The galaxies are all moving away from us.
23. The star is probably too far away for parallax to be used with any accuracy.
24. A spiral galaxy has a pinwheel appearance while an elliptical galaxy is spherical or elliptical in appearance.
25. (a) Black holes appear invisible because their gravity is so great, and light cannot escape them.
    (b) Astronomers know that black holes exist because the material pulled toward the black hole emits electromagnetic radiation, and the black hole's gravity has an effect on passing stars and galaxies.
26. Quasars are very old and very far away. They help us to understand the origin and early development of the universe.
27. This statement means that there are billions of stars in the universe, located in billions of galaxies.
28. (a) visible light—some ultraviolet and infrared
    (b) X rays
    (c) gamma rays
    (d) infrared radiation
29. Terraforming is the transforming a planet to be Earth-like. It would be an incredibly expensive engineering project and would take hundreds of years.
30. Large pieces of space junk can be a hazard for people on Earth if the pieces enter the atmosphere and land on Earth.

Pause and Reflect Answer

Answers might include future space projects, such as the exploration of the Moon and Mars; and contributions of Canadian industry to help build the spacecraft, develop the technology, and supply astronauts to make the journey.

UNIT 4 ASSESSMENT

PROJECT

Designing a Mining Town for the Moon, p. 472

Purpose
- Students synthesize information and skills they have learned.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
3 days before	Assign groups and have students begin thinking about their plans. Discuss different presentation formats with your class.	For each group: – paper for drawings – art supplies, such as felt pens and paints – materials for the scale model

Time Required
- 60–120 min
- This activity will require a 20 min introduction.
- If time permits, allocate one period for research, and one period for collation. If time is not available, research may be assigned as out-of-class study.

Safety Precautions
- Students should be careful when cutting materials for the model.

Science Background
The United States has a renewed interest in returning to the Moon for both scientific and economic reasons. In addition, other countries—including Japan and China—have plans for either Moon bases or lunar hotels. It is most probable that the first settlement on the Moon will involve exploitation of the resources. In this activity, students will design and build a scale model of a lunar mining town.

Activity Notes
- Discuss different presentation formats with your class. Encourage students to try something new for the activity, and discuss their ideas before they begin.
- Review and approve students' designs and lists of materials before they begin building their model.
- Students can start their Internet research at www.discoveringscience.ca.

Supporting Diverse Student Needs
- English language learners should be partnered with students who have strong language skills to help them communicate their ideas. Encourage English language learners to draw sketches and use their research skills.
- This activity will be especially suited to students with visual-spatial, interpersonal, and bodily-kinesthetic intelligences. As much as possible, ensure that each group includes learners with strength in these areas.

Report Out Answers
1. Answers will vary but should include an explanation of their choices (for example, where did the students select to build, why was that location chosen, how large was their installation, were the safety issues and needs of a working mining town addressed).

Other Assessment Opportunities
- Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

INTEGRATED RESEARCH INVESTIGATION

"It's a Bird, It's a Plane, It's an Asteroid!" p. 473

Purpose
- Students broaden their research skills to understand what technology is available to protect Earth from an asteroid collision.

Activity Notes
- Discuss different presentation formats with your class. Encourage students to try something new for the activity, and discuss their ideas before they begin.
- You may wish to spread the activity out over several classes.
- Visit www.discoveringscience.ca. for more ideas that students can pursue in their research.

Supporting Diverse Student Needs
- English language learners should be partnered with students who have strong communication skills.
- This is a good activity for students with visual-spatial, logical-mathematical, naturalist, verbal-linguistic, and interpersonal intelligences.
- Enrichment could include adjusting the depth of presentation required. For example, students could be required to include information about current estimates of the risks and benefits of the chosen technique.

Other Assessment Opportunities
- Consult the Unit front matter for a list of applicable Assessment Blackline Masters.

UNIT 4 REVIEW ANSWERS, pp. 474–477

Visualizing Key Ideas

1. Birth: nebula
   Early Stage: star
   Near Final Stage: red dwarf, supernova
   Final Stage: white dwarf, neutron star or black hole

Using Key Terms

2. Corrected sentences will vary.
   a) false: A collection of stars is called a constellation.
   b) false: The Big Dipper is an example of an asterism.
   c) false: The heliocentric theory states that the Sun is the centre of the universe. The Geocentric theory states that the Earth is the centre of the universe.
   d) false: Jovian planets have gaseous atmospheres. The inner planets have rocky crusts.
   e) true
   f) false: Revolution describes a planet orbiting the Sun.
   g) true
   h) false: Most stars form in a swirling cloud of gas and dust called a nebula.
   i) true
   j) false: Rovers are sent to move across the surface of a planet.
   k) false: A group of billions of stars is called a galaxy.
   l) false: The Big Bang theory suggests the moment the universe was formed.
   m) true
   n) true
   o) true

Checking Concepts

Chapter 10

3. elliptical
4. a) The Earth is the centre of the universe.
   b) The observed phases of Venus prove a Sun-centred solar system.
5. Ptloemy used an astrolabe to locate and predict the motions of the Sun, Moon, and stars.
6. Galileo observed craters on the Moon, spots on the Sun, the moons of Jupiter and the phases of Venus.
7. Kepler's three laws are:
   1. All planets move in ellipses, with the Sun at one focus.
   2. Planets sweep out equal areas of their elliptical orbit in equal times.
   3. The time a planet takes to revolve around the Sun is directly related to how far away it is from the Sun.
8. He developed three laws of motion.

Chapter 11

9. thermonuclear reaction
10. the photosphere
11. They are slightly cooler than the surrounding surface.
12. An astronomical unit (AU) is the average distance from the Earth to the Sun.
13. Any four of the following:
    Mercury: solid, inner planet, no atmosphere, no moons, heavily cratered, extremely hot
    Jupiter: gaseous, outer planet, thick atmosphere, many moons, no solid surface, extremely cold
14. Dwarf planets do not have enough mass (gravity) to clear their orbits of small debris left over from the formation of the solar system.
15. It is an object outside of Neptune's orbit — in the Kuiper Belt or the Oort Cloud. Eris is an example.
16. The payload is the cargo — it could be a satellite, astronauts or other objects.
17. Canadarm 2 is larger and it can move by itself around the exterior of the space station.
18. It is an orbit high enough that it takes 24 hours to orbit the Earth once.
19. freefall

Chapter 12

20. a) The Big Bang Theory
    b) 13.7 billion years ago
21. Astronomical units are too small to use to describe the distance to the stars. The numbers would be too large.
22. The universe is expanding.
23. a spiral galaxy
24. An intermediate mass star becomes a red giat.
25. Some frequencies of electromagnetic radiation do not pass through Earth's atmosphere. Telescopes placed above Earth's atmosphere will detect these.
26. Reward: satisfies our curiosity about the world we live in, new technology developed for use on Earth
    Risk: equipment failure, solar radiation

Understanding Key Ideas

27. Mercury, Venus, Mars, Jupiter and Saturn were named after Roman Gods.
28. How bright the star is and how far away from Earth it is affect its magnitude.
29. The rotation of the Earth causes the constellations to appear to move.
30. a) Aristarchus was the first to proposed a Sun centred solar system.
    b) Eratosthenes measured the diameter of the Earth quite accurately.
    c) Ptloemy developed a model of the solar system that explained retrograde motion.
    d) Copernicus showed that the solar system was heliocentric.
31. They were physicists and astronomers, using mathematics to explain the motions in the solar system.
32. The Earth receives energy from the Sun, which supplies energy to produce our food, it provides light for our eyes to see, and our fossil fuels come from fossilized plants that used energy from the Sun. Radiation from the Sun can also be harmful.
33. The chromosphere lies above the photosphere, beneath the corona and is a 3000 km thick layer of hot low density gas.
34. Solar wind produces aurora and solar storms can knock out communications satellites.
35. The planet would probably be solid and rocky. It would not have any water or ring system. It may or may not have a satellite.
36. A body the size of Mars likely collided with the Earth when the Earth was still a hot molten planet. Gravity caused the debris to collect back together as the Earth and the Moon.
37. An asteroid is a rocky body left over from the formation of the solar system. Most are found between the orbits of Mars and Jupiter. Comets are dirty snowballs composed of ice, rock, and gas found in the Oort cloud.
38. Research on the ISS relates to the effects of microgravity on people.
39. A spacesuit must provide oxygen to breath, air under pressure, a cooling system, and a communications system.
40. An outer planet does not have a solid surface to land upon.
41. a) They are uncrewed robot explorers of celestial bodies.
    b) Probes fly past the body, satellites orbit the body, and rovers land on and explore the surface of the body.
42. a) C
    b) B
43. An expanding universe suggests the universe is "growing" outwards in every direction, like an expanding balloon.
44. Space is not empty, it is filled with interstellar matter including hydrogen gas and dust.
45. Low mass stars live the longest, for 100 billion of years. Intermediate mass stars live for 10 billion years and high mass stars live for only 7 billion years.
46. quasars
47. a) The Hubble Space Telescope observes in visible light, while the Spitzer observes in Infrared light.
    b) The Chandra X-ray Observatory observes in the X-ray part of the electromagnetic spectrum, while the Fermi Gamma-ray Telescope observes in the Gamma Ray part of the spectrum.
    c) Ground based observations observe mostly visible light, while the James Webb Space Telescope will observe infrared wavelengths.

Thinking Critically

48. Astronomers used the accomplishments of their predecessors to build upon ideas to come up with new ones. Kepler used data from Tycho to develop his planetary laws, and Newton used Keplers' laws to develop his laws of motion and gravity
49. The orbits of comets tend to be far more elliptical than those of planets. Comets are believed to be pieces of leftover material from the formation of the early solar system. Not all comets have spherical shapes.
50. Colonizing a moon of Jupiter would require sources of food, oxygen, heat, as well as protection from deadly cosmic radiation. In addition, you would have to consider physical and mental health (i.e., problems caused by isolation, low gravity, etc).
51. Canada has built scientific satellites (Alouette, MOST, Radarsat), helped with the Apollo missions to the moon by building the legs of the lunar module, provided the Canadarm1 for the Space Shuttle, helped with the construction of the International Space Station by supplying the Canadarm2, and provided astronauts to help with the construction and research there.

52. (a) Star A is much closer than star B.
    (b) An object closer to Earth will experience a greater parallax shift than an object closer to the reference star.

Developing Skills

53. (a) A small, rocky planet
    (b) The pattern suggests the large gas giants are closer to the star they orbit.
    (c) 600 million km
    (d) The other rocky planets are evenly spaced.
    (e) Our solar system has the gas giants as outer planets. This solar system has rocky outer planets.
54. (a) Asteroid = 0.0007; Moon = 0.17; Sun = 27.3; neutron star = 271 428.6
    (b) If an object is larger than Earth, the force of gravity will be greater. If the object is smaller, the force of gravity will be less.

Pause and Reflect Answer

Answers will vary, but may include references to concerns about training, fitness, and preparation of the general public. Issues like funding, safety, and security may be raised.

Students should consider the selection process, if space was open to the general public. Who would go? What would the requirements be?