UNIT 4 OPENER, pp. 346–347

The photograph on pages 346 and 347 features a night scene and the summer Milky Way reflected in a lake. It invites us to wonder at the beauty of the scene and ask questions about our past and future.

USING THE UNIT OPENER

Before students open their textbooks, ask, "How far can you see?" Their answers will vary depending on the geography surrounding the school, the position of the class, and the current weather. Raise the issue 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. No matter how good your eyesight is, your unaided eyes cannot distinguish stars from outside of 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; conclusions; development of technology, including telescopes; more precise observations; further data collection; refined conclusions; greater development of technology; and so on. Most students should be aware of optical telescopes and their uses. Have them imagine using a telescope to observe a star. Ask, "What kind of information can you get from an optical (visual) telescope?"

- 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)

Ask students what additional information non-optical telescopes can give us. 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 question should lead students to think about things like touch (heat and infrared) and sound (radio waves transformed into sound on the radio).

As students introduce them, talk about concepts like invisible forms of radiation such as X rays and ultra-violet rays. All of these concepts help to show that the universe is a far more complex and amazing place than can ever be imagined. You may want to hand out BLM 4-1, Unit 4 Summary, and BLM 4-2, Unit 4 Key Terms, to help students record their understanding of the unit and important terms.

GETTING STARTED, pp. 348–349

USING THE TEXT

The opening photograph on page 348 shows a parent holding a child aloft against a seemingly endless backdrop of stars. The symbolism of the photograph emphasizes that humankind's understanding of our place in the universe is still in its infancy, despite the incredible surges of technology. Like children with an unquenchable curiosity, the more we learn, the more we want to know.

Have students read the first paragraph of the Getting Started section, and then discuss what they might do to learn about the rest of the world if they lived on the small island. Once several ideas have been suggested, have students explain how this situation would be like our efforts to understand space. Discuss why humans explore space—specifically, why it is important to understand what is beyond our island. Survey students to determine their level of support for space exploration. Repeat your survey at the end of the unit. It may prove interesting to see if students have or have not changed their opinions over the course of the space unit.

USING THE ACTIVITY

Find Out Activity

What Do You Know about the Universe? p. 349

Purpose

- Students organize their existing knowledge about the universe and identify what they want to find out.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	Obtain chart paper. Copy BLM 4-6, Find Out Activity, What Do You Know about the Universe? (optional)	For each group: – chart paper – felt pens

Time Required

- 15 min

Science Background

The purpose of the activity is to give students an opportunity to demonstrate their existing knowledge of the universe and some of its features. Students are asked to brainstorm and share their understanding of the features, and present their ideas in the form of a table. In addition, the activity encourages students to generate questions about the universe and concepts or features that they may not understand or would like to learn about.

The activity serves three purposes:

- It focusses students' attention on aspects of space.
- It gives an excellent indication of the level of prior knowledge that students are bringing to the unit.
- It defines and heightens students' interest level by having them write down what they would like to know.

Activity Notes

- Whether students are working in pairs or small groups, try to place students of varied abilities in each group.
- Students may require prompting in the What Did You Find Out? section. Suggest students answer the question "What do I wonder about?" Have students refer to the photograph of a night sky on page 348.
- Keep a record of students' questions. They can be reviewed and addressed throughout the unit.
- You may wish to have students complete BLM 4-6, Find Out Activity, What Do You Know about the Universe?

Supporting Diverse Student Needs

- English language learners will require a detailed explanation of the expectations of this activity and should be partnered with a student who has strong language skills.
- This is an excellent activity for visual-spatial learners and those with strong intrapersonal skills. Remind group members to encourage shy students to contribute their ideas, as well as students who have a more outgoing nature.

What Did You Find Out? Answers

1.–3. Students' answers will vary depending on their background. Students can refer to the questions that they wrote on their graphic organizers as they work through the unit, and check each one as it is answered.

CHAPTER 10 OPENER, pp. 350–351

USING THE PHOTO AND TEXT

After reading the text on page 350, have students examine the photograph of the Pic du Midi observatory situated in the Pyreene mountains in France.

In the top right corner of the photograph, the famous constellation Orion can just be made out with its three stars making up the hunter's belt. Ask students if they are familiar with any constellations or star patterns and the stories behind them Many are based on Greek mythology.

Ask students to read the text again and discuss why people have been looking up at the night sky for so many years, and why people think it is important to observe the motions of the stars and planets.

Finally, ask students why astronomers build their observatories on top of mountains—it must be difficult (and expensive) to carry all the necessary building materials and equipment up to these locations.

Links to many images of space and the curious and beautiful features it contains are provided at www.discoveringscience.ca. Where possible, take the opportunity to project these images for the class as a catalyst to engage 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. Have students brainstorm what early models of the solar system might have looked like.

Ask students why they think humans have an insatiable need to explore. What are some examples of human exploration in the past? How do humans learn new things or make scientific discoveries?

Invite a volunteer to read the Why It Is Important section. Ask students what they already know about Earth's place and motion in the universe. (rotating once a day, revolving around the Sun, located in the Milky Way Galaxy)

Encourage students to read the Skills You Will Use section. Discuss observation skills, and why careful observation is important to interpretation. Ask students to think about and share observations that they have made about the objects in space.

USING THE FOLDABLES™ FEATURE

See the Foldables section of this resource.

10.1 OBSERVING THE STARS

BACKGROUND INFORMATION

Astronomy is a mixture of all sciences—physics, chemistry, and biology are all important when learning about planets, stars, and galaxies. What we know about the universe has come from many centuries of observing the sky, making theories, testing the theories, and then building on what we have learned. Later in Chapter 10, students will learn about some of the early astronomers and how they determined the place of Earth in space and the laws of motion.

To begin, students will have the opportunity to make their own observations by looking at the stars and planets, observing and recording their motions, and drawing conclusions about what they have observed.

We often take for granted what we know about the motion of Earth around the Sun and the distances between the planets and stars, but this information took humans thousands of years to learn.

COMMON MISCONCEPTIONS

- Students may have certain preconceived ideas about what to expect when observing constellations. For example, they may think the patterns we identify as constellations will be obvious and easy to find in the sky. It is useful to have an experienced observer to help students navigate the sky, to identify the brighter constellations, and to show students how to use a star chart.

ADVANCE PREPARATION

- Obtain star charts and information from the Internet on the positions of planets visible in the sky at the time that you plan to observe, or make copies of BLM 4-7, Star Charts for Fall, Winter, Spring.
- Gather shoeboxes and beads for Activity 10-1C, on page 363 of the student textbook.
- 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, pp. 352–353

Using the Text

Ask students for examples of celestial bodies. Make a list on the board and group them into two groups: inside the solar system and outside the solar system.

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 4-3, Chapter 10 Key Terms, can be used to assist students.

Using the Did You Know, p. 352

Ask students how they think the observations of early Chinese astronomers survived 4000 years and how studying these observations could be useful today. (They were passed down in literature. Observations of ancient eclipses have told us about small changes in the motions of Earth and the Moon.)

Using the Did You Know, p. 354

Ask students why they think prehistoric humans made cave drawings of a group of stars.

USING THE ACTIVITY

Think About It Activity 10-1A
Constructing Constellations, p. 353

Purpose

- Students experience how constellations were created by finding their own patterns in the stars on a star chart.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Prepare a class set of star charts. Make copies of BLM 4-8, Think About It Activity 10-1A, Constructing Constellations (optional).	For each student: – pencil – pencil crayons – star chart

Time Required

- 20 min

Science Background

In ancient times, it is believed that the first people to use constellations were farmers. Recognizing the time of year in which certain patterns appeared in the sky was essential to keeping track of time and, more specifically, keeping track of the start and end of seasons. For example, the constellation Scorpius, the scorpion, is visible only in the summer in the northern hemisphere. Knowing when to plant, grow, and harvest was necessary in order to supply food for ancient peoples. Anthropologists believe that the legends, myths, and lore associated with the constellations were created to help the farmers keep track of the appearance and disappearance of the star patterns. Today, there are only 88 official constellations, with other star patterns called asterisms. This delineation was created in 1929 by the International Astronomical Union (IAU), the same organization that defined a planet and demoted Pluto from planetary status in 2006.

This activity will allow students to express their creativity while observing a star chart and looking for patterns.

Activity Notes

- Prior to this activity, hold a classroom discussion about constellations. Place a set of well-known star patterns on an overhead slide. Have students guess the constellation, and then superimpose the picture of the constellation on the star pattern. Follow this up by reading a few short stories about the mythology behind constellations to capture students' interest.
- Students should do this activity individually to allow every student to create a personal pattern.
- Prepare a sheet of paper with random dots to simulate stars in a night sky. This may be done by placing black ink (from the art room) on a small brush, or a toothbrush, and gently "flicking" the brush over the paper. It may take a few trials to get the desired effect. Alternatively, you can use BLM 4-8, Think About It Activity 10-1A, Constructing Constellations.
- The initial part of this activity (creating the constellation) may be done in class. The second part of this activity could be used as a take-home assignment, which will give students an opportunity to be creative and artistic with their drawings.

Supporting Diverse Student Needs

- To provide support for students with difficulty following written instructions, model the entire process first. Students can answer the What Did You Learn? questions orally, if writing is challenging for them.
- As an extension, some students may be interested in writing a short story or play about their constellation.

What Did You Find Out? Answers

1. Most students will have unique interpretations of the star patterns.
2. Students should realize that the way the random dots (stars) are interpreted is related to the personal bias of the observer. For instance, students who like cars may see sports cars in the pattern. Similarly, a cultural bias, or traditional perspectives, will definitely affect the interpretation of constellations.
3. A telescope could make the task more difficult. The field of view for a telescope is much narrower than the naked eye. Interpreting patterns with such a narrow field of view may prove difficult.

TEACHING THE SECTION, pp. 354–361

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 any understanding at all of a term, have a student look up the definition in the Glossary. You could build a concept map on the chalkboard together, showing how all the Key Terms interconnect.

During Reading—Note Taking

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 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, particularly visual learners, and student who require support to organize and process the information in written text, may benefit from using graphic organizers to take notes. A variety of types of graphic organizer are presented in Science Skill 8, Organizing Your Learning: Using Graphic Organizers, on pages 495 to 496 of the student textbook. Review the purpose of each type with students and encourage students to make use of these whenever they think they would help.

Reading Check Answers, p. 357

1. A celestial body is a natural object out in space such as a plant, a moon, an asteroid, a comet, or a star.
2. A constellation is a star pattern depicting a person, an animal, or an object.
3. How bright the star is and its distance from Earth
4. We can measure the angle between the two stars in degrees.

Reading Check Answers, p. 361

1. Ursa Major, Ursa Minor, Cassiopeia, Cepheus, Draco, and Camelopardalis are all circumpolar constellations
2. The Sun follows the ecliptic, a path through the zodiacal constellations.
3. Asteroids move against the background stars the same way as the planets (along the ecliptic), while comets' orbits can be above or below Earth's orbit so comets can be seen anywhere.
4. The Earth moves around the Sun so when we look away from the Sun at night, we see a different part of the sky.

USING THE ACTIVITIES

- Activity 10-1A, on page 353 of the student textbook, is best used as an introductory activity. Detailed information about this activity can be found in Introducing the Section.
- Activity10-1B, on page 362 of the student textbook, is best introduced at the beginning of section 10.1. It may take several weeks to set up and run, given weather issues and planning time.
- Activity 10-1C, on page 363 of the student textbook, is best used after students have read about Constellations and Magnitude on pages 354 to 356.

Detailed notes on doing the activities follow.

Conduct an Investigation 10-1B
Observing the Sky, p. 362

Purpose

Students will observe stars, constellations, the Moon, and planets in the evening. Students will identify these objects and note their positions in a log. By observing several times over the course of one evening and over a period of days and weeks, students will record the movements of the stars, Moon, and planets.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1–2 weeks beforehand (plan to observe during week of first quarter Moon)	Prepare star chart handouts by copying BLM 4-7, Star Charts for Fall, Winter, and Spring, or using an on-line star chart. (Visit www.discoveringscience9.ca.) Identify the position of planets (using an on-line resource). Obtain red cellophane and elastic bands for flashlights.	For each student: – a seasonal star chart – coloured pencils – a flashlight with red cellophane filter – a list of the planets that may be visible

Time Required

- 30 min prep time in class
- 1–2 h over several evenings for observing
- 30 min review time in class

Safety Precautions

- If possible, students should observe in pairs or in a group with a trusted and responsible adult present.
- Ensure that students check the forecasted weather conditions for their area and dress appropriately.

Science Background

For many students this may be their first opportunity to observe the sky and actually record their observations. Identifying objects in the sky takes practice and may take a couple of attempts before students feel comfortable. By observing in groups, students can collaborate to understand what they are really seeing.

Once comfortable, students will begin to notice the motion of the sky. This is the purpose of the exercise. It is important that the students observe over a period of weeks to see the apparent movement of the sky due to the revolution of Earth around the Sun. It is also possible that they will notice the motion of a planet with respect to the background stars.

Activity Notes

- First-time observers often have trouble identifying constellations; they expect the patterns to be more obvious or brighter and either smaller or larger. If possible, schedule an observing session at the school to point out the major constellations and show students how to use the star charts. You might also contact a local astronomy club and see if they will host an observing session with students.

Supporting Diverse Student Needs

- Ensure that English language learners understand the activity, and clarify any misconceptions that they may have. This activity provides an opportunity to help English language learners build their vocabulary of common verbs and nouns.
- This activity provides an opportunity for students to develop their intrapersonal skills by completing a task individually.

What Did You Find Out? Answers

1. Circumpolar stars rotate counter-clockwise around Polaris.
2. The Moon appears to move east to west during the night along with the stars as Earth rotates.
3. The Moon moves from west to east (right to left) each night as it orbits Earth. The distance the Moon moves in its orbit in one hour is about the same as its own diameter, so in one day, the Moon will move 24 lunar diameters (12 degrees) from west to east.

4. The constellations in the south appeared farther west a few weeks later when observed at the same time. This change is due to Earth's orbit around the Sun.
5. In a few weeks, the Moon will not be visible in the evening. It will have moved to the other side of its orbit and will be visible in the early morning around third quarter phase. (Look for it in the south at sunrise.)

Think About It Activity 10-1C

Building a 3-D Constellation, p. 363

Purpose

- Students investigate how two-dimensional (2-D) constellations in the sky are actually three-dimensional (3-D).
- Through constructing the 3-D model, students see that the magnitude of stars depends on distance and brightness.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Assemble materials.	For each group: – a small box (for example, a shoebox) – string, scissors, glue, and tape – a Big Dipper diagram – 7 small beads (stars) – a table of the stars and the distances from Earth

Time Required

- 30 min

Science Background

Early stargazers thought all the celestial objects were the same distance away, attached to one big sphere. That is exactly what the night sky looks like. There is little information visible from Earth to show that the Moon is closer than the planets or the planets are closer than the stars. The only clue would come if you saw the Moon pass in front of a star or planet. This happens, but is a rare event.

We now know that the planets' brightness varies over time depending on their distance from Earth. The stars are at various distances from us and also vary in brightness. A bright star is not necessarily the closest and a faint star is not necessarily the farthest away. There are other strategies we use to determine the distance to the stars.

Triangulation, for example, involves measuring the angle of observation to a star from two different locations, such as opposite extremes of Earth's orbit. The difference between these two angles can then be used to determine the distance to the star.

Activity Notes

- We often speak of patterns in the sky as if the sky were 2-D. In this activity, students build a model of the Big Dipper to help them visualize the 3-D nature of space.

Supporting Diverse Student Needs

- For students with poor fine-motor skills, have string already cut and beads threaded for this activity. Have students work with a partner to place the string and beads in the box.
- This hands-on activity is excellent for building visual-spatial and body-kinesthetic intelligences.
- Students who are interested in more of a challenge could determine the colours of these stars and use the appropriately coloured beads.

What Did You Find Out? Answers

1. Alioth appears the brightest. Megrez appears the faintest.
2. It must not be a very bright star, because even though it is close to us, it does not appear bright from Earth.
3. If all the stars were placed at 25 cm (distance on the model), Dubhe would appear the brightest. Alioth and Alkaid would appear fainter as their distances are now nearly 25% – 50% farther away than before. Megrez would appear dimmest. Since it is the dimmest at 16 cm, it would appear even dimmer at 25 cm.

USING THE FEATURE

Science Watch: Stories of Ursa Major, p. 364

Science Watch Answers

1. When Ursa Major is low in the sky in the autumn, the blood from the bear changes the colour of the leaves.
2. Stories will vary, but should relate the appearance of the Big Dipper to events in the story.
3. Students should include evidence for all of the statements they make.

SECTION 10.1 ASSESSMENT, p. 365

Check Your Understanding Answers

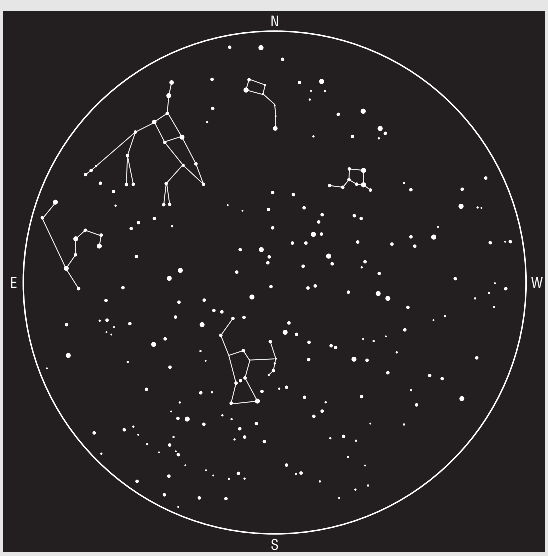
Checking Concepts

1. (a) Bear
   (b) Queen
   (c) Hunter
   (d) Lion

2. Mercury, Venus, Mars, Jupiter, Saturn
3. Rigel is 100 times farther away than Sirius; even though it is the brighter star, it appears dimmer.
4. Although students have not yet read about the astrolabe, they may reason that it would be more accurate. A fist gives an estimate of the angular dimensions while the astrolabe is a measurement tool.
5. Polaris is due north.
6. The zodiacal constellations lie along the ecliptic path that the Sun follows.
7. The orbits of comets are above and below the orbit of Earth.
8. (a) Pegasus, Aries, Pisces, Aquarius, Capricornus
   (b) Orion, Gemini, Canis Major, Taurus, Auriga
   (c) Leo, Ursa Major
   (d) Cygnus, Lyra, Aquila

Understanding Key Ideas

9. There are too many of them. Many are too faint to be seen without telescopes.
10. Various cultures interpret the patterns differently.
11. The two end stars in the bowl of the Big Dipper point toward the North Star.
12. Approximately 20 constellations never rise for us in Canada; Earth blocks them from view.
13.



14. Stellar magnitude

Pause and Reflect Answer

Many myths about constellations are possible. Students may chose to represent Orion as a current sports figure (Sidney Crosby) or a movie star.

Other Assessment Opportunities

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

10.2 EARLY MODELS OF THE UNIVERSE

BACKGROUND INFORMATION

Human beings have always looked up at the sky—in the beginning, in a sense of awe and unknowing. Prehistoric humans probably thought the stars were campfires from other groups of people like themselves. We have seen how generations of people placed star patterns of people, animals, and objects in the sky and recounted stories about these mythological creatures.

The early Greeks were the first people to try and figure out what was really out there—what Earth's place was in the universe and what those points of light were in the sky. With no tools except for their eyes and brains, they developed theories based on what they saw. It is surprising that many answers were discovered so long ago, only to be covered up for centuries due to social or religious attitudes.

The famous Flammarion Woodcut, reproduced at the bottom of page 366, symbolizes this insatiable curiosity humans have had about their universe.

COMMON MISCONCEPTIONS

- Students may be unaware of the different views people had of Earth's position in the solar system or think that early models showed a lack of intelligence. As you read this section, emphasize the small amounts of data that were available to early astronomers compared to what we have today. Remind students that our knowledge is not complete either, and that this process of model building and refining is a common and necessary part of science.

ADVANCE PREPARATION

- Gather the materials required to build the telescope and astrolabe. Ask students to bring in some materials, and order the lenses if you do not have them already.
- Construct the astrolabes using BLM 4-9, Find Out Activity 10-2B, Pointing in the Right Direction.

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

INTRODUCING THE SECTION, p. 366

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 4-3, Chapter 10 Key Terms, can be used to assist students.

Using the Did You Know, p. 371

The 17th century astrolabe discovered in 1981 in southwest Newfoundland is on display at the Gulf Museum in Port aux Basques.

Using the Did You Know, p. 372

As mentioned in the textbook, these four Galilean Moons—Io, Europa, Ganymede, and Callisto—are easily seen in a backyard telescope. Students may be able to see them during Activity 11-2D, on page 410.

Using the Explore More, p. 372

Galileo Galilei did contribute a lot toward science in many ways: in areas of mathematics, physics, astronomy, and philosophy. He has been called the Father of Modern Science. What is also interesting is the reaction that the Church had to his discoveries with the telescope. The Church at the time taught a geocentric view of the solar system, and could not accept Galileo's discoveries of the moons of Jupiter and the changing phases of Venus, which supported a heliocentric model. Galileo was persecuted by religious authorities for his new discoveries. In 1981, the Catholic Church announced that it had erred in its judgment of Galileo.

TEACHING THE SECTION, pp. 367–373

Using Reading

Pre-reading—Predict-Read-Verify

Chunk the text into manageable sections by headings (each astronomer). Before reading, ask students to read the headings, analyze the visuals, and read the captions. Encourage students to use their background knowledge of astronomy to predict what observations and discoveries each of the ancient astronomers is known for. After reading the section, students can verify or revise their predictions.

During Reading—GIST

As students read this section, have them write short summaries for each of the ancient astronomers—including their observations, theories, and discoveries. Encourage students to keep their summaries to 20 words or less.

Supporting Diverse Student Needs

- Before reading, talk with students about the meaning of each Key Term. Each Key Term is defined in the Glossary as well as in this section. 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. Each student in the group writes notes about one astronomer. Then students pass their papers around so that the other group members have a chance to add to their summary notes. At the end, the group has a complete set of jot notes about all five astronomers. Students can each choose one point from their group's 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 two facts that they believe changed our understanding of the universe the most. Then, have them explain (in writing) why they think these ideas caused the greatest change. Alternatively, have them share their explanations in a class discussion. Discuss the data and thought processes that the ancient astronomers used to explain their observations. Also discuss how each astronomer used information discovered by previous astronomers.

- As an extension, students can perform the activity on BLM 4-10, Retrograde Motion, to experience the effects of retrograde motion.

Reading Check Answers, p. 373

1. "Geocentric" means Earth centred. A geocentric universe is one with Earth at the centre and the Sun, Moon, planets, and stars revolving around it.
2. Astronomers were able to use astrolabes to help them locate and predict the positions of the Sun, Moon, and stars.
3. Aristotle visualized a geocentric universe while Copernicus proposed a heliocentric universe.
4. Galileo observed the phases of Venus which could only occur if Venus and the other planets orbited the Sun.

USING THE ACTIVITIES

- Activity 10-2A, on page 373 of the student textbook, is best used after discussing Galileo and his use of the telescope to look at astronomical objects.
- Activity 10-2B, on page 374 of the student textbook, is best used after discussing the astrolabe on page 371 and the Did You Know? feature on the same page.

Detailed notes on doing the activities follow.

Find Out Activity 10-2A
Build Your Own Telescope, p. 373

Purpose

- Students investigate the construction and operation of a refracting telescope.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Have the lenses and all the construction materials ready. Bring in the materials. If students are supplying the materials, ensure that you have some extras for those who forget.	For each group: – ruler – pencil – 1 toilet paper tube (approximately 4 cm in diameter) – 1 paper towel tube (approximately 4.3 cm in diameter) – scissors – 2 convex lenses (approximately 4.5 cm in diameter) – clear adhesive tape – metre stick – page of small-print text (such as a page of a newspaper or magazine)

Time Required

- 60 min

Safety Precautions

- Students should be careful using the scissors.
- Glass lenses are breakable. Ensure that students handle them carefully.

Science Background

Refracting telescopes use lenses to refract light from an object to create an image. Reflecting telescopes, developed later, use mirrors to create an image. Around the year 1608, Hans Lippershey, a spectacle maker in the Netherlands, used a simple refracting telescope to attract customers into his shop. Peering through two lenses, people could see a church spire that was over 1 km away. Within a year, Galileo had heard about the wonderful invention and constructed his own, improved-design telescope. Galileo was able to detect mountains on the Moon, the phases of Venus, moons orbiting Jupiter, and Saturn's rings (which he mistook for moons because of the limits of his telescope).

The basic design of refracting telescopes has not changed in four centuries. They are composed of two main parts: the eyepiece lens and the objective lens. The objective lens is a convex piece of glass that is aimed at the object that one wishes to view. The convex lens causes parallel light rays to come together at a focal point. As technology for constructing larger and more flawless lenses improved, so did the accuracy of telescopes, allowing observers to see farther, more clearly, and deeper into space.

In this activity, students build their own working telescopes and, in doing so, discover the power and limitations of the classical design.

This activity can be a wonderful opportunity to review the main ideas from the Grade 8 Optics unit with students.

Activity Notes

- As there are at least two simultaneous tasks to perform, this activity should be done in pairs or groups of three.
- You may wish to have an assembled telescope on display for students to refer to as they follow the written instructions to build their own.
- Toilet paper tubes and paper towel tubes were chosen because of the way they fit together, as well as matching the standard size used in school science lenses. Larger lenses and different sized tubing may also be used.

Supporting Diverse Student Needs

- This is an excellent activity for body-kinesthetic learners as well as those students with visual-spatial intelligence. Ensure that each group includes students with skills in these areas.
- As enrichment, students could be challenged to build a larger telescope using larger lenses or to implement the design change they recommended in What Did You Find Out? question 4.

What Did You Find Out? Answers

1. Students' answers will vary but may include a reference to the clarity at which the image was observed.
2. (a) To observe an object closer to the telescope, the length of the telescope had to be shortened.
   (b) To observe objects farther from the telescope, the telescope had to be extended.
3. Answers will vary depending on the quality of the lens and the design of the telescope. Some students will be able to see distant objects surprisingly clearly.
4. Students' answers will vary but may include suggestions such as to increase the size of the lenses, make the telescope tubes longer, or improve the quality of the lenses.

Find Out Activity 10-2B

Pointing in the Right Direction, p. 374

Purpose

- Students investigate the use of an astrolabe to record and determine locations of different objects.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Construct the astrolabes using BLM 4-9, Find Out Activity 10-2B, Pointing in the Right Direction.	For each group: – astrolabe – directional compass – pen – paper – BLM 4-9, Find Out Activity 10-2B, Pointing in the Right Direction
1 day before	Collect materials, including compasses, and objects to be placed in room. Determine how and where the objects will be placed.	

Time Required

- 30 min

Science Background

An astrolabe is an example of an ancient astronomical computer. The astrolabe, in its various incarnations, has been used for well over 2000 years. It was used to determine positions of celestial bodies in the sky, such as the Sun, stars, and planets. Early astronomers used the apparatus to determine time based on the position of objects in the sky as well as geographic position. Ancient mariners modified the tool to be used as a navigational instrument on the high seas in the absence of visible landmarks. In the middle of the 17th century, technological advances yielded more accurate devices, and the astrolabe was no longer the most popular astronomical instrument.

In this activity, students will use simplified astrolabes to determine the position of a variety of objects you have placed around the room. Students will see both the accuracy of the instrument, as well as its limitations, for determining the positions of objects.

Activity Notes

- The activity will be much faster if you prepare the astrolabes ahead of time.
- If students construct the astrolabes, they will need the second page of BLM 4-9, Find Out Activity 10-2B, Pointing in the Right Direction.
- A washer makes a good plumb bob.
- Students may work in pairs or individually for this activity. Working in pairs allows for a viewer and a recorder for each sighting.
- Place a variety of items (tennis balls, paper or plastic stars, small toys) at various locations around the room. Use different heights.
- You can make the measurements easier by placing objects no farther than 90° from north. The degree of difficulty you wish to set can be determined by the abilities of students.
- In step 2, students could use the astrolabe to determine the compass angle to the object, for example, 20° east of north, or just 20° east.
- You may wish to distribute the first page of BLM 4-9, Find Out Activity 10-2B, Pointing in the Right Direction, for students to use in recording their data. If you do, you can write the name of each object to locate in the left column before you photocopy the page.

Supporting Diverse Student Needs

- Students with difficulty creating written responses to the What Did You Find Out? questions could answer them orally in an interview with you or with a partner.
- Body-kinesthetic and visual-spatial learners will provide useful expertise to pairs or groups.
- For enrichment, students could use the astrolabe to find the height of the school, a flagpole, or a tree. They can pace the distance from the object to the spot from which they will measure and use the astrolabe to determine the angle (from horizontal) to the top of the object. Using the formula: height = angle × distance (m), students should be able to get a fairly accurate measure of the height.

What Did You Find Out? Answers

1. Answers will vary but may include reference to the difficulty of making accurate measurements as well as holding the apparatus steady to determine the angle of height.
2. Answers will vary but may include suggestions for technological improvements, for example, laser sighting and digital display.
3. Coordinates will change based on the location of the observer.
4. An observer on Earth is subject to the rotation of Earth. A person measuring from the same spot at different times of the day will actually be in a different position in space. This difference in position will affect the angle at which the object is observed.
5. In order for a person to share an observation of an object in the sky, the person must record not only the coordinates of the object, but also the exact viewing location and exact time of day that the object was observed.

SECTION 10.2 ASSESSMENT, p. 375

Check Your Understanding Answers

Checking Concepts

1. They used that information to prepare for changing seasons, animal migrations, flooding rivers, and other natural phenomena.
2. He observed the shadows created on the Moon during a lunar eclipse. Since those shadows had curved edges, Aristotle concluded that Earth must be a sphere.
3. A heliocentric universe has the Sun at the centre and the planets revolving around it.
4. (a) Aristotle proposed a geocentric universe and also that Earth must be spherical in shape.
   (b) Aristarchus was the first to propose a heliocentric universe, and also that Earth and the other planets rotate on their axes.
   (c) Ptolemy observed Mars closely and developed a model of the solar system, based on Aristotle's model, to explain retrograde motion by adding epicycles to each planet's crystal sphere.
   (d) Copernicus proposed a heliocentric universe by observing the night sky and the motion of Earth around the Sun.
   (e) Galileo was the first to turn a telescope to the sky. He discovered the craters on the Moon, spots on the Sun, the phases of Venus, and four "stars" orbiting the planet Jupiter (which turned out to be natural moons).

Understanding Key Ideas

5. Watch a boat moving away from shore—it will appear to sink as it gets farther away.
6. The planets do not orbit around Earth, the stars are not located on a crystal sphere, and the planets' orbits are not circular.
7. Mariners used the astrolabe to compare the positions of celestial objects to positions in tables that were carried on the ship to determine their position.
8. Copernicus' model explains retrograde motion by the positions of the planets with respect to Earth while Ptolemy explains retrograde motion by the use of epicycles and deferents.
9. Galileo observed the moons of Jupiter and the phases of Venus.
10. A geocentric model has Earth at the centre and the Moon, Sun, and planets revolving around it. A heliocentric model has the planets revolving around the Sun, which is at the centre, and the Moon revolving around Earth.

Pause and Reflect Answer

Aristarchus of Samos proposed a heliocentric model of the universe, but Aristotle's geocentric model suppressed and superseded Aristarchus' model for nearly 1900 years.

Copernicus proposed the heliocentric model although people of the day still believed in the Aristotle model. Galileo was imprisoned for publishing his observations and ideas that supported a heliocentric universe.

Other Assessment Opportunities

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

10.3 STANDING ON THE SHOULDERS OF GIANTS

BACKGROUND INFORMATION

The work of Copernicus and Galileo set the stage for further observations and theories about the workings of the universe. Kepler discovered how the motion of the planets could be predicted using mathematics by using Brahe's precise observations of the motions of the planets. We continue to use his laws to predict planetary motion today. Newton devised a way to explain how the planets moved in orbits around the Sun using the force of gravity.

COMMON MISCONCEPTIONS

- Students may not be aware that Earth is in an elliptical orbit around the Sun. Earth is slightly closer to the Sun in January and farther away in July.

- Some students may be aware of our elliptical orbit, but think that it is the cause of summer and winter. That is not the case. Remind students that we are actually closer to the Sun in winter. It is the tilt of Earth's axis that results in summer and winter.

ADVANCE PREPARATION

- Gather materials to model the Sun and planets as described in Find Out Activity 10-3A, on page 381.
- Cut cardboard for Find Out Activity 10-3C, on page 384.

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

INTRODUCING THE SECTION, pp. 376–378

Using the Text

Write Newton's phrase "Standing on the Shoulders of Giants" on the chalkboard. Tell students that the astronomers of the 16th century made many discoveries, but they were all based on the work done by astronomers who came earlier. Review with students what contributions Aristotle, Ptolemy, and the other astronomers in section 10.2 made. As students suggest the contributions, record them on the chalkboard, possibly in a graphic organizer such as a cause-and-effect map or a flowchart.

Tell students that they are now going to learn how a new generation of astronomers built on this knowledge to advance astronomical models. The advantages they had were the careful observations of previous astronomers, and new technology such as advanced telescopes and more sophisticated mathematics.

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 4-3, Chapter 10 Key Terms, can be used to assist students.

TEACHING THE SECTION, pp. 379–380

Using Reading

This section is structured in a very similar way to the previous section, and in many ways is a continuation of it. Students can approach it using similar strategies to those they used in section 10.2.

Pre-reading—Predict-Read-Verify

Chunk the text into manageable sections by headings (each astronomer). Before reading, ask students to read the headings, analyze the visuals, and read the captions. Encourage students to use their background knowledge of astronomy to predict what each of the astronomers observed and discovered. After reading the section, students can verify or revise their predictions.

During Reading—GIST

As students read this section, have them write short summaries for each of the astronomers—their observations, theories, and discoveries. Students can use jot-note form. Encourage students to keep their summaries to 20 words or less.

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 an astronomer from the text, and then another student writes about another astronomer. 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—Summarize and Organize

Have students work in pairs to build a graphic organizer, such as a flowchart, which shows all the models of our solar system that they have learned about in sections 10.2 and 10.3. These graphic organizers can be created on large sheets of paper and put on display for the class or a wider audience.

Reading Check Answers, p. 380

1. The Sun is at the centre of the solar system and the planets move in circular orbits, or paths, around the Sun.
2. Law 1. All planets move in ellipses, with the Sun at one focus.
   Law 2. Planets sweep out equal areas of their elliptical orbit in equal times.
   Law 3. The time a planet takes to revolve around the Sun is directly related to how far away it is from the Sun.
3. Gravity
4. Inner planets and outer or Jovian planets

USING THE ACTIVITIES

- Activity 10-3A, on page 381 of the student textbook, can be completed at any time during or after reading this section.
- Activity 10-3B, on pages 382 and 383 of the student textbook, is best used after students have read the Scale of the Solar System section on pages 379 and 380.
- Activity 10-3C, on page 384 of the student textbook, is best used as students read about Kepler's laws of planetary motion, on page 377.

Detailed notes on doing the activities follow.

Find Out Activity 10-3A

The Length of the School Year on Different Planets, p. 381

Purpose

- Students investigate the length of a school year on other planets.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
Day of instruction	Provide students with graph paper. Make copies of BLM 4-11, Find Out Activity 10-3A, The Length of the School Year on Different Planets (optional).	For each group: – pencil – paper – calculator – graph paper

Time Required

- 30 min

Science Background

The length of a year on a planet is determined by the amount of time it takes to make a complete revolution of the Sun. On Earth, that amounts to 365.25 days. Planets farther from the Sun than Earth have longer years, and those that are closer have shorter years. The purpose of this activity is to illustrate the different periods of revolution for different planets. Students will relate the data they learn to data with which they can identify: the proportion of the year they spend in school. A typical school year is nine months. Students calculate the length of a school year on other planets in Earth-months.

Activity Notes

- For step 3, the suggested y-axis "month" scale is large. It is suggested that students plot only to Saturn or Uranus. The change in slope will not be any less dramatic. Guide students in choosing an appropriate scale for their graphs.
- You may wish to distribute BLM 4-11, Find Out Activity 10-3A, The Length of the School Year on Different Planets, for students to use in recording their data.

Supporting Diverse Student Needs

- This activity may be done in pairs or individually. If students work in pairs, ensure students who need support with graphing are paired with students who have strong mathematical skills.
- Some students may require help with the initial calculation. Invite a student to use the model provided in the student textbook to calculate the length of the school year on Venus on the chalkboard. Have other students prompt the demonstrator step-by-step.

What To Do

PLANET	PERIOD OF REVOLUTION (RELATIVE TO 1 EARTH-YEAR)	SCHOOL YEAR (MONTHS)
Mercury	0.24	2.16
Venus	0.61	5.49
Mars	1.7	15.3
Jupiter	11.9	107.1
Saturn	29.5	265.5
Uranus	84.0	756.0
Neptune	165.0	1485.0

What Did You Find Out? Answers

1. The length of the school year increased as the distance from the Sun increased.
2. The length of school year for the outer planets increases at a faster rate than the length of the school year for the inner planets.

Core Lab Conduct an Investigation 10-3B

Strolling Through the Solar System, pp. 382–383

Purpose

- Students investigate scale distances and sizes of the solar system.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Purchase the materials to be used for planetary models.	For each group: – materials to model the Sun and planets: ball bearing, or similar sized ball (~2.8 mm diameter), baby powder, coarse and fine-grained sand, salt, cake sprinkles, and small candies or decorations – 9 index cards – clear adhesive tape – 9 sticks (at least 15 cm long) – measuring tape (100 m)
1 day before	Check weather reports, if activity is to take place outside. If the activity will take place inside, ensure you have booked space for it. Make copies of BLM 4-12, Core Lab Conduct an Investigation 10-3B, Strolling Through the Solar System (optional).	
Day of instruction	Prepare the materials.	

Time Required

- 60 min

Safety Precautions

- Remind students not to eat anything in the science room.

Science Background

Most students will be able to name the basic components of the solar system: a star (the Sun), planets, asteroids, and comets. This may, however, be the first opportunity students have had to explore the concept of scale in the universe. Typically, the solar system is illustrated in two parts: a comparison of the planetary sizes and a diagram showing the relative orbits of each planet. This activity will address the issues of size and distance in our solar system as one exercise, and will offer a new perspective of proper scale.

The first thing students will realize is the solar system is mostly empty. Celestial bodies are separated by vast expanses of empty space. The size of each of the planets is many times smaller than the distance that separates them. As students will have learned earlier in this section, the orbital paths of the planets are elliptical, with the Sun at one focus of the ellipse. The paths of revolution are almost circular and most lie on the same elliptical plane. Mercury is the exception, with an orbit tilted about 7° from the elliptic.

All of the planets orbit in the same direction around the Sun—counterclockwise when looking down toward the Sun's North Pole. The purpose of the exercise is for students to gain an appreciation of the comparative sizes of the planets in relation to one another and to understand the concept of distance in the solar system. This will lead to better comprehension of the vastness of distances in space.

Activity Notes

- Introduce this activity with a discussion about the sizes of planets and the distances between them. Have students rank planets by size and predict between which two neighbouring planets the greatest distance will be.
- This activity is suitable for groups of three or four students. Models will use large amounts of space, and too many groups will get in one another's way.
- This activity would ideally take place outside. It can, however, be completed using a long hallway, or gym area. It may be an idea to set up the Sun (ball bearing/table tennis ball) in the centre of a soccer field, and have each group radiate outward from the centre like spokes on a wheel. Ideally, the length required for each model is 90 m.
- There will be a huge temptation for some students to eat the solar system objects. Encourage them to fight this urge for the sake of their health. They do not know what any of the materials in the science room may have come into contact with.
- In Conclude and Apply, students should use a scale of 1 m = 50 million km to complete the table and create their model, as well as to add Proxima Centauri.
- You may wish to distribute BLM 4-12, Core Lab Conduct an Investigation 10-3B, Strolling Through the Solar System, for students to use in recording their data.
- Students may wish to make a rough sketch of their model to show the approximate relative sizes and locations of planets.

Supporting Diverse Student Needs

- Explain and demonstrate the steps involved in this activity to students if they would benefit from support following written instructions.
- As much as possible, ensure that each group includes logical-mathematical learners, body-kinesthetic learners, and students with strong reading skills.
- For enrichment, have students determine landmarks that correspond to the last two scale distances from the Sun listed in the table that students completed in the Conclude and Apply section (57 m and 90 m).

Analyze Answers

1. (a) The size of the inner planets in this activity (like the actual inner planets) is considerably smaller than the outer planets.
   (b) The distances to the outer planets in this activity (like the actual distances) are all considerably greater than the distances between the inner planets.
2. The distances between the inner planets in this activity (like the actual distances) are all considerably smaller than the distances between the outer planets.

Conclude and Apply Answers

1.

SOLAR SYSTEM OBJECT	ACTUAL DISTANCE FROM SUN (KM)	SCALE DISTANCE FROM SUN (M)	DISTANCE FROM PREVIOUS PLANET (M)
Sun			
Mercury	58 million	1.16	
Venus	108 million	2.16	1.00
Earth	150 million	3.00	0.84
Mars	228 million	4.56	1.56
Asteroid Belt	~ 400 million	~ 8	~ 3
Jupiter	778 million	15.56	11.00
Saturn	1 430 million	28.60	13.04
Uranus	2 870 million	57.40	28.80
Neptune	4 500 million	90.00	32.60

The scale distance to Proxima Centauri would be 60 000 000 m.

2. Based on the scale model, and the calculations to the objects listed, it is unlikely that humans would ever travel beyond Neptune because the distances are so immense.

Find Out Activity 10-3C

Easy Ellipses, p. 384

Purpose

- Students investigate the shapes of planetary orbits by constructing a variety of ellipses.

Advance Preparation

WHEN TO BEGIN	WHAT TO DO	APPARATUS/MATERIALS
1 week before	Prepare the materials. Make copies of BLM 4-13, Find Out Activity 10-3C, Easy Ellipses (optional).	For each group: – 2 corrugated cardboard squares (30 cm ? 30 cm) – blank piece of paper (28 cm ? 21.5 cm) – ruler – clear adhesive tape – pencil – string (or thread) about 20 cm long – 2 pushpins

Time Required

- 30 min

Safety Precautions

- Caution students to be careful with the pushpins. If they drop one, they must pick it up immediately. They should only use the pins for the intended purpose.

Science Background

Johannes Kepler was a German astronomer and an assistant to the great astronomer Tycho Brahe. In the early part of the 17th century, Kepler was intent on promoting the heliocentric (that is, Sun-centred) concept of the solar system. For centuries, scholars had declared that Earth was the centre of the universe. Kepler believed that the solar system operated on its own unique set of mathematical rules—an innovative (and unpopular) idea at the time. One of the biggest challenges for Kepler was to find data that supported his theory.

A heliocentric model demanded circular orbits for the planets, or so it was thought. However, the data recorded by Brahe did not match this concept and, as a consequence, did not support the model. Kepler, a mathematician, studied the positions of Mars extensively and determined that the planets revolved in elliptical, rather than circular, orbits. The data now matched the theory.

At last, using elliptical orbits and a heliocentric model of the solar system, planetary motion could be explained as well as predicted. It would be half a century later that a British scholar named Isaac Newton would explain that gravity is the concept that unifies all planetary motion.

The purpose of this activity is to acquaint students with the different sizes and shapes of ellipses. This will allow students to experience roughly the same conclusion reached by Kepler, and proposed as his first law: the orbit of a planet or comet about the Sun is an ellipse with the Sun's centre of mass at one focus.

Activity Notes

- This activity may be done individually or in pairs to support one another.
- The most difficult part of this activity will be tying the thread. Students can help one another, if necessary.
- Two corrugated cardboard squares are required so that the push pins do not go through the cardboard and scratch the desk or table. A square piece of ceiling tile can be substituted for the two cardboard squares. Students should not pull hard on the string, or the pins will come out of the cardboard.
- You may wish to distribute BLM 4-13, Find Out Activity 10-3C, Easy Ellipses, for students to use in recording their data. It includes a correct table for recording data. The table in the first printing of the student textbook should have these heads:

	d1	d2	Sum of Distances (d1 + d2)
A			
B			
C			

Supporting Diverse Student Needs

- Arrange pairs of students so logical-mathematical, verbal-linguistic, and body-kinesthetic learners can support one another.
- For enrichment, ask students to predict what would happen if a longer piece of string was used (following the same procedure as described in the activity), for example, 80 cm. Although the numbers will be larger, the relationship does not change. Students can work in a group to test various lengths.

What Did You Find Out? Answers

1. The sum of the distances for each point on the ellipse should be relatively equal.
2. (a) The shape of the ellipse flattens out (gets squished) the farther apart the foci (pushpins) are.
   (b) The ellipse becomes more circular (round) the closer together the foci (pushpins) are.
3. The sum of the distances should be equal, as they were for previous calculations.
4. When the pushpins are placed together, (that is, one focus), the result is a circle.
5. The sum of the distances from the foci to any point on an ellipse is equal for every point on the ellipse.

SECTION 10.3 ASSESSMENT, p. 385

Check Your Understanding Answers

Checking Concepts

1. An astrophysicist is someone who is an astronomer and a physicist.
2. As a planet gets closer to the Sun, its speed increases.
3. (i) Its orbit is elliptical.
   (ii) Its speed is not constant—it speeds up as it gets closer to the Sun and slows down as it gets farther away.
   (iii) The time a planet takes to revolve around the Sun is directly related to how far away it is from the Sun.
4. Sir Isaac Newton showed that the force of gravity affects all celestial bodies causing them to remain in orbit. He also invented the reflecting telescope.
5. Gravity extends beyond the surface of Earth and affects all celestial bodies causing them to remain in orbit around larger bodies.
6. The rotation of the planet on its axis causes it to have day and night.
7. Mercury, Venus, Mars, Jupiter, and Saturn
8. Inner planets are small, have solid cores, and have rocky crusts. Outer planets have gaseous atmospheres, have cold temperatures, and lack a solid surface.

Understanding Key Ideas

9. Brahe made accurate observations of the motions of the planets. Kepler used this information to develop his theories of planetary motion.
10. Once Kepler assumed that the planets were in elliptical orbits, he could use new technologies to make accurate observations and then mathematically describe and predict the planets' motion.
11. The farther a planet is from the Sun, the longer it takes to orbit the Sun.
12. The planets are in elliptical orbits.
13. A Newtonian reflecting telescope could be built larger and could observe more precisely than the refracting telescopes, which used lenses.
14. Astronomers noticed that the orbit of Uranus was not a perfect ellipse and reasoned that another planet outside of Uranus' orbit was exerting a gravitational force on it.

Pause and Reflect Answer

Laws of Planetary motion: 1. Planets orbit the Sun in elliptical orbits; 2. The planet's speed is not constant—it speeds up as it gets closer to the Sun and slows down as it gets farther away; 3. The time a planet takes to revolve around the Sun is directly related to how far away it is from the Sun.

Law of gravity: All celestial bodies are held in orbit by gravity.

Other Assessment Opportunities

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

CHAPTER 10 ASSESSMENT, pp. 386–387

PREPARE YOUR OWN SUMMARY

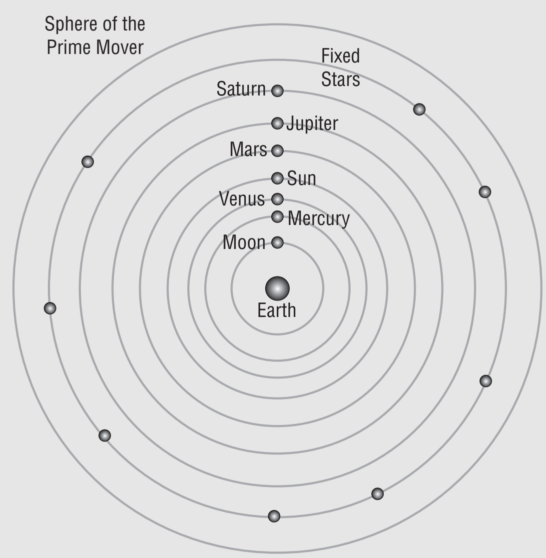
Students' summaries should incorporate the following main ideas:

1. Constellations and Stars
   - Constellations are patterns of stars depicting objects, people, or animals.
   - Stars vary in magnitude.
   - The Sun appears to move along a path called the ecliptic due to Earth's motion in its orbit.
   - Different constellations are visible at different times of the year
2. Contributions of Ancient Greek Astronomers
   - Aristotle and Ptolemy developed models of a geocentric universe to explain observations of planetary motion.
   - Eratosthenes was able to measure the circumference of Earth.
   - Aristarchus' model of a heliocentric universe was suppressed for 1900 years.
3. Heliocentric Model of the Universe
   - Copernicus used observations of the motions of the celestial bodies to support a heliocentric universe.
   - Galileo's observations with a telescope proved the heliocentric model.
4. Galileo's Invention of the Telescope
   - Galileo observed the Moon, Sun, planets, and stars with a small telescope.
   - Galileo discovered the moons of Jupiter, phases of Venus, craters on the Moon, and spots on the Sun.
5. Contributions of Kepler and Newton to Astronomy
   - Kepler developed three laws of planetary motion which described how planets move around the Sun.
   - Newton developed a law of gravity describing how objects are held in orbit around larger bodies.
   - These laws are still considered valid today.

CHAPTER REVIEW ANSWERS

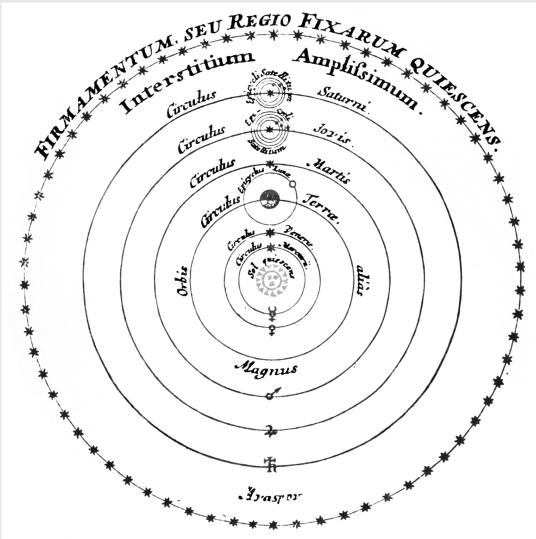
Checking Concepts

1. Ursa Major, Leo, Orion, and Cassiopeia
2. An asterism is a smaller group of stars within a constellation (for example, the Big Dipper in Ursa Major).
3. Stars are assigned a number for their brightness where the lower the number, the brighter the star.
4. The stars would move from east to west. (Circumpolar stars would move counterclockwise around the North Celestial Pole.)
5. A circumpolar constellation is a constellation which is close to the North Celestial Pole and does not set.
6.



Aristotle's Universe

7. The shadow of Earth on the Moon during a lunar eclipse had curved edges so Aristotle concluded that Earth must be a sphere.

8. 

9. His observations of the Sun, Moon, and planets through a telescope confirmed the heliocentric theory of the universe.
10. The three laws of planetary motion developed by Kepler
11. Newton developed three laws to describe and predict motion, he developed the law of gravity, he invented a reflecting telescope, and he was a mathematician (he developed calculus).
12. We can predict the motions of the planets in their elliptical orbits about the Sun. We can use these laws to predict the motion of any object orbiting another object (an Earth satellite, a star orbiting another star, or stars orbiting the centre of a galaxy). Celestial bodies are kept in orbit by gravity.

Understanding Key Ideas

13. A celestial body is a natural object out in space such as a planet, a moon, an asteroid, a comet, or a star. A constellation is a pattern of stars which depicts an object, person, or animal.
14. You could use your hand at arm's length to estimate the angular dimension.
15. Since the orbits of Mercury and Venus are inside that of Earth, they always appear close to the Sun. The outer planets are in orbits outside of Earth's orbit, so they can be seen throughout the night.
16. Aristotle proposed a geocentric universe with Earth at the centre. Aristarchus proposed a heliocentric model, with the Sun at the centre.
17. Mars moves in a retrograde motion, slowing down and stopping and moving in the opposite direction for a time. Ptolemy proposed that each planet revolved around a point on its orbit called an epicycle to explain this motion.
18. A geocentric model with Earth at the centre would see the Sun and planets rising and setting as they orbit Earth, which is what we see. A heliocentric model would also see the Sun and planets rising and setting as Earth rotates. It is the observed phases of Venus that would prove the heliocentric theory.
19. A Jovian planet is primarily made of gas and does not have a solid surface to land on.
20. Copernicus proposed the heliocentric theory. Galileo proved the heliocentric theory. Kepler developed the three laws of planetary motion.

Pause and Reflect Answer

Timelines could show the following events:

Cave pictures in France—approximately 16 500 years ago

Chinese astronomers—4000 years ago

Aristotle—383–322 B.C.E.

Aristarchus—310–230 B.C.E.

Eratosthenes—276–194 B.C.E.

Ptolemy—83–168 C.E.

Copernicus—1473–1543

Galileo—1564–1642

Brahe—1546–1601

Kepler—1571–1630

Newton—1643–1727