CHAPTER 11 OPENER, pp. 388–389

USING THE PHOTO AND TEXT

After reading the text on page 388, have students examine the photograph of the Hubble Space Telescope in orbit around Earth (since 1990). In just under 20 years, the discoveries of the Hubble Space Telescope have forced astronomers to change the way they understand the universe. Ask students if they know why scientists would go to the trouble and expense to place a telescope in Earth orbit (above the atmosphere).

Students could then be asked to reread the text on page 388 and discuss how space exploration has changed our lives here on Earth. What do they know about Canada's involvement in space exploration—crewed and uncrewed? Links are provided at www.discoveringscience.ca 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 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. Ask students to explain why the Sun is important and to list the different ways it impacts our lives here on Earth. What tools do students know of that we are using to explore the solar system and the rest of the universe? What new discoveries have we made?

Have students read the Why It Is Important section, and ask them how understanding the other planets in the solar system might help us to better understand Earth. Ask, "How have we benefited from the technologies developed for exploring space?"

Encourage students to read the Skills You Will Use section. Ask students if they have ever looked at celestial bodies through a telescope. Ask, "What can be seen?"

USING THE FOLDABLES™ FEATURE

See the Foldables section of this resource.

11.1 THE SUN AND ITS EFFECT ON EARTH

Science Background

The Sun is a star like the other stars we see in the night sky. It is just much closer to us and appears brighter. Its light and heat enable life to grow on Earth, and the tremendous energy that falls on Earth is converted into food, which sustains all life on our planet. Although the Sun looks like an active place with storms and flares, it is a rather passive star, which is good news for us on Earth. If the Sun were to vary its energy output over time, it could have a damaging effect on us. In fact, we might not be here at all if the Sun did not emit energy at constant levels.

The Sun provides us with a close-up star to study. Its light takes eight minutes to reach us, whereas the light from the next closest star takes over four years to reach us! By understanding our Sun, we can understand the other stars we see.

COMMON MISCONCEPTIONS

- Students may not know that the Sun rotates. Its rotation takes about one month. In Conduct an Investigation 11-1A, Observing Sunspots, on pages 395 and 396, students will track the location of sunspots as they move across the Sun's surface, showing that the Sun does rotate.
- Students may think it is impossible to safely observe features on the Sun. In fact we can, as long as the proper kinds of equipment—including solar filters—are used. If possible, bring in a solar filter to allow students to see how much light it blocks, and how different it is from a sunglass lens. Remind students to never look at the Sun through sunglasses or smoked glass of any kind.
- Students may imagine the Sun's surface as solid. The surface of the Sun is not solid, and it is beyond our experience to imagine what the Sun's surface is: a gaseous, churning surface over 5500°C.

ADVANCE PREPARATION

- Obtain materials, including an Astroscan telescope, for Conduct an Investigation 11-1A, Observing Sunspots, on pages 395 and 396.
- Consider introducing Core Lab Conduct an Investigation 11-3B, Designing a Space Station, on page 422, early in this chapter, so that students can add to their plans as they learn about characteristics of the Sun and of satellites.
- 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. 390

Using the Text

Ask students for ways in which the Sun affects our lives here on Earth. Some examples can be inferred from the photograph on page 390. Students will think of other examples from their own experiences. List these examples on the chalkboard.

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 4-4, Chapter 11 Key Terms can be used to assist students.

Using the Did You Know, p. 391

The numbers in this feature are very large. If you do the math, you will notice that in fact the Sun should last much longer than 10 billion years, which is because only the hydrogen in the core can be used for the reactions. The main thrust of this paragraph is to show that there is an incredible process going on in the centre of the Sun, about 150 000 000 km away.

Using the Did You Know, p. 392

Ask students how they think storms on the Sun might affect Earth's climate.

TEACHING THE SECTION, pp. 390–394

Using Reading

Pre-reading—Key Word Concept Map

This section contains Key Terms that may be unfamiliar to many students. Before they begin reading, have a student read each Key Term and invite volunteers to explain to the class what they understand about that term. If no one has an understanding of a term, have a student look up the definition in the Glossary.

During Reading—Note Taking (Cornell Format)

Encourage students to 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.

After Reading—Reflect and Evaluate

Have students review their notes and select three facts 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

- For visual-spatial learners, as well as students who require support reading, display an overhead transparency or projection of Figure 11.3, on page 392. Have volunteers point out the main features and describe them using the callouts in Figure 11.3 or their own words. Alternatively, you could draw a simple diagram of the Sun and have students sketch each feature as they describe it.
- Encourage students to use diagrams in their notes if they find them helpful.

Reading Check Answers, p. 394

1. Answers may vary. Students' answers may include the following: the Sun's energy helps to grow/supply our food on Earth; we can see by receiving reflected sunlight, fossilized plants have stored solar energy resulting in the creation of oil which we collect and turn into gasoline.
2. Hydrogen makes up 90 percent of the Sun's mass.
3. Sunspots
4. Solar wind is the hot, energetic gas spewed out of the solar corona.
5. (a) The northern lights and southern lights, or auroras. In the northern hemisphere, this phenomenon is called aurora borealis; in the southern hemisphere, aurora australis.
   (b) These lights occur when some of the high energy particles in solar wind enter Earth's atmosphere at the poles and collide with gases in the atmosphere.

USING THE ACTIVITY

- Activity 11-1A, on pages 395 and 396 of the student textbook, can be used any time during the unit. It is best introduced right away during Chapter 10. It may take several weeks to set up and run, depending on weather and planning time. Detailed notes on doing the activity follow.

Conduct an Investigation 11-1A

Observing Sunspots, pp. 395–396

Purpose

- Students use a telescope or binoculars to observe features on the surface of the Sun.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Ensure that the telescope or binoculars are working properly and safely. .	For each group: – light surface, such as a white piece of paper – clipboard Shared: – Astroscan telescope and/or pair of binoculars with lens caps
1 day before	Optional: Photocopy BLM 4-15, Conduct an Investigation 11-1A, Observing Sunspots.	

Time Required

- 90 min (spread over 5 days)

Safety Precautions

- Extreme precautions must be made to prevent students from looking at the Sun through an optical device such as binoculars or a telescope. The Sun's intense heat will permanently damage the retina instantly. Inform students that even a glance is dangerous. Since the retina does not have nerves, students will not feel pain if the retina is damaged so precautions must be made and adhered to.

Science Background

The sunspots will appear as dark spots on the surface of the Sun. By observing over a period of days, students should be able to estimate how long it will take for the spots to move once around the Sun. The sunspots will change in shape and number day to day, as well as position. The Sun takes approximately 24.5 days to rotate once. It takes 26.24 days for the same spot to rotate back to the same apparent position with respect to Earth, due to the movement of Earth around the Sun. Any answer in the area of 25 to 28 days is acceptable given the errors inherent in this activity.

Activity Notes

- Please note that using binoculars or a telescope to project the image of the Sun is safe as long as students do not look through the optical device—it is meant to project the image only. Enforce this rule with students, and explain that severe, instantaneous eye damage could occur if they look through the binoculars or telescope.
- Students should do this activity in groups of three or four, in order to adjust the telescope or hold the binoculars and make the observations.
- At the time of writing this textbook (July, 2009), the Sun has been virtually sunspot-free for over a year. Scientists are a little unsure why and there is the possibility that this situation could last for another year or so.
- Over the five observations, have group members change roles so that everyone has a chance to operate the telescope and record the sunspots.
- If weather conditions or other considerations prevent you from completing this activity, students can use BLM 4-15, Conduct an Investigation 11-1A, Observing Sunspots to estimate the Sun's rate of rotation.

Supporting Diverse Student Needs

- Students will need a clear understanding of what to do and what to look for. If students require support reading, explain the activity in detail for them, demonstrate how to set up the equipment, and have them work with a classmate who has strong reading skills.
- This is an excellent activity for visual-spatial learners and those with intrapersonal intelligence. As much as possible, ensure that each group includes students with skills in these areas.

SECTION 11.1 ASSESSMENT, p. 397

Check Your Understanding Answers

Checking Concepts

1. (a) Thermonuclear reactions occur when there is tremendous pressure and heat, which occurs in the centre of the Sun.
   (b) Two or more atoms fuse, or combine, to create a different, larger atom.
   (c) A tremendous amount of energy in the forms of heat, light, and other electromagnetic radiation is created.
2. The Sun has provided Earth with heat and light for billions of years, which has allowed life to flourish.

3.

FEATURE OF THE SUN	CHARACTERISTICS
A. Solar prominence	Large loops of super-hot gas that extend out from the Sun's surface, associated with sunspot activity, and can stretch out great distances
B. Solar flare	Extremely violent eruptions of gas that can last for a few hours and heat gases to 11 000 000°C
C. Sunspot	Indicate parts of the surface that are slightly cooler, about 3500°C, compared with the surrounding areas, and can be larger than Earth. The number of sunspots increases and decreases in an 11-year cycle.
D. Photosphere	A thin, turbulent area where hot gas rises to the surface, cools, and then sinks back into deeper layers. It is the area most familiar to us. The photosphere reaches about 5800°C.
E. Corona	A layer of gas that is the outer-most part of the Sun's atmosphere and can reach over 3 000 000°C
F. Chromosphere	Beneath the corona, a 3000 km thick layer of hot, low-density gas

4. The hottest layer of the Sun is the corona.
5. Solar wind consists of high-energy particles. This dangerous radiation would be fatal to living organisms.
6. Earth's magnetic field acts as a shield and deflects the solar wind around the planet.
7. The particles in the solar wind enter the atmosphere and collide with gases in the atmosphere.

Understanding Key Ideas

8. Scientists know how much hydrogen is in the Sun and the rate at which hydrogen is used up in the core, so they can calculate that it has been giving off heat and light for 5 billion years and it has enough hydrogen to last another 5 billion years.
9. The force of all the material trying to collapse the star (due to gravity) is equally balanced by the force of solar radiation moving out from the core of the star.
10. Earth is in an orbit which is neither too close to, nor too far from, the Sun. The heat we receive from the Sun is just right for life to flourish.
11. Within the photosphere, a cycling process of hot gas rising to the surface, cooling, and then sinking creates convection cells that give the photosphere a blotchy look.
12. (a) Space weather is the effect of the Sun on the inner solar system.
    (b) Solar storms can knock out communication satellites, which would have a devastating effect on global communications.

Pause and Reflect Answer

If the Sun were 10 percent warmer, it would have a devastating effect on Earth. Imagine more serious global warming than we are experiencing today—affecting the climate, food production, animal and sea life, and resulting in potential harmful impacts on people. Life would be very different on Earth if it received 10 percent more solar radiation.

Other Assessment Opportunities

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

11.2 CHARACTERISTICS OF THE CELESTIAL BODIES OF THE SOLAR SYSTEM

BACKGROUND INFORMATION

Early astronomers observed and interpreted the movement of the planets as wandering stars. With the invention of the telescope, these "stars" became worlds with their own characteristics. As the technology improved and we used bigger and better telescopes, we learned more about these worlds and their unique characteristics.

By using different types of telescopes (optical and radio), we are able to determine how inhospitable most of these other worlds are to humans. By sending space probes to fly close to, orbit around, or land on these worlds, we have learned much more about each planet. We have also learned more about asteroids and comets by sending spacecraft to pass close to or even land on their surfaces.

COMMON MISCONCEPTIONS

- Students often confuse meteors and comets. Meteors enter Earth's atmosphere at a high speed while comets are in orbit around the Sun millions of kilometres away from us.
- Since comets have the appearance of something swooshing through space, students may think that they move across the sky quickly like a meteor or shooting star. Explain that they move slowly, maybe moving only a degree or two each day, depending on their distance from us. It may take a week for a comet to move across a constellation the size of Ursa Major.

- Although media stories may have led students to believe that the planets sometimes line up in a straight line, the planets never do this. Refer students to Figure 11.9, on page 399, to give them an idea of the planetary positions. Explain that the solar system is made up of mainly empty space. and have students review their notes from Core Lab Conduct an Investigation 10-3B, on pages 382 and 383.
- Students may believe that all planets have solid surfaces. The inner planets have solid surfaces, but the outer planets do not. You cannot land and walk around on the gas giants.
- Students may have trouble accepting the demotion of Pluto to a dwarf planet. If they think of it as a reclassification of Pluto into a different type of planet, and once they see that there are other bodies similar to Pluto, it may make sense.
- Meteors are called "shooting stars," so students may think that they are stars. Explain to students that shooting stars are actually small pieces of rock that burn up as they enter Earth's atmosphere at high speed.

ADVANCE PREPARATION

- Materials for Find Out Activity 11-2B, Making Craters in the Classroom, on page 409, will require some set-up time.
- Conduct an Investigation 11-2D, Nighttime Activities for the Astroscan—Observing Planets, on page 410, may require parental permission and assistance. Ensure that telescopes are available. Contact a local astronomy club and see if they will assist you by bringing additional telescopes and pointing out the objects in the night sky. Prepare a star chart for the month that you will be observing.

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

INTRODUCING THE SECTION, p. 398

Using the Text

We have seen how early astronomers have used newly invented technology to form new ideas and theories about the universe. As technology improved, our views of celestial bodies improved and we understood more. The amount of information obtained since the dawn of the space age in the 1960s rewrote the book on what we know about the other planets, asteroids, and comets in our solar system. Every few years, a space probe makes a new discovery by landing on a comet or passing by a moon of a distant planet.

For a graphic demonstration of how technology has improved our view of space, hold a small photograph at the front of the classroom and ask students to describe what they see in it. They will probably be able to tell if it includes people, if it was taken indoors or outdoors, and so on. Then pass it around and invite them to tell you what else they see, now that it is closer. The increased detail they now see is analogous to the changes in our views of the planets since powerful telescopes were sent into space.

The three pictures of Saturn on the bottom of page 398 show how space probes in orbit around a planet vastly improve the views we get compared to Earth-orbiting telescopes such as the Hubble Space Telescope or ground-based telescopes. Have students examine these photographs and compare them. What can they learn from each photograph?

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.

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Using the Did You Know, p. 404

There are over 300 known planets orbiting other stars but up until now, we have not found one which is Earth sized or Earth like.

Telescopes in space like Kepler are looking for Earth-sized planets orbiting nearby stars.

Using the Did You Know, p. 406

There was quite a bit of panic in 1910 when Comet Halley returned to the inner solar system. As in 1910, during Halley's more recent visit in 1986, entrepreneurs made a lot of money selling telescopes and souvenirs. During the 1986 visit, space probes passed by the nucleus and gave us our first close-up look at a comet.

TEACHING THE SECTION, pp. 399–407

Using Reading

Pre-reading—Build on Prior Knowledge

- Have students look at the photographs of the planets on pages 400 and 401 and tell what they already know about each one. What do they know about other solar system bodies? Explain that detailed views of each planet, like the ones on pages 400 and 401, became available only when telescopes were sent into space.
- Clarify the meaning of the Key Terms “asteroid,” “astronomical unit,” “comet,” “dwarf planet,” “Kuiper Belt,” “meteor,” “meteorite,” “meteoroid,” “moon,” “Oort Cloud,” “planet,” and “transit” with students, and discuss how these terms are related to the solar system.

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 celestial body.

Supporting Diverse Student Needs

- 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 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. Class summaries can be created and left on display for students to refer to.

After Reading—Reflect and Evaluate

- Have pairs of students choose two celestial bodies and create a Venn diagram to compare and contrast them. The diagrams can be shared with the class. To avoid repetition, you could assign different celestial bodies to each pair.
- Discuss with students in what ways the discoveries in this section built on the discoveries made by the astronomers mentioned in Chapter 10.

Reading Check Answers, p. 407

1. To be considered a planet, a body must orbit one or more stars, be large enough that its own gravity holds it in a spherical shape, and be the only body occupying the orbital path.
2. Mercury and Venus do not have moons.
3. One: Earth
4. Most asteroids are found in a band between the orbits of Mars and Jupiter.
5. Meteors can be chunks of asteroids or planets broken by collisions with other asteroids or other bodies, or they may even be debris left over from the formation of the solar system, which burn up as they enter the atmosphere at high speeds.

USING THE ACTIVITIES

- Activity 11-2A, on page 402 of the student textbook, is best used after discussing the section on the planets (pages 399 to 401).
- Activity 11-2B, on page 409 of the student textbook, is best used after discussing meteors and impact craters on pages 406 and 407.
- Activity 11-2C, on page 409 of the student textbook, is best used after discussing comets on pages 404 and 405, and the Did You Know? feature on page 406.
- Activity 11-2D, on page 410 of the student textbook, is best started right away since it requires several evenings of clear skies.

Detailed notes on doing the activities follow.

Think About It Activity 11-2A

Terrestrial and Jovian Planets, p. 402

Purpose

- Students investigate the differences between terrestrial and Jovian planets.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Optional: Photocopy BLM 4-16, The Planets.	None

Time Required

- 30 min

Science Background

CRITERIA	TERRESTRIAL PLANETS (INNER)	JOVIAN PLANETS (OUTER)
Size	Smaller	Larger
Motion	Faster	Slower
Composition	Rock	Gas
Distance from Sun	Closer (0.39 to 1.5 AU)	Farther (5.3 to 30 AU)
Temperature	Varies (–63°C to +467°C)	Cold (–150°C to –215°C)
Density	Denser than outer planets (mass/volume)	Less dense than inner planets

Activity Notes
- This activity could be done in pairs to facilitate discussion of planetary characteristics.

Supporting Diverse Student Needs
- Students who require support should be partnered with students who have good language skills.
- If students require significant support, distribute BLM 4-16, The Planets, and have students use different coloured highlighters to identify the relevant information for each row of the table before they complete it.

Find Out Activity 11-2B
Making Craters in the Classroom, p. 409

Purpose
- Students investigate the effect of impacting bodies into a planetary surface. Mass, velocity, and trajectory are varied to give different results.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 day before	Collect materials.	For each group: – newspaper – about 3–5 small round rocks and/or balls of different sizes, about 1–3 cm in diameter – plastic tub – flour – cocoa powder – flour sifter or salt shaker – metre stick or measuring tape

Time Required
- 30–40 min

Safety Precautions
- Clean up spilled flour or cocoa right away to prevent slips.

Science Background
Craters on the Moon are the result of bombardment billions of years ago. These impacts were from the rocky debris left over from the formation of the solar system. The inner solar system must have been full of debris of varying sizes. At one point, Earth must have looked like the Moon—covered in craters. Billions of years of weathering and plate tectonics have eroded the craters on Earth.

Activity Notes
- Depending on the number of tubs of flour and cocoa powder available, students may be working in large groups. Ideally, groups of five work well, providing a balance of students and tasks.
- Have materials on hand to clean up spills, and tell students to clean up any spills immediately.

Supporting Diverse Student Needs
- This is a very good activity for body-kinesthetic and visual-spatial learners, and it also reinforces interpersonal skills. Ensure that groups include students with a variety of learning styles.
- If students are not able to complete this activity in an orderly manner, it could be done as a demonstration, with carefully chosen volunteers dropping the rocks or balls, while the others watch and record the results.
- For enrichment, students could vary the sizes and weights of the impacting bodies as well as the heights and angle of impact. Making a video recording of the event and playing the impact back in slow motion will help students analyze the event. Students should note the ray patterns spreading out from the craters. Look at a map of the Moon and note craters which have similar ray patterns (Tycho, Copernicus).

What Did You Find Out? Answers
1. The larger the meterorite, the larger the crater.
2. Dropping the meteorite from a higher point will make a larger crater.
3. The impact brings the deeper material (white flour) to the surface.
4. Impacts bring material from deeper in the Moon to the surface. This material might consist of minerals not normally found on the surface.
5. The craters are elongated and the ejected material falls off to one side.

Think About It Activity 11-2C
Comet Orbits, p. 409

Purpose
- Students investigate the shape and period of a famous comet.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Collect information on comets.	– newspaper clippings, articles

Time Required
- 30 min

Science Bcakground
Comets can be in different types of orbits—closed or open. Comets in closed orbits will return to the Sun at some point in the future and follow an elliptical path. Open orbits are not elliptical, but parabolic or hyperbolic in shape. Once comets in open orbits pass by the Sun, they leave the solar system never to return.

Comets get knocked out of the Oort cloud and make their way to the Sun by the gravitational field of a passing star. The inward trip can take millions of years. Once in the inner solar system, if the comet happens to pass close to a planet like Jupiter, for example, the gravity of the planet can alter the comet's orbit, changing its period from thousands to hundreds or even dozens of years (like Comet Halley).

Activity Notes

- Students may work in pairs or individually for this activity.

Supporting Diverse Student Needs

- English language learners could be encouraged to draw sketches or provide photographs and illustrations to explain their research.

What Did You Find Out? Answers

1. Halley's comet is in an orbit that returns to the inner solar system every 76 years.
   Comet Shoemaker-Levy 9 was destroyed on impact with Jupiter.
   Hyakutake will not return for 29 500 years. Hale Bopp will return in 2500 years.
2. Hyakutake and Hale-Bopp were both easily visible to the naked eye. Hale-Bopp—a very bright comet—was visible to the naked eye for 18 months. Comet Halley was not all that bright in 1986, barely visible to the naked eye away from city lights. Shoemaker-Levy 9 was only visible through a telescope.
   The brightness of a comet depends on its size, its distance to the Sun, and its distance to Earth. If the comet is releasing a lot of dust, the dust reflects sunlight and makes the tail more visible. The amount of water present can also affect the brightness of a comet.
3. The gravity of a planet can adjust the orbit of a comet. Shoemaker-Levy 9's orbit was affected by Jupiter, such that the comet collided with the planet. The orbits of comets Halley and Hale-Bopp were both adjusted by the planet Jupiter.

Conduct an Investigation 11-2D

Nighttime Activities for the Astroscan—Observing Planets, p. 410

Purpose

- Students observe planets in the nighttime sky with a telescope.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Prepare a star chart for the month showing the positions of the planets. Determine the observing site. Request permission for an evening stargazing activity. Make repeated requests for students to bring binoculars from home, if possible.	For each group: – Astroscan telescope – star chart showing the night sky and positions of planet(s) – planet-drawing chart – clipboard – flashlight (with red filter) – pencil – several pairs of binoculars (optional)
1 day before	Check the weather to determine if the chances are good that the skies will be clear.	

Time Required

- 120 min

Safety Precautions

- Adequate adult supervision is required for this evening activity.
- Remind students to dress appropriately for the weather.

Science Background

During an evening observing session, students will require time to find the planets, note the positions in the constellations, use and become familiar with the telescope, and make observations.

Activity Notes

- Students should work in pairs or groups of three for this activity. A clipboard for the note paper and a flashlight with a red filter are essential. Students can take turns drawing what they see and holding a flashlight to illuminate the clipboard paper.
- With several students, this activity can take a while in order to give everyone a chance to observe the planet and record what they see. Having more than one telescope and/or several pairs of binoculars will be helpful.
- While waiting to use the telescope, students can recognize constellations, share binoculars to observe the planets, and work on their planet drawings.

Supporting Diverse Student Needs

- To accommodate students' schedules, and to observe in a smaller group, you could offer two or three sessions and have students sign up for the one that suits them best.

- If possible, have a visual-spatial learner in each group to support others as they look for stars and planets.
- For enrichment, students can use the Internet to determine the position of Jupiter's moons on the night they were observed to identify the moons on their drawings.

Analyze Answers

1. Venus is the brightest because it is covered with white, reflective clouds. Jupiter is also covered in clouds, but these are not all white and the planet is farther away so it is therefore fainter. Saturn is farther still and is fainter than Jupiter. Mars is smaller and although it is closer, it is usually fainter than Saturn although from time to time it can be very close to Earth making it very bright.

2. to 4. Answers will vary depending on the planets that are visible at the time of year. Jupiter is currently an autumn object; Saturn is visible in the spring.

Conclude and Apply Answers

1. The disc of the planet and details on its surface can be made with a telescope.
2. Answers will vary. The planets should look similar to photographs in the textbook. Students may see fewer details due to turbulence in the air caused by weather or by heat rising off surfaces.
3. Answers will vary. Students may be surprised what can be seen on the planets through a small telescope. Saturn's rings and Jupiter's clouds and moons are always a surprise.
4. A telescope magnifies the view of the planet, bringing it closer.

USING THE FEATURE

www Science: Is Anybody Out There? p. 408

This feature is an excellent starting point for several inquiry topics.

- What is the likelihood of Earth being the only planet in the universe with life? Address these three points in a class discussion:
  (a) There are billions of stars in a galaxy;
  (b) There are billions of galaxies in the universe; and
  (c) Astronomers are finding an ever-increasing number of planets orbiting stars (the implication suggests planetary systems around stars are quite common).
- What are the implications of the discovery of organic molecules in space? What does the presence of the building blocks of life on Earth suggest about life elsewhere?
- Radio telescopes provide different information than optical telescopes. How do astronomers using radio telescopes hunt for signals in space that may indicate the presence of extraterrestrial life?

SECTION 11.2 ASSESSMENT, p. 411

Check Your Understanding Answers

Checking Concepts

1. The composition of the planet and its atmosphere.
2. (a) Jupiter
   (b) Mars
   (c) Venus
   (d) Uranus
   (e) Mercury
3. Earth's Moon most likely formed when a body the size of Mars collided with it, sending debris into space in orbit around what was left of Earth. Gravitational forces brought much of the debris back together to form Earth while other debris formed the Moon.
4. (a) A dwarf planet is a celestial body orbiting the Sun that is generally smaller than a planet but massive enough for its own gravity to give it a round shape.
   (b) Pluto, Ceres, Eris, Haumea, Makemake
5. Near Earth Asteroids
6. Outside the orbit of Neptune
7. (a) A comet is composed of ice, rock, and gas.
   (b) Once a comet nears the Sun, the surface ice melts releasing dust which forms the tail.
8. A shooting star is a meteor—a small piece of rock burning up in our atmosphere.

Understanding Key Ideas

9. The distances between the planets are so great, so it is easier to use an astronomical unit.
10. He observed a transit of Venus from St John's, Newfoundland, and timed when Venus moved in front of and off of the Sun. From this they were able to get a value for the astronomical unit.
11. (a) A planet is a celestial body orbiting a star, and a solar system is the collection of the star and everything orbiting it.
    (b) A comet is a large dirty snowball orbiting the Sun, and an asteroid is a rocky body, smaller than a planet, orbiting the Sun.
    (c) Trans-Neptunian objects orbit the Sun outside the orbit of Neptune. A meteorite is a meteor that has survived its fiery plunge through Earth's atmosphere and has reached Earth's surface.

12. Asteroids are small bodies that primarily orbit in between Mars and Jupiter in the asteroid belt. They are not large enough to be planets, and most are irregular in shape.
13. The Oort Cloud is held in orbit around the Sun by its gravity, even though it lies one quarter of the distance to the next nearest star to us, Proxima Centauri.
14. A: Saturn—rings
    B: Jupiter—clouds, Great Red Spot
    C: Mars—polar ice cap, red colour

Pause and Reflect Answer

Large amounts of material from the impact would be thrown into the atmosphere and block out the sunlight for months or even years, destroying the food supply.

Other Assessment Opportunities

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

11.3 THE EXPLORATION OF SPACE

BACKGROUND INFORMATION

On July 15, 2009, Space Shuttle Endeavour was launched for a 16-day mission to the International Space Station (ISS). This mission made history in more than one way: Canadian astronaut Robert Thirsk, who was already part of the ISS crew, and Canadian astronaut Julie Payette, who was onboard Endeavour as the flight engineer, became the first two Canadian astronauts to be in space at the same time. In addition, NASA astronaut Chris Cassidy became the 500th human being to travel to space.

The photographs on page 412 of the student textbook show areas in which Canadians have participated in space exploration. Canada was the third country to build and launch a satellite (NASA launched it for us), and a Canadian company built the Canadarm. Canadians also participated in planning the Apollo Moon landings. You can use the photographs in several ways:

- The photographs show some of the technology that is required for humans to explore space. Students could be prompted to suggest what a space suit does for an astronaut. The space suit must simulate most of the conditions on Earth, including oxygen, pressure, heat, and even a place to urinate. In addition, the space suit must protect the astronaut from cosmic rays normally blocked by Earth's atmosphere.
- The photographs also show one of the greatest successes in Canadian technological history. The Canadarm, and its successor, Canadarm 2, are the ever-dependable "workhorses" of NASA's shuttle program. The Canadarm has been part of the shuttle system since the late 1980s and has performed flawlessly throughout its tenure. Students could be asked to perform a quick Internet search for other Canadian contributions to space exploration. They can start their search at www.discoveringscience.ca.
- Point out the background of the photograph that shows the thin layer of atmosphere against the dark backdrop of space. That thin line is what separates life from death. Ask students to brainstorm the different ways that the atmosphere protects humans. For example, it provides oxygen for breathing, heat regulation, water and protection from cosmic radiation (like ultraviolet radiation), meteoroids, and solar storms.

This section is an opportunity for students to learn about the many ways in which humans have used technology to extend their understanding beyond their home planet.

COMMON MISCONCEPTIONS

- Students have many misconceptions about space-flight—probably from movies and television shows. Space travel appears easy in these stories; however, it is not. To introduce some of the difficulties of space travel, invite students to talk about depictions of space travel they have seen in movies or on television that do not seem realistic to them (for example, spacious spacecraft, fresh food, and open doors or windows).
- Students may think that the space shuttle and space station can go to the Moon. They cannot—they can travel only in low Earth orbit, some 400 km above Earth's surface.
- Students may think that there is no gravity in space because floating astronauts make it look that way. As mentioned in the textbook, there is gravity everywhere in the universe. The floating is a result of the falling action of the spacecraft around Earth.

ADVANCE PREPARATION

Book a computer lab for Think About It Activity 11-3A, Canada's Contributions to Space Exploration, on page 413.

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

INTRODUCING THE SECTION, p. 412

Using the Text

You might create a time line on the board to illustrate the history of Canada's space contributions. Information can be found at www.discoveringscience.ca.

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 4-4, Chapter 11 Key Terms can be used to assist students.

Using the Did You Know, p. 413

When a space probe is sent to the planets, it receives all of its energy from the initial rocket. The speed and direction the rocket gives to the probe has to be perfect for the probe to reach its target. From then on, Sir Isaac Newton is doing the driving—Newton's first law of motion will keep the probe going until something acts upon it. The space probe uses its small rockets to adjust its trajectory slightly based on its navigation system.

Students may be interested to know that new propulsion technologies, such as ion propulsion, now exist. These provide continuous thrust and can result in much shorter travel times.

Using the Did You Know, p. 420

Large radio telescopes in Ontario and British Columbia have been combined in the process of interferometry. By connecting them remotely and looking at the same object, it is like having a radio telescope as wide as the distance from Ontario to British Columbia!

TEACHING THE SECTION, pp. 413–420

Using Reading

Pre-reading—Predict-Read-Verify

Chunk the text into manageable sections by headings. Before reading, ask students to read the headings, analyze the visuals, and read the captions. Encourage students to use their background knowledge of space exploration to predict how rockets work; how the ISS is used; how Canada has contributed to space exploration; how space suits work; and how space probes, rovers, and different types of telescopes work, and how they are used. After reading the section, students can verify or revise their predictions.

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

- 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 one type of technology from the text, while another writes about another type of technology. Then students pass their summaries around and add to the summaries of other group members. When the group is done, they have a complete summary of every type of space technology included. 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 select three facts from the section that they found the most interesting or that they would like to learn more about. Then, ask them to write a statement about why they found these facts interesting. Have students share their facts and how each fact relates to climate, with the class in a class discussion. Students can summarize what they have learned.

Reading Check Answers, p. 416

1. Explosive fuels combine to create thrust.
2. The payload is the cargo the rocket is carrying into orbit.
3. Microgravity is the condition of weightlessness experienced by all objects, including spacecraft and humans, in space. It is very weak gravity, less than one millionth the effect on Earth.

4. Canadarm 2 is a Canadian-made mobile remote manipulator system designed for the ISS and used to move large payloads, dock the shuttle, and assist astronauts with repair and assembly duties.

Reading Check Answers, p. 420

1. An artificial satellite is an electronic device put in orbit around Earth to relay information.
2. Remote sensing satellites can monitor forest fires, measure ground movement, monitor migrating salmon.
3. There is no risk to human life; the probe does not have to return to Earth; it tells us all about the planet and what we need to know before we send humans; and it is a lot less expensive to send a probe.
4. Radio telescopes collect signals at longer wavelengths than those of visible light and reveal characteristics of celestial objects that cannot be studied using optical telescopes.

USING THE ACTIVITIES

- Activity 11-3A, on page 413 of the student textbook, can be used at any time during this section, and part of it can be assigned as homework.
- Activity 11-3B, on page 422 of the student textbook, should be introduced early in this chapter. Students can add to their plans as they learn about the Sun, satellites, and space exploration.

Detailed notes on doing the activities follow.

Think About It Activity 11-3A

Canada's Contributions to Space Exploration, p. 413

Purpose

- Students investigate Canada's contributions to space exploration.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Weeks before	Collect and assemble information on Canada's contribution to the crewed and uncrewed space program. Book a computer lab.	Access to the library and the Internet

Time Required

- 30 min

Science Background

Sending scientists into space to observe definitely has its advantages. Humans in space can adapt to new discoveries and adapt procedures and plans on the spot. They can also verify observations immediately, instead of depending on gathering a large number of samples and transporting them to Earth safely. However, human spaceflight has disadvantages as well. It is very costly to maintain the environment that a human being needs during space travel. Many destinations are simply too far away for humans to travel to, and travelling far from Earth is still quite unsafe. In these cases, scientists, including Canadians, design technology that will collect data for them.

Activity Notes

- This activity may be done in pairs or individually. Pairs of students could support one another as they search for and analyze information related to the inquiry topic.
- Have students develop their own list of advantages and disadvantages before they compare lists with a classmate. Then allow them to revise their list based on their discussion.

Supporting Diverse Student Needs

- Students who need support finding relevant information and analyzing it should be partnered with students who have good research skills.
- If students need help identifying Canada's contributions, this part of the research could be done first, then shared to create a class list. This would then provide some ideas on which students can build in their own research.

What To Do Answers

1. Alouette, ISIS, Hermes, Radarsat 1 and 2, Anik, MOST, Scisat satellites, Canadarm 1 and 2 and Dextre on the Space Shuttle/ISS, legs of the Apollo lunar module, astronaut team, scientific experiments in zero gravity on MIR, ISS
2. Advantages: obtain knowledge of celestial bodies, space environment
   Disadvantages: expensive, risky, human spaceflight risks human life
3. Earth-based research can be done with telescopes but is limited. Space exploration to the Moon and planets can return vast amounts of knowledge about the celestial body.

Core Lab Conduct an Investigation 11-3B

Designing a Space Station, p. 422

Purpose

- Students design a space station.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Obtain research material about the ISS from NASA or the Canadian Space Agency.	– materials as required by students to build a model of their space station

Time Required

- 60–120 min

Science Background

A space station resides in a hostile environment—solar radiation, intense heat and cold, the vacuum of space, and collision with debris are all threats. The ISS is only 450 km from Earth, but it is isolated. It is expensive to lift 1 kg of supplies to the station and supply ships may arrive only once every two or three months. Astronauts are essentially on their own except for the vital radio link with Mission Control.

Activity Notes

- To ensure that students consider all relevant issues and options, establish checkpoints after Procedure steps 2 and 4. Discuss each group's list of factors and technology and their design of a station before they proceed to the next step.
- When students check in with you after Procedure step 2, require them to show you a list of the sources they consulted.
- Point out to students that their presentation should, in some way, answer Analyze questions 1 to 7. Each group member should also answer these questions in writing on their own.
- Students may benefit from answering Conclude and Apply questions 1 to 3 after they have viewed all of the group presentations.

Supporting Diverse Student Needs

- Encourage students to develop creative presentations that suit their own learning styles.
- A significant amount of co-operation is required for this activity. Ensure that each group includes students with a variety of learning styles, including an interpersonal learner to support group functioning.
- Students with difficulty writing could answer Analyze questions 1 to 7 orally.

Analyze Answers

1. Zero gravity, solar radiation, objects hitting the station
2. Used thermal shielding to protect astronauts from the solar radiation.
3. Station maintenance and fixing parts that break, running experiments, preparing food, going on space walks, flying the spaceship home
4. Supply ships from Earth. Water from the air and urine can be purified and recycled.
5. Solar panels convert sunlight into electricity.
6. Fix them or use spares onboard, if possible. Otherwise, see if replacements can be delivered.
7. Wear a space suit, and take out tools to make the repairs. A robot such as Dextre on the end of the Canadarm 2 system has been designed to perform limited maintenance and repairs.

Conclude and Apply Answers

1. They bring to the design their experiences. Looking at how an outpost in the Antarctic is designed would help.
2. It would be very important to have people with different skills working together because you never know what will go wrong and it helps to have a variety of people working together to solve problems (for example, someone with medical experience for medical emergencies, and someone with knowledge about how the different components were designed and built to help with repairs).
3. It would be important to have people with engineering skills to run the station, medical skills for emergencies, scientific skills for experiments, and space flight experience to fly the spaceship home and to deal with the unexpected.

USING THE FEATURE

Science Watch: Canada's Suitcase Satellite Searches for Other Earths, p. 421

After students have read the Science Watch feature and answered the questions, ask questions such as the following:

- Why is MOST called the "suitcase" satellite? (The MOST satellite is about the size of a suitcase, although it still has to be launched into space by a rocket, just like any other satellite.)
- What does the size and success of MOST suggest about the economy of space exploration? (MOST shows that big results can come from small packages. The data generated by MOST are giving

astronomers new insights into the way stars like our Sun are born, how stars evolve during their lives, and how planets form around other stars.)
- Are wealthy countries or corporations the only players in the space exploration game? (The answer is a resounding no! On a very modest budget, MOST is delivering valuable, and for the better part of its life, unique information about distant worlds and environments.)

Science Watch Answers

1. Planets do not give off their own light, they only reflect light. The light, or glare, from the planet's star is far brighter, which makes detecting the reflected light from planets very difficult.
2. As a planet revolves around its star, it will often pass between its star and Earth. This will cause the brightness of the star to dim. The change in brightness can indicate the size of the orbiting planet.
3. Any two of: How does our Sun compare with other stars? How do the planets in our solar system compare with planets in other solar systems? How were planets able to form at all?

SECTION 11.3 ASSESSMENT, p. 423

Check Your Understanding Answers

Checking Concepts

1. The Space Shuttle robotic arm (Canadarm 1), the International Space Station robotic arm (Canadarm 2), and Dextre
2. A rocket transports materials and astronauts into space.
3. The ISS is being built and run by people from sixteen countries.
4. Dextre is a two-armed robot that can perform tasks that were previously performed by astronauts during dangerous spacewalks.
5. (a) Satellites are in orbit around Earth while space probes travel to the planets, a moon, a comet, or an asteroid.
   (b) Optical telescopes collect visible light and radio telescopes collect radio waves.
6. Earth rotates once in 24 hours, and a satellite placed above the equator at a distance of 36 000 km would take 24 hours to make one orbit. Therefore, satellites in this geosynchronous orbit appear to sit above the same place on Earth, so receivers can be pointed at them.
7. An astronaut in Earth orbit still feels the gravity from Earth. They are in fact falling around Earth.
8. A refracting telescope uses a lens to gather and focus light while a reflecting telescope uses a series of mirrors.

Understanding Key Ideas

9. Expensive to put there, difficult to point and keep pointed at an object, requires a space shuttle mission to fix anything
10. (i) (c), (ii) (d), (iii) (b), (iv) (a)
11. Experiments performed on the ISS are in a microgravity environment, which is the condition of weightlessness. This environment allows astronauts to take advantage of a freefall condition to perform experiments.
12. The time it takes radio signals to go from Mars to Earth does not allow them to be controlled "live" from Earth. By the time a controller on Earth sees the rover heading for a big hole and sends a command for it to stop, it is already at the bottom of the hole.
13. Canadarm 1 was built for the space shuttle, and Canadarm 2 was built for the Space Station.
14. A space suit must provide oxygen to breathe, a communications system, a cooling system, and a system to simulate the air pressure on Earth.
15. Students' answers will vary, but they may say that space should be owned by everyone.

Pause and Reflect Answer

Students should weigh the risk of travelling to Mars with the benefits. Do the benefits outweigh the risks? Is exploration worth the risk? It is a personal decision.

Other Assessment Opportunities

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

CHAPTER 11 ASSESSMENT, pp. 424–425

CHAPTER REVIEW ANSWERS

Checking Concepts

1. The Photosphere, the Corona, and Sunspots
2. Students' diagrams should be similar to Figure 11.3, on page 392.
3. Sunspots are slightly cooler than the rest of the photosphere
4. A solar storm could expose astronauts to deadly radiation.
5. Astronomical unit (AU)
6. A comet's tail is affected by the solar wind and is pushed away from the Sun.

7. Venus' atmosphere is composed almost completely of carbon dioxide and some sulphuric acid, and is a temperature of 467°C. Mars' atmosphere is thin carbon dioxide with an average surface temperature of –63°C.
8. "Shooting stars" are small meteoroids burning up in Earth's atmosphere.
9. (a) thrust
   (b) The propulsion system uses explosive fuels to create the thrust.
10. The Hubble Space Telescope is above Earth's atmosphere so it has a clearer view of the universe than ground-based telescopes.
11. Space probes do not need to support human life so they can be smaller and since they do not have to be designed to come back to Earth, they are less expensive.

Understanding Key Ideas

12. The photosphere is 5800°C, the chromosphere is between 6000–20 000°C, and a solar prominence can be up to 11 000 000°C.
13. Astronauts could be harmed by doses of dangerous solar radiation during a solar storm.
14. It would be similar to the Jovian outer planets—gaseous (hydrogen and helium) with a temperature of –200°C or so, and it may have rings.
15. The surface of Neptune is not a solid surface; it is a gas.
16. The can would melt in your hand on Venus, and on Mars, the liquid in the can would freeze and expand, and the can could explode.
17. The Oort Cloud is still in orbit around the Sun; it is within the Sun's gravitational influence.
18. Earth might have broken up into many smaller objects—possibly dwarf planets.
19. The father away a satellite is from Earth, the longer it takes to make one orbit.
20. Making new materials that form better without gravity, studying people to see the effects of long-term exposure to microgravity, conducting research for trips to Mars
21. Very hot surface temperatures, sulphuric acid rain
22. There are limited seats, people would have to be trained, and there may be health issues.
23. (a) Food would float away.
    (b) You would float out of your bed and would need to be strapped in.
    (c) You would float, probably bouncing off the walls, until you got used to zero gravity.
    (d) The water would be floating, although water in an orbiting space hotel would be very scarce, and people would probably have only sponge baths.
    (e) New zero gravity games will probably have to be invented.

Pause and Reflect Answer

Students' answers will vary. They should make reference to the material they have learned in this chapter, such as the safety concerns of travelling to space, the characteristics of celestial bodies, and the benefits of space exploration.