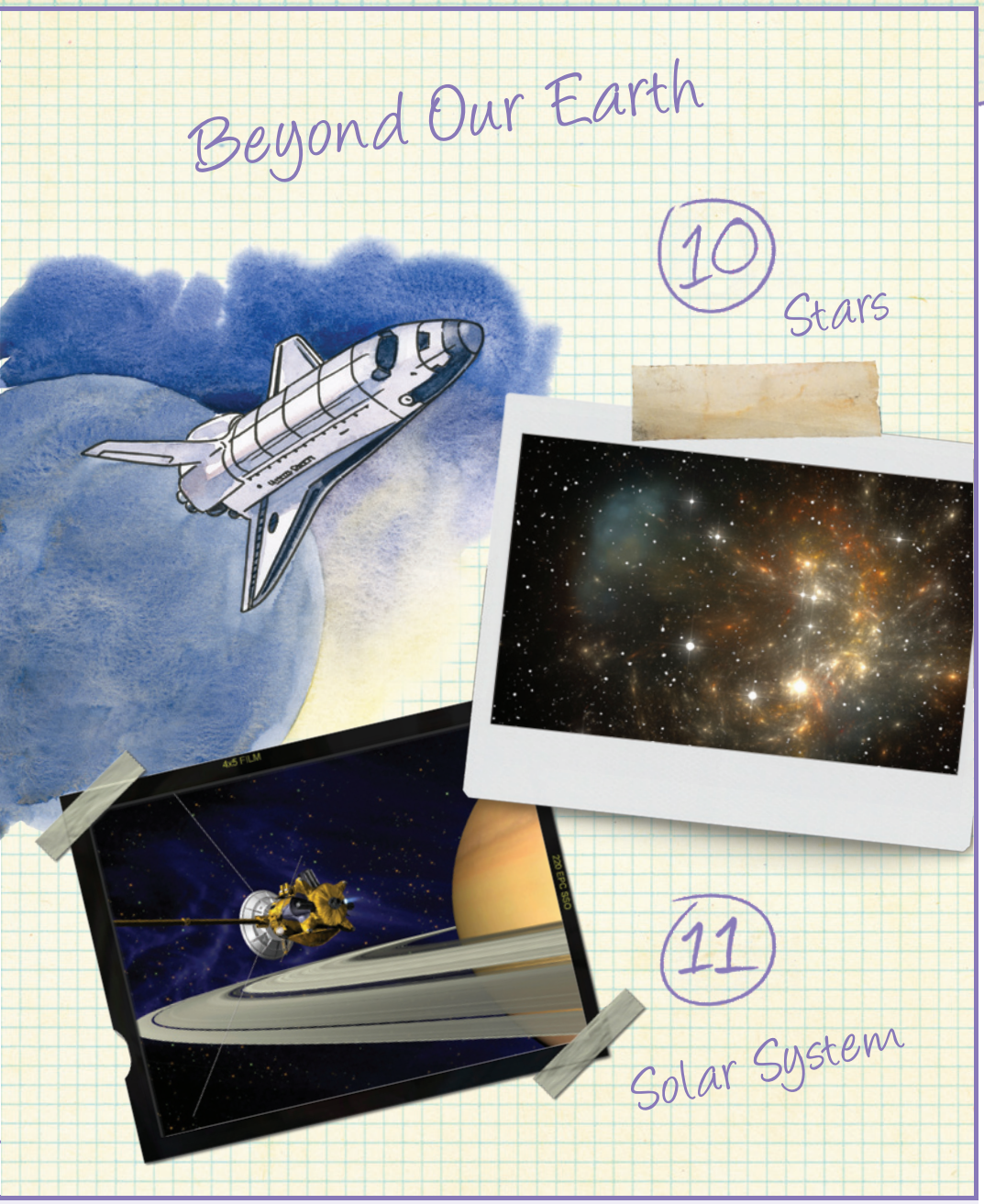
Unit 4 Overview

Lesson	TE pages	ST pages	AM pages	Assessment	Content
Chapter 10: Stars					
115	253–55	233–35	157		• Unit and chapter opener • Preview the unit and chapter content
116	256–59	236–39	158		• Characteristics of stars • Colors of stars • Sizes and distances of stars
117	260–63	240–43	159–60	Quiz 10-A	• Variable stars • Novas • Supernovas • Neutron stars • Black holes
118	264–67	244–47	161		• Constellations • Astrology • Telescopes • Spectroscopes
119	268	248		Rubric	Activity: Pinhole Constellations • Modeling constellation patterns
120	269	249		Rubric	Exploration: A Different Look • Modeling the distances of stars in a constellation
121	270–75	250–55	162–64	Quiz 10-B	• Star groups • Star clusters • Galaxies • The Local Group • Asteroids, meteroids, comets
122	276–77		165–66		• Reading a star chart • Observing the night sky
123	278–79	256–57	167–68	Rubric	Activity: Crater Creations • Observing relationships between mass, height, and depth of craters • Testing hypotheses
124	280	258	169–70		**Chapter Review** • Apply knowledge to everyday situations
125	280			Test	**Chapter 10 Test**
Chapter 11: Solar System					
126	281	259	171		• Chapter opener • Preview the chapter content
127	282–85	260–63	172		• Space exploration (rockets, space shuttle, satellites, probes, international space station)
128	286–87	264–65	173–74		**Technology: Inflatable Spacecraft** • Recognizing the benefits of inflatable technology
129	288–89	266–67	175–76	Rubric	Activity: Rocket Race • Hypothesizing how design affects the performance of a balloon rocket • Demonstrating Newton's third law of motion
130	290–93	268–71	177–78	Quiz 11-A	• Parts of the sun • Solar storms • Seasons
131	294–97	272–75	179–80		• Planets • Mercury, Venus, Mars
132	298–301	276–79	179–82	Quiz 11-B	• Earth and the moon • Project Apollo • Solar and lunar eclipses
133	302–3	280–81	183–84	Rubric	Activity: Spare Parts Solar Oven • Designing and building a solar oven
134	304–7	282–85	179–80, 185	Quiz 11-C	• Outer planets • Jupiter, Saturn, Uranus, Neptune • Dwarf planets
135	308–9		186	Rubric	Exploration: A Solar Walk • Constructing a scale model of the solar system
136	310–11		187–88	Rubric	Exploration: Travel Brochure • Researching and designing a travel brochure for a planet
137	312	286	189–90		**Chapter Review** • Apply knowledge to everyday situations
138	312			Test	**Chapter 11 Test**



Weblinks
The BJU Press website offers additional information and links you may find helpful throughout the unit.

www.bjupress.com/resources

Unit opener photos and art
The upper photo shows a colorful nebula in space. The lower photo is an artist's conception of the space probe *Cassini* during its mission to Saturn. The art on this page is an illustration of the space shuttle.

Lesson 115

Objectives
- Recognize the interrelationship of science concepts in the unit
- Relate how God's glory is reflected in the vastness of the stars
- Preview the unit and chapter content

Introduction

The purpose of this unit is to showcase God's marvelous universe. It is not intended to be an exhaustive study but to provide basic knowledge that will be further developed in secondary science.

Both chapters emphasize the importance of gravity on celestial bodies and the vast distances in the universe.

Chapter 10 discusses stars and star groups as well as asteroids, meteoroids, and comets. It explains some of the ways that man learns about the universe.

Chapter 11 narrows the focus of the universe to the solar system. The most important star to us, the sun, is discussed, as are some of the distinctive features of Earth, its moon, and other planets. The chapter concludes with a lesson on how man learns about the solar system.

Look through Unit 4. What kinds of topics do you think you will be studying? Possible answers: stars, telescopes, planets, space exploration, Earth, the moon

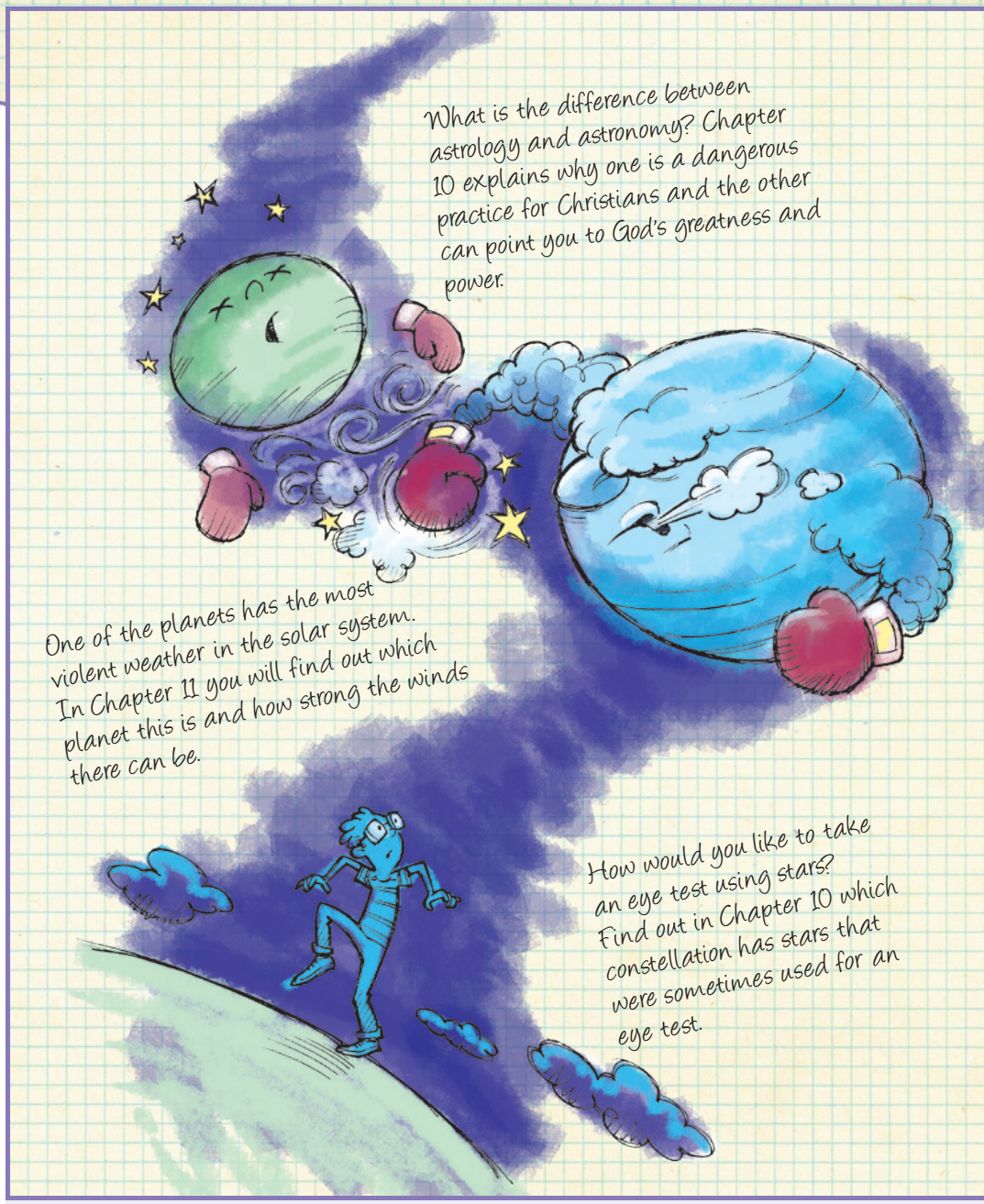
How do the chapters relate to each other? Answers will vary, but elicit that both are mainly about astronomy and space.

Project Idea

The project idea presented at the beginning of each unit is designed to incorporate elements of each chapter as well as information gathered from other resources. You may choose to use the project as a culminating activity at the end of the unit or as an ongoing activity while the chapters are taught.

Unit 4—Moon Base

The student should design a base on the moon. After choosing what scientific function the base will have, he needs to plan transportation (both to and from Earth, as well as on the moon), food, and shelter needs. The student should consider gravity, threat of meteorites, lack of atmosphere, and other features of the moon as he plans his base.



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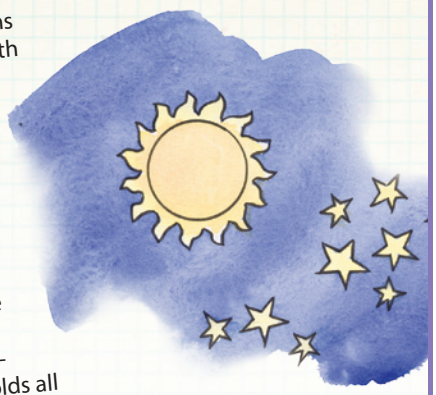
Stars

Long ago the psalmist David wrote that "the heavens declare the glory of God; and the firmament sheweth his handywork" (Ps. 19:1). David realized that the heavens and the objects in them provide a marvelous testimony to the greatness of our God. Only God knows how many stars are in the sky. There are many, many more than man can count. On a clear, dark night, man can see only about 3,000 stars. With telescopes and other tools, scientists have discovered so many more stars that they can only estimate how many there might be. Some scientists think there might be as many as 300 sextillion stars—300 with twenty-one zeros after it! And the Bible says that God holds all of it together (Col. 1:17). Few things declare the glory of God like the vastness of the universe.



TEACHER HELPS

Chapter preview
Other preview and prereading activities may include using a K-W-L chart, a probe, or an anticipation guide.

Chapter photo
The photo on this page shows an observer looking at the Milky Way galaxy.

Student Text diagrams
Diagrams from the Student Text are included on the Teacher's Toolkit CD.

SCIENCE BACKGROUND

Early astronomers
Most ancient civilizations studied astronomy. They used the movement of the moon and the stars to make calendars. The Egyptians used the movement of the stars to predict when the Nile would flood. The ancient Polynesians were sailors who used stars for navigation. Both the Babylonians and the Chinese kept detailed astronomical records. The Chinese have records of a solar eclipse that occurred in 2136 BC.

Introduction

The more astronomers study the universe, the more they are amazed at the things they discover. How much more should a Christian be amazed at the God who made it all with nothing but His word (Gen. 1:14).

Where in the Bible does it say "The heavens declare the glory of God"? Psalm 19:1

Who said this? David

Why do you think he said this? Possible answer: He saw the night sky covered with thousands of stars.

How can the stars and the universe cause us to glorify God? They can cause us to think on the immensity and beauty of the universe. A Christian is glorifying God each time he stops and considers all that was created by God and what God must be like to have accomplished those things.

Teach for Understanding

Provide time for the student to complete Looking Ahead, Activity Manual page 157. For part B, encourage the student to think of things he would like to learn about characteristics of stars and the Milky Way. He should write his answers in question form, such as, "Which star is the biggest star?"

Provide the answers for part A and allow the student to check his work. After the chapter is finished, you may choose to have him look back at this page and check his understanding of the items he missed.

As time allows, discuss student questions from part B about stars and the Milky Way. You may choose to provide trade books or other resources to help answer questions that are beyond the scope of this chapter.

Allow the student to leaf through the chapter, looking at the headings, pictures, captions, charts, etc., and discuss the things he thinks he will be learning about.

Activity Manual

Preview, page 157
The Looking Ahead page is intended to assess the student's prior knowledge before beginning the chapter.

Lesson 116

Student Text pages 236–39
Activity Manual page 158

Objectives
- Explain how stars produce their own light
- Distinguish between apparent magnitude and absolute magnitude of stars
- Identify classifications of stars according to color
- Explain ways distance is measured in space
- Interpret diagrams

Materials
- meter stick

Vocabulary
magnitude
apparent magnitude
absolute magnitude
dwarf
giant star
supergiant
light-year
parallax

Introduction
Direct a student to measure the length and width of the room using centimeters. Record the measurements. Multiply the numbers to find the area of the room.

Are centimeters the best unit of measurement to find the area of this large room? no **Why?** Possible answer: Using larger units to measure the room would be easier because larger units of measurement give smaller numbers to multiply.

What would be the best unit to use for measuring the room? meter

Would a meter be a good unit to use to measure distances in space? no **Why?** Possible answer: The measurements would have very large numbers.

As scientists began to explore and study space, they developed other units of measure to help them measure large distances.

Teach for Understanding
Purpose for reading
What are some ways distances are measured in space?

Does the brightness of a star tell us accurately how far the star is from Earth?

Discussion
On what day did God create the sun, moon, and stars? the fourth day of Creation

Name some times that God used stars in a specific way in the Bible. Possible answers: as a lesson to Abraham; to announce Jesus' birth to the wise men

Which star do scientists study the most? the sun **Why?** Possible answer: It is the closest star to Earth.

What are stars? glowing balls of burning gases

What are the percentages of the main elements that make up most stars? 70% hydrogen, 28% helium, and 2% other elements

When you look up into the clear night sky, it appears as though sparkling jewels have been thrown across a dark velvet cloth. Perhaps you have wondered how far away the stars are and why some are brighter than others. Like you, millions of people have been dazzled by the brilliance of particular stars and have wanted to know more about the beautiful lights in the sky.

God created the sun, moon, and stars on the fourth day of Creation. "And God said, Let there be lights in the firmament of the heaven to divide the day from the night; and let them be for signs, and for seasons, and for days and years: . . . he made the stars also" (Gen. 1:14, 16). And like all the rest of His creation, "God saw that it was good" (Gen. 1:18).

For thousands of years, man used God's lights to mark the passage of time. With today's modern technology, man does not often rely on just the sun, moon, and stars. But God's lights still serve His purposes. They still overwhelm man with his insignificance (Ps. 8:3–4). God used the stars as an object lesson to Abraham when He told him he would be the father of a great nation, one that would be as numberless as the stars (Gen. 15:5). Though the stars seem numberless to man, Psalm 147:4 says that God "telleth the number of the stars; he calleth them all by their names." God knows everything about His creation.

Our Closest Star
The sun is one of billions of stars in the sky. It is the star nearest Earth, about 150,000,000 km (93,000,000 mi) away. Because the sun is very near to us (compared to other stars), scientists can study it. What they learn they apply to the understanding of other stars.

Like other stars, the sun is a glowing ball of gases made up of about 70% hydrogen, 28% helium, and 2% other elements. Unlike planets and moons, which only reflect light, the sun and the other stars produce their own light by nuclear fusion. The inside of a star is so hot that hydrogen atoms fuse together to form helium atoms. As this fusion occurs, the star releases energy in the form of heat and light.

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SCIENCE BACKGROUND

Apparent magnitudes
Many heavenly bodies vary in their brightness; therefore, their location on the Hipparchus scale may vary as well.

The approximate apparent magnitudes of the sun, moon, and Venus are the following: sun –27, moon –12, and Venus –4.

LANGUAGE

Appear
The words *apparent* and *appear* come from the Latin word *apparere*, which means "to show." *Apparent* is an adjective form of the verb *appear*.

Absolute
The word *absolute* means "complete" or "pure." Adjusting the viewing distances of all the stars as if they are equal removes the variable of distance and makes the measurements "pure."

BIBLE

God knows the stars
Today one of the ways a person can honor another person is to name a star after him.

The Bible says that God knows the number of the stars and the name of each one (Ps. 147:4).

How can knowing that God names each of the stars be a comfort for us? Answers will vary, but elicit that if God knows each star individually, then He also knows and cares for each person individually.

Characteristics of Stars

By looking at the night sky, a person can see that stars are different. Some are bright. Some are dim. Some are reddish or bluish, and others look pure white. As the Bible says, "There is one glory of the sun, and another glory of the moon, and another glory of the stars: for one star differeth from another star in glory" (1 Cor. 15:41). Stars are different and their different properties, or characteristics, help us classify them.

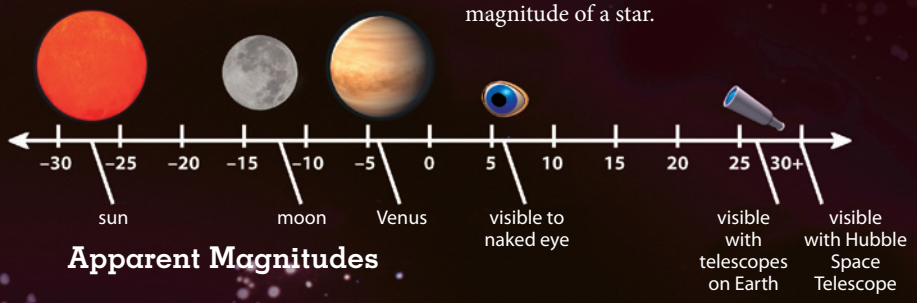
Brightness

The brightness of a star is called its **magnitude**. The magnitude of a star depends on the star's size, temperature, and distance from Earth.

When we look at the stars and say that one is brighter than another, we are talking about how bright each star appears to us. Astronomers call this a star's apparent brightness, or **apparent magnitude**. Some stars, such as our own sun, appear brighter because they are larger or closer to Earth than other stars. Stars that are farther away appear as faint lights in the sky.

Astronomers use a set of numbers to represent apparent magnitude. Lower numbers represent brighter stars. Hipparchus (hih PAHR kus), a Greek who lived 130 years before the time of Christ, devised the system still used today to classify stars by their brightness. In Hipparchus's day, no telescopes existed. Hipparchus classified the brightest stars he could see as +1 on his scale. He classified the faintest stars as +6. Since telescopes now allow men to see much farther into space, astronomers have had to adjust Hipparchus's scale. With huge telescopes today we can see stars as faint as magnitude +29 or greater. Astronomers have also added negative numbers to represent objects that are even brighter than many stars.

The true brightness of a star, called its **absolute magnitude**, measures how bright a star really is, not just how bright it appears to be. Astronomers determine absolute magnitude by imagining that all stars are the same distance from Earth. How bright a star would appear at that distance is the star's absolute magnitude. Special measurements and mathematics help astronomers calculate the absolute magnitude of a star.



Apparent Magnitudes

Discussion

How do stars produce their own light? by nuclear fusion

What happens during nuclear fusion? Hydrogen atoms fuse together to form helium atoms and the star releases energy in the form of heat and light.

What is a star's brightness called? its magnitude

How is apparent magnitude different from absolute magnitude? Apparent magnitude is how bright a star appears from Earth. Absolute magnitude is how bright the star actually is.

Why might one star appear brighter than another star? It may actually be brighter, but it may also be only closer or larger than other stars.

How do scientists determine absolute magnitude? They treat all the stars as if they were the same distance from Earth.

When Hipparchus classified the stars that he could see, he used the numbers 1–6. Later, scientists wanted to rank other objects, such as the sun, moon, and planets that are brighter than stars with a magnitude of 1. Scientists assigned these objects negative numbers.

Look at the *Apparent Magnitudes* scale. What is the approximate magnitude of the moon? −12

What is the approximate magnitude of the faintest stars seen by the Hubble Space Telescope? 30+

Do you think we will ever see stars fainter than those seen by the Hubble Telescope? Answers will vary, but elicit that scientists continue to improve telescopes, so they will probably continue to find fainter stars.

DIRECT A DEMONSTRATION

Demonstrate that star size and distance affect apparent magnitude

Materials: 2 flashlights of the same size, a piece of foil or dark paper with a 0.5 cm diameter hole in the middle, a rubber band

Direct students to stand at the side of the room. Choose two students to hold flashlights and stand two meters in front of the other students.

Darken the room and turn on the flashlights. Instruct the two students to hold the flashlights so that the other students can see that the lights are the same.

How do the apparent magnitudes of the lights appear? the same

Cover one flashlight with the piece of foil and secure with the rubber band.

How do the apparent magnitudes of the lights appear? The covered light looks smaller or weaker.

Uncover the flashlight and move one student with a flashlight to the opposite side of the room.

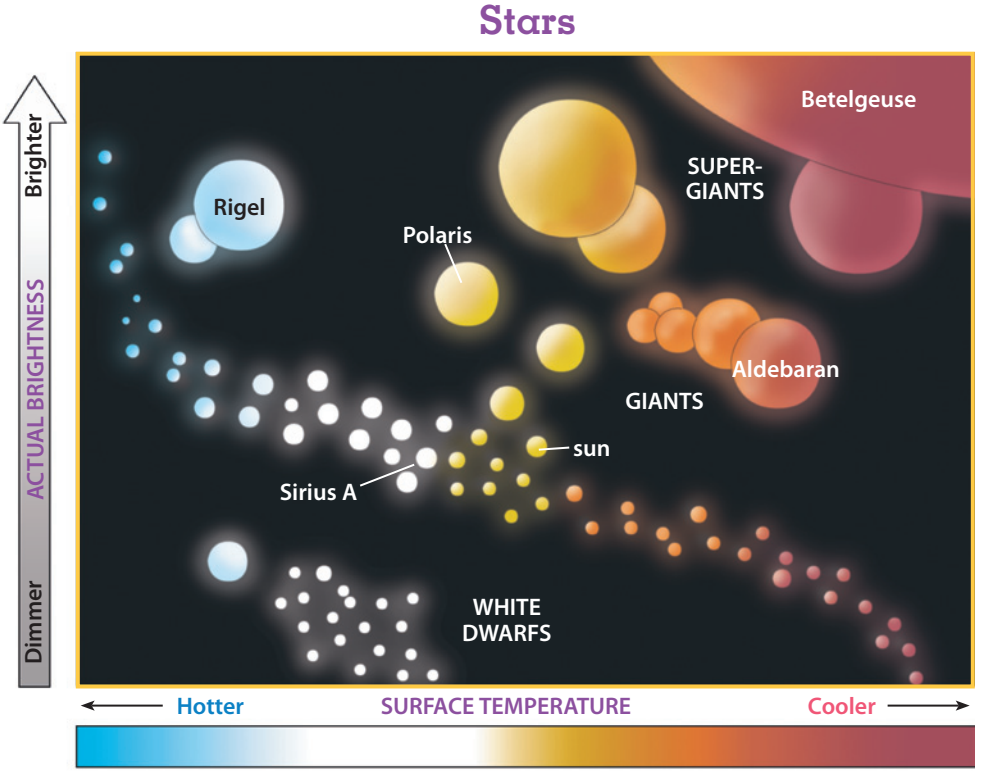
How do the apparent magnitudes of the lights appear? The light farther away looks fainter, or weaker.

Conclude that both the size and distance affect apparent magnitude.

Colors of Stars

When you first look at the stars, they all may appear to be white. However, stars are actually many colors. A star's color is closely related to its surface temperature. The coolest stars are a dull red, and the hottest stars are blue.

On a clear night you may be able to see the colors of some large stars. You need to be away from lights. Give your eyes time to adjust to the dark. Some stars will show a faint color. Study the stars in the sky to find out whether you can see any colors.



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Discussion

What is the color of a star related to? the star's surface temperature

What are some colors of stars? Possible answers: white, yellow, red, orange, blue

What color are the coolest stars? the dull red ones

What color are the hottest stars? blue

Discuss the *Stars* diagram.

Which term could be used in place of *actual brightness*? absolute magnitude

Which stars have a low actual brightness but are hot stars? white dwarfs

Which has a brighter absolute magnitude—a white dwarf or a blue giant? blue giant

Why would a supergiant have a brighter absolute magnitude than a white dwarf? Possible answer: The supergiant is larger.

Does a supergiant have a hotter or cooler surface temperature than a white dwarf? cooler

What is the general relationship between size and magnitude? Larger stars have a brighter absolute magnitude.

Using the chart, how would you describe the sun? average brightness, average surface temperature, average size

Describe Betelgeuse. cool surface temperature; very bright; huge supergiant

What kind of star is Aldebaran? a red-orange giant

The line of stars in the middle of the chart is called the main sequence. Most stars are part of the main sequence.

Besides the sun, what is another named star that is part of the main sequence? Sirius A

SCIENCE BACKGROUND

Classifying stars

Scientists classify stars by their magnitude (sometimes called luminosity), color, temperature, size, and composition.

Star diagram

The diagram on Student Text page 238 is a form of a Hertzsprung-Russel diagram, a type of graph in which the position of the stars gives their absolute magnitude and temperature.

DIRECT A DEMONSTRATION

Relate flame color to its hotness

Materials: candle in a holder, goggles, Bunsen burner or other gas flame source, matches

Note: Check on any open-flame restrictions for the classroom.

1. Light the candle and the gas flame.
2. Direct the student to observe the color differences between the two flames.

What is the color of each flame? The candle flame is yellow. The gas flame is blue.

Relate the colors of the flames to the colors of surface temperature on the *Stars* diagram on Student Text page 238.

Which flame is hotter? the blue gas flame

Without using a thermometer, how could we test to find out which flame is hotter? Possible answer: Place containers of equal amounts of water over the flames and observe which boils first.

Sizes and Distances of Stars

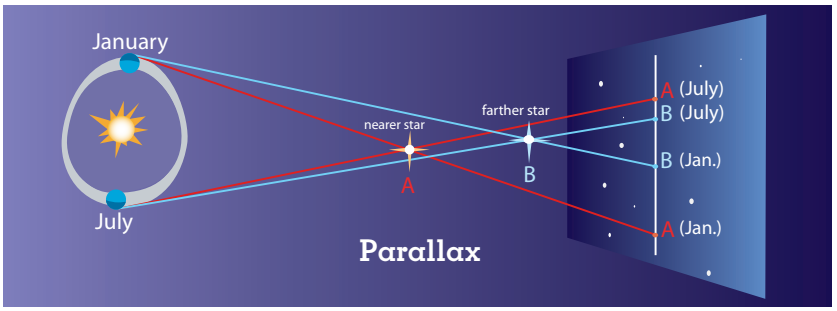
Stars come in many sizes. The small- and medium-sized stars are called **dwarfs**. Our sun has a diameter of 1,400,000 km (865,000 mi). Though it seems large to us, the sun is only a medium-sized yellow star. **Giant stars** are tens to hundreds of times larger and hundreds of times more luminous than the sun. **Supergiants** are hundreds of times larger than the sun and thousands of times brighter. If placed where our sun is, the supergiant star named VV Cephei (SEE fee ee) would span all the way to Jupiter's orbit.

After the sun, the next closest star to Earth is Proxima Centauri (PRAHX-ih-muh sen-TAW-ree). This star is 270,000 times farther away from Earth than the sun! Because distances in space are very great, measuring in kilometers (or miles) requires enormous numbers. Astronomers solve this problem by using other units of measurement. One of these is the **light-year**, the distance that light travels in one year. Proxima Centauri is 4.2 light-years away.

Astronomers can determine how far away from Earth some stars are by measuring how far stars appear to move compared to even more distant stars. To determine the distance a star appears to move, astronomers take pictures of the star at six-month intervals. These pictures enable them to view the star from opposite points in Earth's orbit around the sun. A star that is close to Earth will appear to move more than a star that is far away. Scientists examine the photographs, noting a star's change in position in relationship to more distant stars. The apparent movement or change in position of one star in relationship to other stars is known as **parallax**.

QUICK CHECK

1. Describe the difference between apparent and absolute magnitude.
2. What color is the star with the hottest surface temperature?
3. Name one unit of measurement scientists use for distances.



Calculating a light-year
Use the following exercise to help students understand how huge a light-year is. You will need to use a calculator.

1. Light travels at a rate of approximately 300,000 km per second.
2. To find out how far it travels in a minute, multiply its speed by 60 (seconds per minute). 18,000,000 km per minute
3. To find out how far it travels in an hour, multiply its speed per minute by 60 (minutes per hour). 1,080,000,000 km per hour
4. To find how far it travels in a day, multiply its speed per hour by 24 (hours per day). 25,920,000,000 km per day
5. To find how far it travels in a year, multiply its speed per day by 365.25 (days per year). 9,467,280,000,000 km per year

Even if you cannot complete the exercise, students will quickly see how huge a number will be formed by the calculations.

Discussion

What are small and medium stars called? dwarfs

How large are giant stars compared to the sun? tens to hundreds of times larger

How much brighter are giant stars than the sun? hundreds of times brighter

How large and bright is a supergiant compared to the sun? hundreds of times larger and thousands of times brighter

Other than the sun, what is the closest star to Earth? Proxima Centauri

Why would kilometers not be a good way to measure distance in space? the distances are too great

What have scientists done to solve this problem? They have created another measuring unit—a light-year.

What unit is the basis for a light-year? the distance that light can travel in one year

What do we call the apparent change in a star's position that allows scientists to determine the star's distance from Earth? parallax

Look at the *Parallax* diagram. Which star appears to have moved the most? star A; the closer star

How do scientists measure parallax? They compare the distance that a star appears to move over a six-month period.

Answers

1. A star's apparent magnitude is how bright the star appears to be from Earth. A star's absolute magnitude is the star's true brightness.
2. blue
3. a light-year

Activity Manual

Reinforcement, page 158

Lesson 117

Student Text pages 240–43
Activity Manual pages 159–60

Objectives

- Differentiate between a pulsating variable star and an eclipsing variable star
- Describe the causes of novas and supernovas
- Describe how astronomers think neutron stars and black holes are formed

Vocabulary

variable star
pulsating variable star
eclipsing variable star
nova
nebula
supernova
neutron star
pulsar
black hole

Introduction

Have you ever observed a flower, such as a rose, slowly open from a bud to an open bloom?

You could watch for hours and never see the petals move. This action happens so slowly that you may not detect it.

How can you tell the flower has bloomed? Possible answer: by observing the flower before it blooms and after it blooms

Another way to observe a flower bloom is with time-lapse photography. This technique uses movie film to take pictures at spaced intervals and then plays them rapidly in sequence to allow you to observe an action that is too slow for you to detect. In a similar way, astronomers are able to detect changes in stars.

Teach for Understanding

Purpose for reading

What are some ways that stars change?

What are pulsars and how are they found?

Discussion

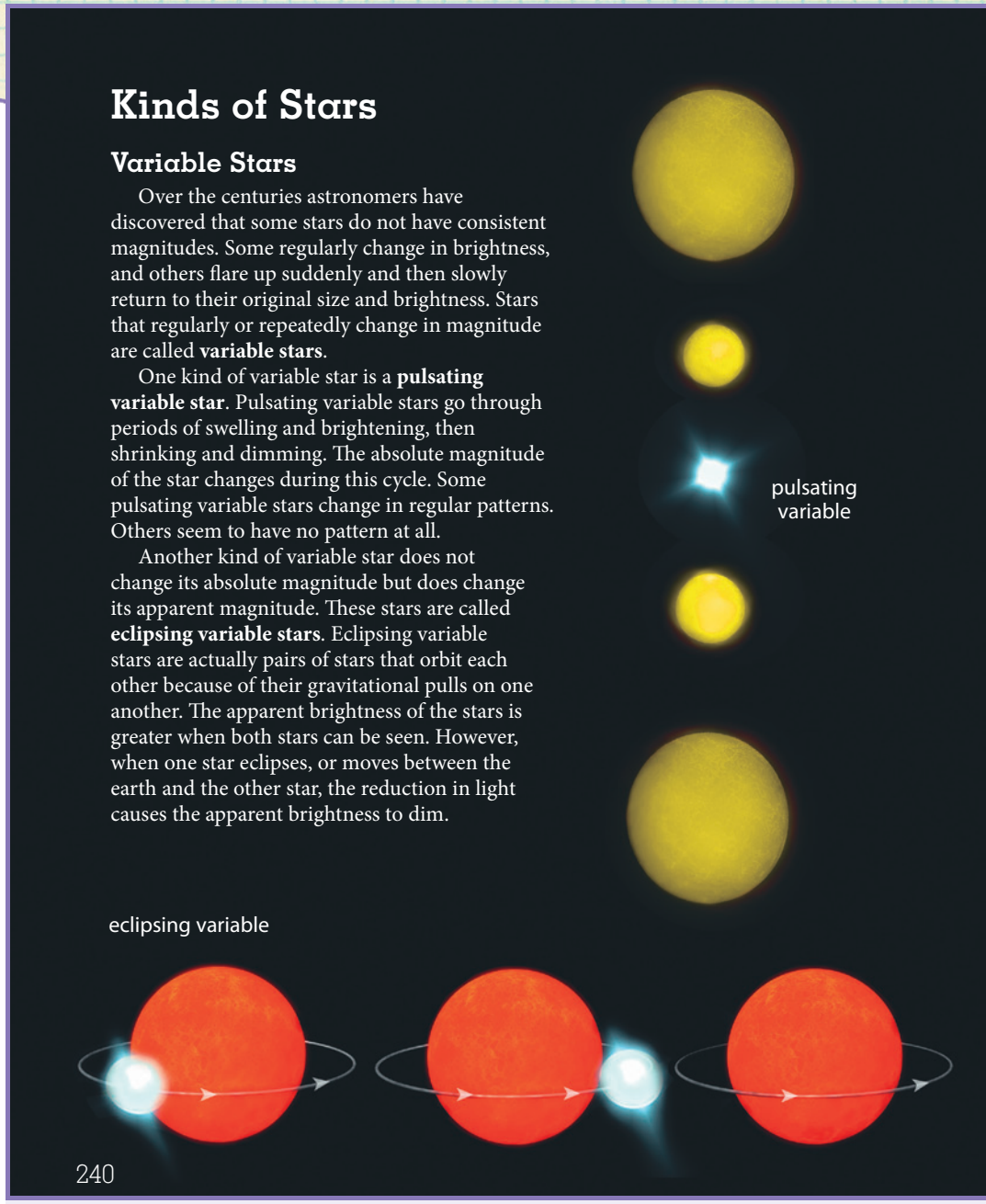
What is a variable star? a star that regularly or repeatedly changes in magnitude

What is a pulsating variable star? a star that goes through periods of swelling and brightening, then shrinking and dimming

Does a pulsating variable star change its absolute or apparent magnitude? absolute **Why?** The star actually changes in brightness.

What are eclipsing variable stars? Pairs of stars that orbit each other. The apparent brightness is greater when both stars are seen. But when one star eclipses, the light appears to dim.

What kind of magnitude changes for an eclipsing variable star? apparent **Why?** The star stays the same brightness. The brightness appears to change because one star blocks the light of the other.



SCIENCE BACKGROUND

Going nova
Some binary stars repeatedly "go nova."

Variable stars
Pulsating variable stars are also called *Cepheid variables*. Because they come in pairs, eclipsing variable stars are sometimes referred to as *eclipsing binary stars*.

LANGUAGE

Stellar and nebula
The Latin word for star is *stellar*. *Interstellar* means "between or among stars."

The plural of *nebula* is *nebulae*.

WRITING

Creative Writing
Encourage the student to write a short story describing the reactions of people in a small village in the past to the sight of a nova.

SCIENCE MISCONCEPTIONS

Birth of a star
Secular astronomers believe that new stars form from nebulae; however, astronomers have never witnessed a star birth, and there are many scientific reasons why this theory is unlikely. Some scientists want it to be possible for stars to form from nebulae to justify their beliefs in the origin of the universe without the need for God.

SCIENCE & THE BIBLE

When Jesus Christ was born, the Bible says that a star led the wise men to the place "where the young child was" (Matt. 2:9). Many scholars have speculated as to what exactly this "star" was. Early astronomers had a good knowledge of the night sky, yet we have no record of a new star in the time around Jesus' birth. Every natural and supernatural event is in God's control and brings worship and honor to His Son. Whether the "star" of Matthew 2:11 was a new star or some other event, we should respond just as the wise men did: "And when they were come into the house, they saw the young child . . . and fell down, and worshipped him."

Novas

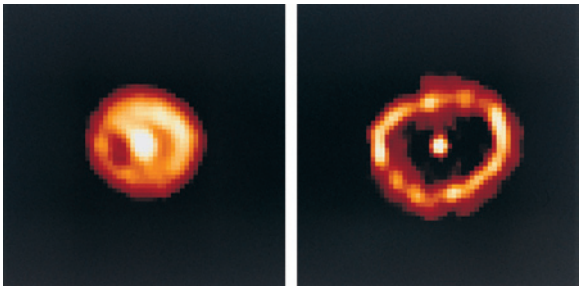
Sometimes scientists will notice a star where one was not visible before. The star then fades over the next few nights, weeks, or months. In the past when such a phenomenon lit the skies, many regarded it as a signal from the heavens that an important or disastrous event would soon occur. Some believed that it signaled the birth of a star. Astronomers called such a star a **nova** (NOH vuh), which means "new" in Latin. Scientists now believe that a nova forms when an existing star suddenly flares up and becomes hundreds or thousands of times brighter than normal. Novas are part of pairs of stars and flare because one star's gravity pulls gases from the other star.

Novas are not common occurrences. Seeing a nova without the help of a telescope is very rare. Even with telescopes, people spot only about two to three novas in our galaxy each year.

On February 19, 1992, astronomers were excited to observe Nova Cygni (SIG nee) 1992. It was the brightest nova in recent history and could be seen without a telescope.

When a star "goes nova," it spews dust and gases into space. Its outer layers gradually float off into space, usually leaving a smaller, dimmer star behind. A cloud of interstellar gases and debris is called a **nebula**. Nebulas can be seen either because they glow from light within or because they block light from behind them and look like dark clouds.

Nova Cygni 1992
Taken by Hubble Space Telescope faint object camera



Pre-COSTAR Raw Image
May 1993

With COSTAR Raw Image
Seven months later

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DIRECT A DEMONSTRATION

Demonstrate pulsating variable stars and eclipsing variable stars

Materials: two unshaded lamps (one with a 3-way switch), one 3-way light bulb, two 40-watt light bulbs

Place the 3-way bulb in one lamp. Darken the room. Turn the switch from the lowest setting to the medium setting and then to the highest setting.

Which kind of variable star does this represent? pulsating variable star

In what way does our model differ from a pulsating variable star? The lamp can go only from low to medium to high, then off and back to low. A pulsating star can gradually become brighter and then gradually get dimmer.

Place the 40-watt bulbs in both lamps. Darken the room. Rotate one lamp around the other.

When does the brightness of the bulbs appear greatest? when you can see both bulbs

How often does the brightness dim? each time one lamp eclipses (hides) the other

Often in a pair of stars, one star is larger than the other. Therefore, one star may completely eclipse the other, but the smaller star may not completely eclipse the larger star.

Discussion

What is a nova? a star that appears where none was visible before and then fades away

How did some people in the past respond when they saw a nova? They thought that an important or disastrous event was about to occur.

Why would people have thought that? Possible answer: It was an unusual occurrence and caused fear because people could not explain it.

Why did astronomers give this phenomenon the name nova? Some thought that it was the birth of a new star, and nova means "new."

How does a nova form? A nova forms when an existing star suddenly flares up and becomes hundreds or thousands of times brighter than normal.

What do astronomers believe causes a nova? Novas are part of pairs of stars. One star's gravity pulls gases from the other star onto its surface.

Why can scientists not be sure exactly what causes a nova? Possible answers: It is so far away. It occurs only a few times a year in our galaxy.

What results when a star "goes nova?" Dust and gases are spewn into space, leaving a smaller, dimmer star behind.

What is a nebula? a cloud of interstellar gases and debris

Compare the two pictures on page 241. What does the second picture show you about Nova Cygni? Possible answer: After seven months the debris spread, leaving a much smaller star in the center.

Discuss *Science & the Bible*.

What led the wise men to the place where the young Christ child was? a star

People have frequently tried to prove the Star of Bethlehem scientifically. Historically, the word *star* has been more of a general term, often used to refer to any astronomical body that gives light. It has been suggested that the star could have been planets, a comet, or even a nova. None of these truly match with the literal reading of Matthew 2. The star could also have been a supernatural occurrence of light seen only by the wise men. Regardless of what the star was, it was planned by God to lead them to the Messiah, the Savior of all.

Who controls all events? God

What should our response to Christ be? to worship Him

Discussion

What is a supernova? the death explosion of a star

What causes a supernova? A massive star uses up its hydrogen fuel. The star starts to collapse, but the pressure of the star's gravity causes the star to heat up quickly and explode. After increasing in size and brightness, the star fades and collapses.

What is left of the star after a supernova occurs? a neutron star or a black hole

How often does a supernova occur in our galaxy? less than once a century; However, there has not been one since 1604.

Who recorded a supernova in AD 1054? Chinese astronomers **What was the result of this supernova?** the Crab Nebula

Point out the photo of the Crab Nebula.

Do you think it would be a special event to witness the occurrence of a supernova? Answers will vary.

How do astronomers believe a neutron star is formed? When a supergiant collapses, the pressure is so great that the protons and electrons of the star's core are crushed together to form neutrons.

Why can astronomers only theorize about what forms a neutron star? Possible answers: They cannot see it happen. They cannot duplicate the process on Earth.

What do scientists believe about the weight of the core of a neutron star? The core is so tightly packed that a piece the size of a teaspoon would weigh one billion tons on Earth.

Discuss the cartoon.

What do you think the cartoon is showing? Answers will vary, but elicit that the "superhero" is trying but is unable to lift the weight of a neutron star compacted into the area of a teaspoon.

Crab Nebula

Supernovas

The death explosion of a star is called a **supernova**. Astronomers believe that a supernova occurs when a massive star has used up its hydrogen fuel. The star starts to collapse, but the tremendous pressure created by the star's gravity causes the star to heat up quickly and explode. The star increases in size and brightness and can become brighter than a galaxy. Sometimes a supernova can even be seen during the day. After brightening, the star fades and collapses. This explosion usually results in the complete destruction of the star, and the remnant often becomes a neutron star or a black hole.

Supernovas occur less than once a century in our galaxy. The last supernova in our galaxy occurred in 1604. Some supernovas that occur in other galaxies can be seen from Earth with telescopes.

In AD 1054 Chinese astronomers observed a supernova. The remnants from this supernova explosion form the Crab Nebula, the closest nebula to Earth caused by a supernova.

Neutron Stars

Astronomers think that when some supergiants collapse, the extreme pressure in the star's core crushes the protons and electrons together to form neutrons. The core is then made up mostly of neutrons. A star that began as a supergiant hundreds of millions of kilometers in diameter may become as small as a few kilometers in diameter. Because the neutrons are very tightly packed in this **neutron star**, just one teaspoon of the star's core might weigh one billion tons.

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SCIENCE BACKGROUND

Black holes

At the center of a black hole is a point called a *singularity*. Around that point is an area where the gravitational pull is so great that even light cannot escape. This area, the *event horizon*, is what astronomers are talking about when they speak of the size of a black hole. Some astronomers believe certain black holes have existed since the beginning of time. For those who believe the Bible, that would be at Creation.

Gravitational pull

Both neutron stars and black holes have approximately the same mass as the star that collapses. That is why only the collapse of a massive supergiant can cause a black hole.

TECHNOLOGY

Gravitational waves

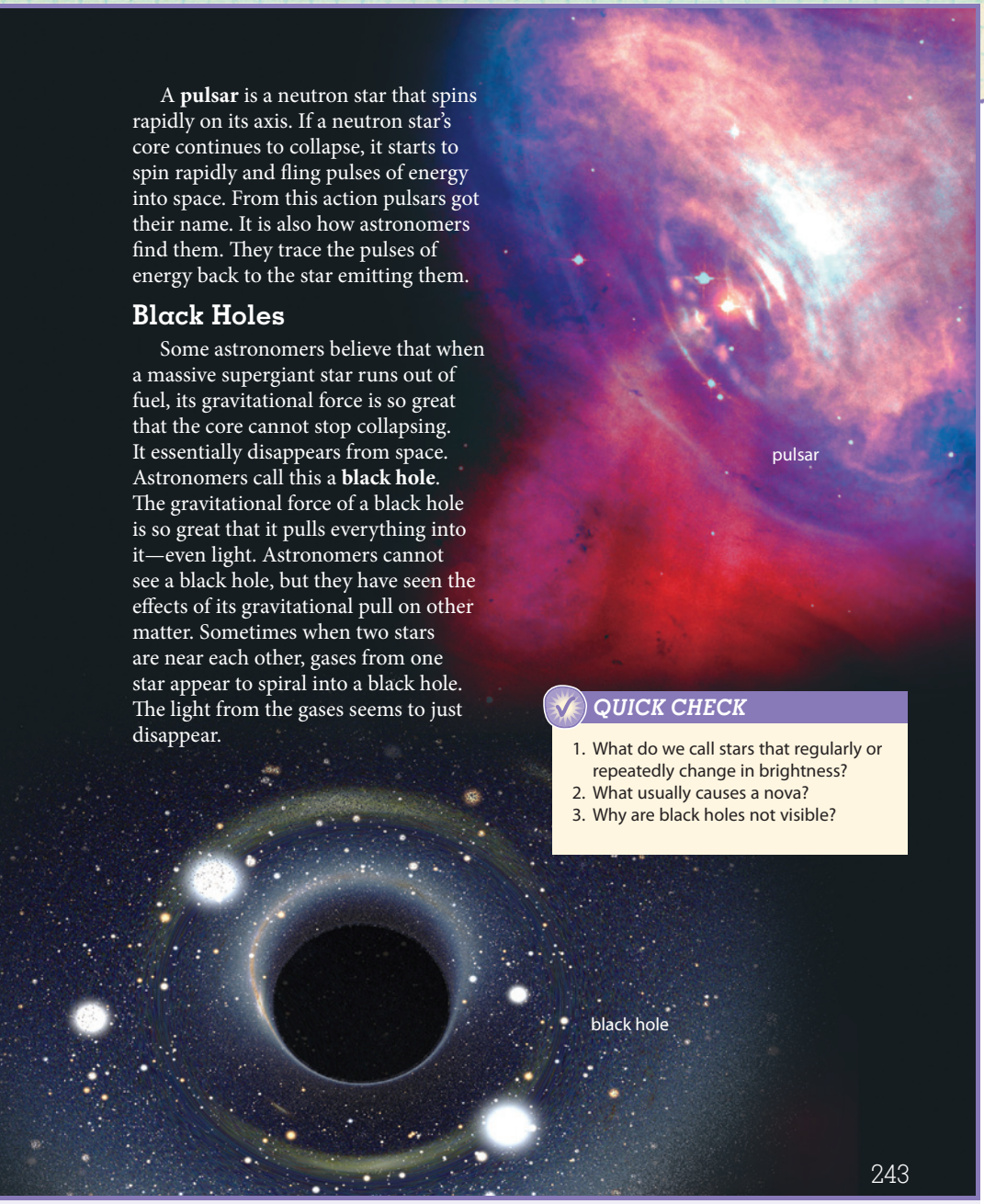
Some astronomers think there is a phenomenon called *gravitational waves*. They think that large disruptions in space, such as supernovas, neutron stars, and black holes cause gravitational waves.

These gravitational waves are so tiny that no instrument available today can measure them. However, scientists are developing new instruments that should be able to measure these waves.

A **pulsar** is a neutron star that spins rapidly on its axis. If a neutron star's core continues to collapse, it starts to spin rapidly and fling pulses of energy into space. From this action pulsars got their name. It is also how astronomers find them. They trace the pulses of energy back to the star emitting them.

Black Holes

Some astronomers believe that when a massive supergiant star runs out of fuel, its gravitational force is so great that the core cannot stop collapsing. It essentially disappears from space. Astronomers call this a **black hole**. The gravitational force of a black hole is so great that it pulls everything into it—even light. Astronomers cannot see a black hole, but they have seen the effects of its gravitational pull on other matter. Sometimes when two stars are near each other, gases from one star appear to spiral into a black hole. The light from the gases seems to just disappear.



QUICK CHECK

1. What do we call stars that regularly or repeatedly change in brightness?
2. What usually causes a nova?
3. Why are black holes not visible?

DIRECT A DEMONSTRATION

Demonstrate that the mass of a star is compacted

Materials: foam ball, tape measure (or string and yardstick), balance, plastic sandwich bag

Direct the student to follow the procedure. Measure and record the circumference of the foam ball and place it in the plastic bag. Measure and record the mass of the ball and the bag. Crush the ball. Compress the pieces into a ball shape in one corner of the bag. Measure and record the approximate circumference. Measure and record the mass. Compare the measurements.

Has the size (circumference) changed? yes

Has the mass changed? no

How does this compare to what happens when a supergiant collapses? In the same way that the mass of the foam does not change when the size changes, the resulting neutron star has about the same mass as the original supergiant before it collapsed.

Discussion

What is a pulsar? a neutron star that spins rapidly on its axis, emitting pulses of energy

How do astronomers find pulsars? They trace the pulses of energy back to the stars emitting them.

How do astronomers believe a black hole forms? They believe that a massive supergiant collapses with such great gravitational force that its core cannot stop collapsing.

Gravity is related to the mass of an object. Therefore, a massive supergiant star would have a massive gravitational pull.

What happens to light and matter around a black hole? The gravitational force pulls light and matter into the black hole.

How do scientists detect a black hole? Although they cannot see a black hole, they detect its gravitational pull on other matter.

Answers

1. variable stars
2. Novas are usually part of a pair of stars and flare up because one star's gravity pulls gases from the other star.
3. Scientists think the gravitational force of a black hole is so great that even light is pulled into it. Without light, people cannot see.

Activity Manual

Reinforcement, page 159

Review, page 160

This page reviews Lessons 116 and 117.

Assessment

Quiz 10-A

The quiz may be given any time after completion of this lesson.

Lesson 118

Student Text pages 244–47
Activity Manual page 161

Objectives
- Identify various constellations
- Defend why a Christian should not be involved in astrology
- Describe the difference between a reflecting telescope and a refracting telescope
- Identify instruments used to study the stars

Materials
- magnifying glass
- star chart or planisphere (optional)

Vocabulary
constellation
circumpolar constellation
astrology
astronomy
refracting telescope
reflecting telescope
radio telescope
spectroscope
redshift

Introduction
Allow several students to look at a text page with the magnifying glass.

How do you think this magnifying glass produces a larger image of the text page? Accept any answer, but explain that the light is bent as it passes through the glass, producing a larger image of the page.

Principles of magnification are also used in telescopes.

Teach for Understanding

Purpose for reading
Why is the practice of astrology wrong?

What are some instruments that are used to observe the heavens?

Discussion
What is a constellation? a group of stars that seem to form patterns

How many official constellations are there today? eighty-eight

Have you ever found the Big Dipper? Answers will vary.

What constellation is the Big Dipper part of? the Great Bear, or Ursa Major

The Big Dipper and Little Dipper are actually asterisms (clusters of stars smaller than constellations).

Observing the Heavens

Constellations

For thousands of years stargazers have watched the night sky. They found patterns in groups of stars that reminded them of ancient heroes, animals, mythological characters, and objects in nature. These groups of stars in a pattern, called **constellations** (kahn stuh LAY shunz), make stars easier to find. Three hundred years before Christ, Aratus of Soli listed forty-four constellations. Today there are eighty-eight official constellations.

In the northern hemisphere, many people can find the Big Dipper. These seven stars form the back and tail of the constellation called the Great Bear, or Ursa Major. If you follow a straight line from the two stars at the front of the Big Dipper's bowl, you will be able to locate the North Star, or Polaris (puh LEHR is), which sits over Earth's gravitational North Pole. The North Star is also part of the group of stars called the Little Dipper. These stars are part of the constellation Little Bear, or Ursa Minor.

Once you find one or two constellations, you can use them as markers to find others. Draco the Dragon winds its way like a huge serpent between the Big and Little Dippers. The stars in the nearby constellation Cassiopeia (kass ee uh PEE uh) appear as a giant *W*.

During the year, the Great and Little Bears, Draco, and Cassiopeia seem to revolve around the North Star (Polaris). For that reason, astronomers call these constellations **circumpolar** (sur kum POH lur) **constellations**.

When looking for Orion (oh RY un) the Hunter, you should locate three stars lined up closely together in the sky. These stars mark Orion's belt. Around the three stars is a larger box of four stars. The top left star is the orange-red supergiant Betelgeuse (BEET ul jooz), the shoulder of Orion. The bottom right star is brilliant blue-white Rigel (RY jul). This star marks Orion's ankle.

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SCIENCE BACKGROUND

Planisphere (star wheel)
A star wheel, also called a planisphere, is a useful tool for locating constellations in the night sky. Many websites have free planisphere patterns to download and assemble. To read the planisphere without interfering with the view of the night sky, use a red light, such as a flashlight covered with red cellophane.

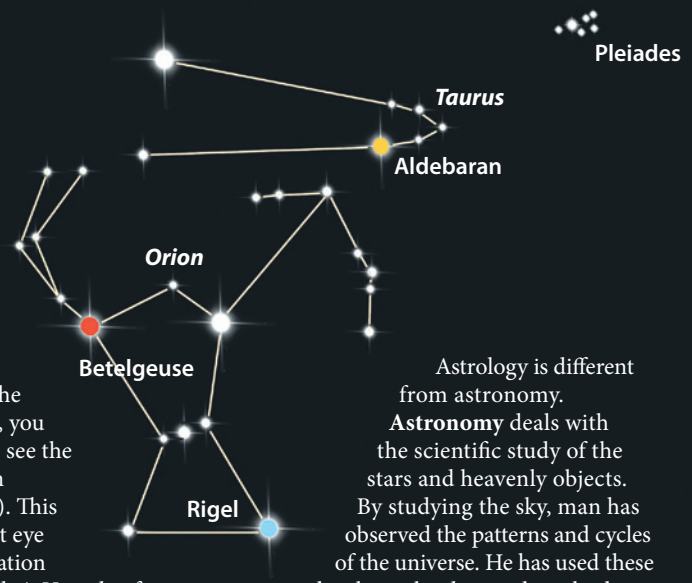
Pleiades
The star cluster Pleiades is called the Seven Sisters. However, only six of the seven stars can be seen with the naked eye.

BIBLE
Constellations in the Bible
Several constellations are mentioned in Scripture. Examples are Orion (Job 9:9 and 38:31), Pleiades (Job 9:9 and 38:31), and the crooked serpent Draco (Job 26:13).

GEOGRAPHY
Constellation names vary
Not all countries and cultures use the same names for the constellations. Encourage the student to use the library and Internet to find the names used in other countries for constellations.

SCIENCE MISCONCEPTIONS

Stars in constellations
The stars in a constellation do not always outline the picture but merely indicate its key points.



If you look above and to the right of Orion, you may be able to see the star Aldebaran (al DEB ur un). This star is the right eye of the constellation Taurus the bull. A *V* made of stars marks his horns and nose. On the shoulder of the bull is the star cluster called Pleiades (PLEE uh deez).

Astrology

God created the constellations and all the stars in the entire universe by the power of His word. He made these for man to use. But ever since man fell into sin, he has repeatedly chosen to worship God's creation rather than worshiping God Himself. Many people believe that the stars actually influence the lives of people and determine their destiny. This belief is part of the practice of **astrology**. Astrologists teach that the positions of the sun, moon, planets, and stars at the moment of a person's birth determine his destiny. People who believe in astrology often consult a daily horoscope to give them guidance.

Astrology is different from astronomy. **Astronomy** deals with the scientific study of the stars and heavenly objects. By studying the sky, man has observed the patterns and cycles of the universe. He has used these to develop calendars and methods of navigation. Astrology, though, is the belief that the positions and movements of the stars and heavenly bodies influence what happens on Earth. Astrology is an unbibilical teaching for two reasons. It exalts the creation of God above the Creator, and it denies the truth about God revealed in the Bible. The Bible very clearly condemns the worship of the heavens. The Bible also warns against seeking advice from the stars or from other heavenly objects. Both Isaiah and Daniel pointed out the foolishness of relying on astrologers (Isa. 47:13; Dan. 2:27–28). As Daniel told the king, only God can reveal secrets and make known the future. The Bible, rather than the stars, is to be a Christian's guide (Ps. 119:105).

DIRECT AN ACTIVITY

Making a constellation

Materials: one index card per student

Constellations are simply man's imaginations. Different cultures have looked at the same stars and found different images.

Give each student an index card. Each student is to draw seven stars in random order on the unlined side of his index card.

Students exchange index cards and design a "constellation," using the seven stars on the card they receive. On the back of the card, they should write the name of the constellation and the reason for the picture and name.

LANGUAGE

Astrology and the Christian's response

Read and discuss the following verses that note how God forbids the worship of the sun, moon, and stars, and condemns those that "divide the heavens" (Is. 47:13–14, Dan. 2:27, 4:7, 5:7–8). Guide a discussion about how God has given us all we need in Jesus Christ (2 Pet. 1:2–3; Heb. 1:1–2). In order to find Jesus, we are directed to His Word (2 Tim. 3:16–17) where we are changed by the Spirit of the Lord (2 Cor. 3:18). James says that if we lack wisdom, we only need to ask God in faith (James 1:5).

Discussion

How can you find Polaris in the sky? Follow a straight line up from the two stars at the front of the Big Dipper's bowl to the handle of the Little Dipper.

What is another name for Polaris? the North Star

If you were lost at night, how could you use Polaris to help you find your direction? Polaris sits over the gravitational North Pole, so if you went toward Polaris, you would be going north.

What constellation is the Little Dipper part of? the Little Bear, or Ursa Minor

What are some other constellations that you might see in the Northern Hemisphere? Possible answers: Draco, Cassiopeia, Orion, Taurus

What does *circumpolar* mean? revolves around the North Star or Polaris

Which stars form Orion's shoulder and ankle? Betelgeuse—shoulder; Rigel—ankle

Where is the star cluster Pleiades located? on the shoulder of Taurus the Bull

As specific stars are discussed, refer the student back to the *Stars* diagram on Student Text page 238 to help him gain a perspective of the sizes of the stars.

What is astrology? the belief that the positions and movements of the stars and heavenly bodies influence what happens on Earth

How is astrology different from astronomy? Astronomy is the scientific study of the stars and other objects in space. Astrology is the practice of studying those stars and heavenly bodies to receive information or guidance about the future.

Why would it be wrong for a Christian to participate in astrology? Astrology exalts the creation of God above the Creator and denies the truth about God revealed in the Bible. God clearly condemns the worship of the heavens and warns against seeking advice from the stars or other heavenly objects.

What should a Christian do for guidance? A Christian should read God's Word, the Bible. [BATs: 8a Faith in God's promises; 8b Faith in the power of the Word of God]

Discussion

What does a refracting telescope use to magnify images? convex and concave lenses

What is the difference between a refracting telescope and a reflecting telescope? A refracting telescope bends light to make an object seem larger. A reflecting telescope reflects light to make an object seem larger.

What is the disadvantage of a refracting telescope? As light is refracted (bent), the colors are distorted.

What does a reflecting telescope use to magnify images? mirrors

In which way is a reflecting telescope better than a refracting telescope? The light is reflected rather than bent, so the colors are not distorted. The magnified image is clearer.

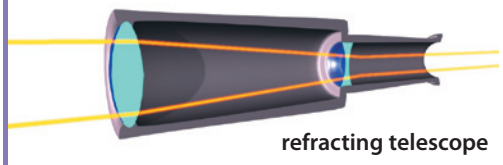
Why do telescopes in space have clearer images than telescopes on Earth? Earth's atmosphere is moving and contains dust and water droplets that prevent telescopes on Earth from showing clear images. Telescopes in space are located above Earth's atmosphere.

Which telescope solved some of these problems? the Hubble Space Telescope **Why?** because it orbits above Earth's atmosphere all the time

How do you think viewing images taken from the Hubble Space Telescope has caused astronomers to change their views of the universe? Accept any answer, but suggest that additional information usually causes man to reevaluate his theories.

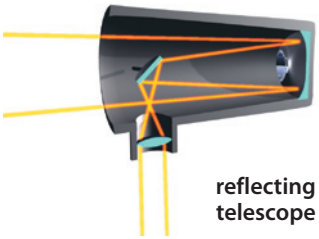
Telescopes

Ever since Galileo made his first telescope in 1609, the telescope has been the most important instrument astronomers use to find new stars. Early versions were **refracting telescopes** that bend, or refract, light to make objects seem larger. The light enters a convex (curved outward) lens and then travels through a concave (curved inward) lens to the eyepiece. The convex lens makes the image look bigger but blurry, and the concave lens makes the object look smaller but clear. The combination of the two lenses produces a clear, magnified image. However, a refracting telescope causes color distortions, because the light bends at different angles as it is refracted.

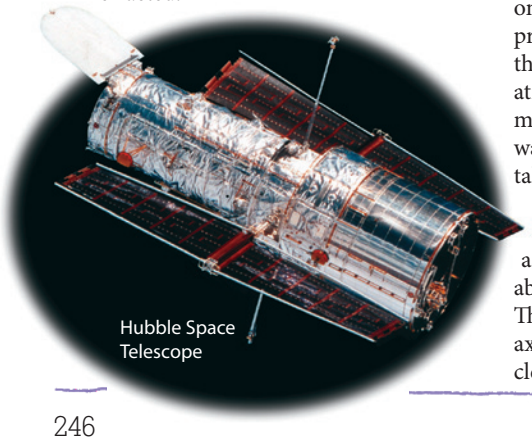


refracting telescope

About seventy years after Galileo made his telescope, Sir Isaac Newton invented a reflecting telescope that solved some of the problems of color distortion caused by refracting telescopes. A **reflecting telescope** produces a clearer magnified image than the refracting telescope because light is reflected rather than bent. Light enters the telescope and reflects off a large concave mirror to a smaller flat mirror. It then enters the eyepiece.



reflecting telescope



Hubble Space Telescope

Over the years since Newton's invention, astronomers have continued to make bigger and bigger telescopes with hopes of being able to see farther and farther into space. Telescopes on Earth, though, have one great problem. They must view the stars through thousands of meters of Earth's atmosphere. The atmosphere constantly moves and carries dust particles and water droplets in it. As a result, pictures taken of the heavens are often unclear.

The launch of the Hubble Space Telescope (HST) in 1990 at last gave astronomers a telescope that stays above Earth's atmosphere all the time. The pictures it has taken of distant galaxies and our solar system are bright, clear, and beautiful.

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SCIENCE BACKGROUND

Types of telescopes

There are at least five types of telescopes used to observe space. Each is designed to detect a specific type of wavelength. In addition to visual and radio telescopes, there are infrared, x-ray, and gamma ray telescopes.

Invention of the telescope

The invention of the telescope is generally credited to Hans Lippershey in 1608. Galileo made his own version of the telescope and was the first person to make scientific discoveries with the telescope. Galileo is said to have "reinvented" the telescope when his discoveries made it popular.

HISTORY

Early lenses

Some of the first eyeglasses were called "spectacles." Spectacles were worn as early as AD 1300. The same type of lenses used for spectacles were used for early telescopes. When telescopes were first introduced, many people thought what they saw was a hoax or an optical illusion.

DIRECT AN ACTIVITY

Using lenses

Place convex and concave lenses in a learning center along with a newspaper article, and allow the student to look through the lenses to try to read the article. The student should observe how each lens produces a different size and quality image.

radio telescope

Refracting and reflecting telescopes are not the only instruments scientists use to study the stars. In addition to light waves, stars emit other kinds of waves, such as radio waves. Radio telescopes collect radio waves from space using a large concave-shaped disk. **Radio telescopes** can detect objects that do not give off enough light to be detected by other telescopes.

Spectroscopes

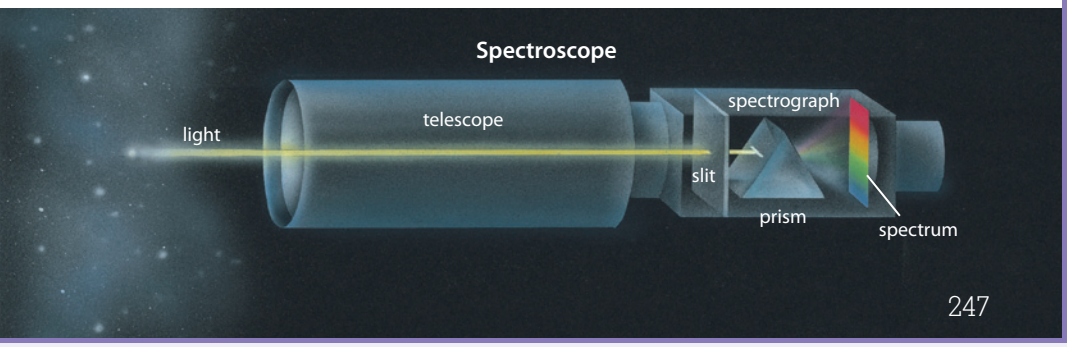
A **spectroscope** breaks down the light given off by a star into all its colors. Some use a prism, which breaks white light into the spectrum of color. The study of a star's color spectrum gives information about its temperature and composition. It also shows that all heavenly bodies, from dwarf stars up to the biggest galaxies, are moving. If an object is moving away from Earth, its colors' wavelengths become longer, and the colors shift more toward the red end of the spectrum. This action is called **redshift**. Astronomers have been amazed to learn that all the spectra outside our own galaxy show a definite redshift.

SCIENCE & THE BIBLE

Many Creationists believe that most of the observed redshift is due to the stretching of space. The Bible says in Isaiah 40:22 that God "stretcheth out the heavens as a curtain, and spreadeth them out as a tent to dwell in." Only an omnipotent God can stretch the universe to bring glory to Himself.

QUICK CHECK

1. What does *circumpolar* mean?
2. What is the difference between astronomy and astrology?
3. Why do scientists use spectroscopes when observing stars?



DIRECT A DEMONSTRATION

Demonstrate separating colors of light

Materials: prism, flashlight, overhead projector (optional), white paper

Shine light through a prism. You may do this with a flashlight, by placing the prism on a lighted overhead projector, or by holding the prism in a beam of sunlight near a window. Ask the students to describe what they see. Explain that a prism is similar to a spectroscope.

Try using flashlights with different types of bulbs, such as halogen or fluorescent bulbs, to see how light from different types of bulbs breaks into different spectrums.

DIRECT A DEMONSTRATION

Demonstrate that stretching affects how far apart objects are

Materials: balloon, permanent marker, measuring tape

Make two large dots on the uninflated balloon. Direct a student to measure the distance between the dots. Record the measurement.

Blow up the balloon. Direct another student to measure the distance between the dots. Record the measurement.

What happened to the distance between the dots? It increased.

This is what many Creationists think is happening in the universe. As the universe stretches, the distances become greater and cause redshift.

Discussion

Light waves are only one type of electromagnetic waves. They are the only waves visible to the human eye. What are some other kinds of electromagnetic waves? Possible answers: radio waves, microwaves, infrared waves, ultraviolet rays, x-rays, and gamma rays

Which kind of waves are used by a radio telescope? radio waves

What advantage does a radio telescope have over other telescopes? It can detect objects that do not give off enough light to be detected by other telescopes.

What is a spectroscope? an instrument that separates light into all of its colors

Discuss the path of light through the spectroscope in the diagram.

Why do astronomers study a star's color spectrum? Possible answers: to find out information about the star's temperature, composition, and movement

Name the colors of the spectrum in order. red, orange, yellow, green, blue, indigo, violet

The order of the colors of the spectrum can be remembered easily through the acronym Roy G. Biv.

What is redshift? If an object is moving away from Earth, its color spectrum has longer wavelengths, and the colors shift more toward the red end of the spectrum.

Discuss *Science & the Bible*.

What do many Creationists believe causes the redshift? God's stretching of the heavens

Answers

1. revolves around the North Star
2. Astronomy is the scientific study of the stars. Astrology is the practice of studying the stars and heavenly bodies to receive information or guidance about the future.
3. A spectroscope breaks light into colors, which helps scientists learn about the temperature and composition of stars.

Activity Manual

Reinforcement, page 161

Objectives
- Make a model of a constellation
- Recognize and name several star groups and constellations

Materials
- dark umbrella
- self-stick dots or white chalk
- copy of *Constellation Patterns* (IA), for each student
- See Student Text page

Introduction
Prepare the umbrella by using the self-stick dots or chalk to mark the stars of constellations on the inside of the open umbrella.

Can we always see the same stars in the sky each night? no **Why?** Because Earth rotates around the sun, Earth's position changes, giving it different viewpoints of the stars.

Show the constellations inside the umbrella. With several students looking up at the "stars" under the umbrella, turn the umbrella slowly. Then hold the umbrella still, directing the students to circle slowly under the umbrella while looking at the "stars."

Which way do you think best demonstrates the way Earth and the stars move? Moving under the still umbrella best shows that the view of the stars changes as the Earth moves.

Learning the names and locations of constellations and stars will help you find them in the sky at different times of the year. This activity will help you learn to recognize some of the common star groups and constellations.

Teach for Understanding
Purpose for reading
The student should read the page before beginning the activity.

Procedure
Guide the student in making his model.
Use the questions in the Science Process Skills to discuss modeling.

Assessment
Rubrics
Select the prepared rubric, or design a rubric to include your chosen criteria.

ACTIVITY

Pinhole Constellations

Process Skills
- Making and using models
- Observing

Sometimes the constellations in the night sky can be difficult to find. It is helpful to familiarize yourself with the constellations before trying to find them. This activity will give you an opportunity to make a representation of a constellation in order to help you learn what some constellations look like.

Procedure
1. Choose a constellation pattern.
2. Attach the pattern to the bottom of the can with the dots facing up. Use the nails to punch holes in the bottom of the soft-drink can to make a constellation. Use the larger nail to make the larger holes on the pattern and the smaller nail to make the smaller holes.
3. Label the can with the name of the constellation it represents. Hold the can up to the light and look through the tab opening. Can you recognize the constellation?
4. Trade cans with your classmates. Keep a record of how many constellations you can name without looking at the labels.

Materials
Constellation Patterns page
clean, empty soft-drink can
finishing nail
6d common nail
hammer
blank label or masking tape
pen

Conclusions
- What makes finding constellations difficult?

Follow-up
- Research to find out if, when, and where each constellation can be viewed from your home.

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TEACHER HELPS

Other containers
Although soft-drink cans with small openings work best, this activity will also work with other cans or small plastic containers. If a plastic container is used, cover the outside of the container with dark paper to reduce the amount of light entering the container. Remind the student to attach the pattern with the dots facing up.

Learning center option
If you do not have time to include this activity in the unit, you may choose to make a set to place in a learning center and keep the constellation cans to reuse each year.

SCIENCE MISCONCEPTIONS

The Big Dipper and Little Dipper are not constellations. Because they each form a picture within a larger constellation, they are called *asterisms*.

SCIENCE PROCESS SKILLS

Making a model
How will using the pinhole constellations help you find constellations at night?
Answers will vary, but elicit that repeatedly being able to see the shape of the stars without the distraction of other stars will help in identification.

Lesson 120

A Different Look

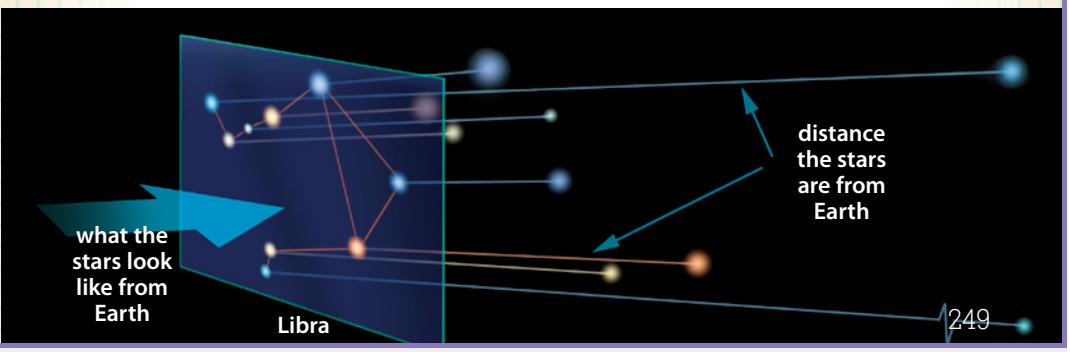
All constellations appear to be approximately the same distance from Earth. However, in many constellations some stars are actually thousands of light-years farther from Earth than other stars.

In order to gain an appreciation for the varied distances of stars in a constellation, you will be constructing a three-dimensional model of a constellation.

What to do

Materials
Star Coordinates card
graph paper
cardboard (approximately 20 cm x 30 cm) or foam meat tray
spool of thread
aluminum foil
centimeter ruler
large-eyed needle
tape
flashlight

1. Use the *Star Coordinates* card your teacher gives you to plot the points for a given constellation on the graph paper.
2. Tape your plotted graph to the piece of cardboard or to the back of a foam meat tray.
3. Use one-inch squares of aluminum foil to make small balls at the end of 20 cm pieces of thread. You will need as many "stars" as there are points on your graph.
4. Use a large-eyed needle to poke holes in the cardboard or foam tray at each point plotted on the coordinate graph.
5. For each star, use the needle to pull the thread through the hole. Attach a piece of tape to the thread on the top side when the thread measures the correct length.
6. Repeat for the other stars.
7. Hold your constellation at eye level. Shine a flashlight across the strings. The shadows you see on the wall show the constellation as seen from Earth.



TEACHER HELPS

Graph paper
If needed, *Graph Paper* is provided on the Teacher's Toolkit CD for reproduction.

Coordinate points
This activity requires a basic knowledge of coordinate points. You may need to review how to read coordinates and mark them on a graph. The first number in the parentheses is the *x coordinate*. The *x* numbers are along the bottom of the graph.The second number in the parentheses is the *y coordinate*. The *y* numbers are along the side of the graph.

Star sizes
Encourage some of your more advanced students to research the absolute magnitude and/or the size of the stars in their constellations and adjust the sizes of the foil balls to model the varying sizes.

Objectives
- Make a model of a constellation
- Plot points on a graph
- Relate the model to the relative distances of stars

Materials
- picture of a mountain range
- *Star Coordinates* (IA)
- See Student Text page

Introduction

Display the picture of the mountain range.

Have you ever traveled where you could see mountains such as these in the distance?

The mountains probably appear close, but it may take hours or even more than a day to get to them. Mountains and other objects often appear closer than they really are.

As you approach a range of mountains, you will often notice that not all of the mountains are touching each other as they first appeared. The distances between them may be very great.

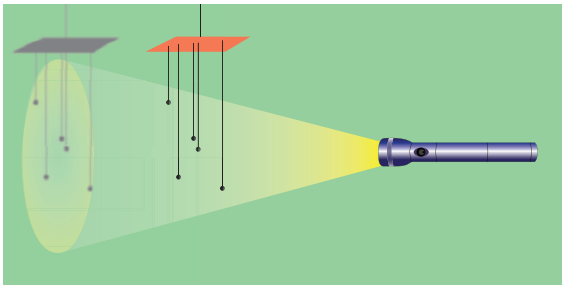
This exploration will help you "see" how the different distances of the stars relate to form the constellations we view from Earth.

Teach for Understanding

Purpose for reading
The student should read the page before beginning the exploration.

What to do
Assist the student in plotting his points and attaching stars as needed. The required length of each string is given on the Star Coordinates cards. The distance of squares on the graph models the distance the stars are from each other. The varying lengths of string show how far away the stars are from Earth.

Arrange the materials as illustrated to "see" the constellation.



Assessment

Rubrics
Select the prepared rubric, or design a rubric to include your chosen criteria.

Lesson 121

Student Text pages 250–55
Activity Manual pages 162–64

Objectives

- Identify how many stars are in a binary star group and in a multiple star group
- Differentiate between an open star cluster and a globular cluster
- Identify our galaxy as the Milky Way
- Recognize that our galaxy is part of a cluster of galaxies called the Local Group
- Describe asteroids, meteoroids, meteors, meteorites, and comets

Materials

- star chart or picture of the night sky
- world map or United States map

Vocabulary

binary system
multiple star group
star cluster
galaxy
Local Group
asteroid
meteoroid
meteor
meteorite
comet

Introduction

Display the star chart or picture of the night sky.

When you look at this picture, you see thousands of stars. Some of these points of light are not actually individual stars. One point of light may be a star group that has several stars in it.

Today we are going to learn about galaxies and other types of star groups.

Teach for Understanding

Purpose for reading

What kind of galaxy is the Milky Way?

What kinds of objects (besides planets and the sun) occupy the solar system?

Discussion

What percentage of stars are part of a star family? 85 percent

What holds star groups together? gravitational attraction

What is a binary system? It is the smallest star group, containing only two stars.

Why do the stars in a binary group revolve around each other? Their gravitational pulls hold them together.

What would happen if one star in a binary group became weaker? Possible answer: It would be drawn toward the stronger star, possibly causing it to "go nova."

Star Groups

Very few stars travel through the universe alone. Most of them, about 85 percent, are members of a star family. The groups can be as large as galaxies with billions of stars or as small as a binary system made up of only two stars within a galaxy. The gravitational attraction of the stars on each other holds these groups together.

Small Groups of Stars

The smallest star group is a **binary system**, which contains only two stars. The two stars revolve around each other, held together by their gravitational pulls on each other. About half of all star groups are binary.

Beta Lyrai (LEER eye) is two stars. The stars are so close to each other, only 35 million kilometers (22 million miles) apart, that the gravity of each star pulls the other into an egg shape. They make one revolution around a center point every thirteen days.

Other small star groups have three or four stars and are called **multiple star groups**. Alpha Centauri (AL-fuh sen-TAWR-ee) is in a group of three stars. Like other star systems, multiple star groups remain together because of the attraction of their gravitational fields.

Alpha Centauri, a multiple star group, is part of the constellation Centaurus.

SCIENCE & HISTORY

In ancient times a famous binary star system was commonly used as an eye test. The middle "star" in the Big Dipper's handle is actually two stars, Alcor and Mizar. The brighter one is Mizar, and the dimmer one is Alcor. If a person could see both stars, he passed the eye test. However, modern telescopes show that there are more than two stars in that spot. Today most astronomers think these stars are actually six stars. Mizar is a four-star system, and Alcor is a binary star.

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SCIENCE BACKGROUND

Visual doubles
Pairs of stars that appear to be binary but that are too far apart to have gravitational attraction may be called *visual doubles*, *visual pairs*, *optical doubles*, or *optical pairs*.

Mizar and Alcor
What was once thought to be the binary system of Mizar and Alcor may actually be six stars. When it was first discovered that Mizar was a binary pair, the two stars were named Mizar A and Mizar B. Through the use of spectroscopes, astronomers have determined that Alcor, Mizar A, and Mizar B are each binary stars. Binary stars such as these, which can be seen only with a spectroscope, are called *spectroscopic binaries*.

LANGUAGE

***Bi-* prefix**
The prefix *bi-* means "two." A binary star system contains two stars.

globular cluster

Star Clusters

Some star groups are larger than three or four stars. A **star cluster** is a large group of stars close enough to be held together by gravity. A *globular* (GLAHB yuh lur) *cluster* is a group of several thousand to a million stars. The stars are close to each other and are arranged in the shape of a ball. From a distance a globular cluster looks like a huge, fuzzy ball of light. High-powered telescopes are able to see the individual stars in a globular cluster.

An *open star cluster* is a group of several hundred to a few thousand stars with no particular arrangement. The stars in this kind of cluster look more "open" and less concentrated than the stars in a globular cluster. One of the most famous open star clusters is Pleiades, which forms the right shoulder of the constellation Taurus. Pleiades is often called the Seven Sisters, although there are many more than seven stars in the cluster. Large telescopes have shown that Pleiades has thousands of stars, many of which are surrounded by clouds of shining gases.

open cluster

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DIRECT A DEMONSTRATION

Demonstrate binary stars

Instruct two students to stand facing each other. Instruct them to clasp left hands and right hands, forming an *X* between them. Instruct them to move in a circle around the center point made by their hands. The clasping of their hands is the "gravity" that keeps the two students "in orbit" around each other.

Observe the students as they move.

Can you always see both students completely? no

How does this compare to how we see binary stars? Possible answer: As binary stars orbit each other we may see both stars or only one at a time.

Discussion

What kind of star group is Alpha Centauri? a multiple star group consisting of three stars

How many stars make up a multiple star group? three or four

What is a star cluster? a large group of stars close enough to be held together by gravity

What are two kinds of star clusters? globular clusters and open star clusters

What is a globular cluster? a group of several thousand to a million stars that are close to each other and are arranged in the shape of a ball

What is an open star cluster? a group of several hundred to a few thousand stars with no particular arrangement

What is a famous open star cluster? Pleiades

How are an open cluster and a globular cluster different? Possible answers: number of stars, arrangement of stars

Discuss *Science & History*.

Which stars were used as an eye test? Mizar and Alcor; the middle "star" in the Big Dipper's handle

How many stars actually make up Mizar and Alcor? six; Mizar is four stars and Alcor is two.

Discussion

What is a galaxy? a huge star system that contains millions or billions of stars and covers many light-years of space

What is the name of our galaxy? the Milky Way

How large do astronomers think the Milky Way is? It measures about 100,000 light-years and contains about 300 billion stars.

If the sun and solar system were only the size of a coffee cup, about how big would the Milky Way be? the size of North America

What criteria do astronomers use to classify a galaxy? its shape and symmetry

What are three classifications of galaxies? spiral, elliptical, and irregular

What type of galaxy is the Milky Way? barred spiral

Why do you think our galaxy got the name "Milky Way"? Possible answer: Through telescopes, the stars clustered together look milky white.

Discuss the pictures of the different galaxies.

How is a barred spiral galaxy different from a spiral galaxy? A spiral galaxy looks similar to a wheel with at least two curved spokes. A barred spiral galaxy is a type of spiral galaxy that appears to have a straight bar through the center with the spokes coming from either end of the bar.

Can a galaxy contain binary systems, constellations, and star clusters? yes

SCIENCE BACKGROUND

Our sun in the Milky Way

The stars in a galaxy revolve around the galaxy's center point. Astronomers are not certain about what is at the center of the Milky Way but suspect it might be an immense black hole. Our sun is just one of the stars that travels around the center of the Milky Way galaxy. The trip is a long one. Even though the sun moves through space at 240 km (150 miles) per second, it would take it about 200 million years to complete one revolution. The time needed for a star to complete one revolution around the center of its galaxy is called a *galactic year*.

LANGUAGE

Galaxy

Originally *galaxy* and *Milky Way* were interchangeable names for our star system. The Greek word for milk is *gala*. The name was used for our star system because of its milky appearance in the sky. According to the *Oxford English Dictionary*, Geoffrey Chaucer was one of the first people to use *galaxy* instead of Milky Way as a noun. It appeared in his poem "The House of Fame," written around 1384.

The Local Group

Our galaxy does not travel through space alone. More than thirty galaxies, including the Milky Way, form a cluster called the **Local Group**. These galaxies are our closest galactic neighbors. Altogether they take up an area in space three million light-years in diameter. The Milky Way and the Andromeda (an DRAHM ih duh) galaxies are two of the biggest in the Local Group.

Astronomers have discovered thousands of other galaxies. Most of these galaxies also occur in groups. One such cluster contains about 10,000 galaxies and makes our Local Group seem quite small in comparison.

Less than a century ago, though, astronomers were convinced that nothing existed beyond the boundary of the Milky Way. They thought our galaxy was a universe floating all alone in an enormous sea of empty space.

The expanse of our own galaxy is more than we can comprehend. Then we remember that there are trillions of other galaxies, each holding millions and millions of stars spaced light-years apart. The universe is immense beyond our imagination. Yet God created all of it with a word and oversees it all with a glance. The more we learn about space, the more amazing we find our Creator's power to be and the more limited we see our own knowledge and abilities to be.

DIRECT AN ACTIVITY

Understanding relative sizes

Help the student understand that sizes are relative. Instruct the student to start with his classroom and list progressively larger and larger locations. A possible list may include the following: classroom, school, city, county, state, country, continent, hemisphere, Earth, solar system, Milky Way, Local Group, universe. Emphasize the places discussed in this chapter.

Challenge each student to make his own list. Make a compiled list of all the student lists. The goal is to include as many locations as possible.

Discussion

What is the Local Group? a cluster of galaxies, including the Milky Way, that travel together in space

How does the size of the Milky Way compare to the sizes of other galaxies in the Local Group? It is one of the biggest galaxies in the Local Group.

Which other large galaxy is part of the Local Group? Andromeda

Is the Local Group the only group of galaxies that travels together? No, it is quite small in comparison to some groups of galaxies.

Reiterate that God spoke the universe into existence.

What can we learn about God by studying the universe? Accept any answers that indicate an understanding of God's omnipotence and majesty along with man's limitations.

Discussion

What are asteroids? irregularly shaped pieces of rocks, metal, and dust

What is one of the largest known asteroids? Vesta

How big is Vesta? about the size of the state of Arizona

Point out the state of Arizona on the map. Arizona is about 500 km (310 mi) wide and 645 km (400 mi) in length.

Are all asteroids that large? No, some are as small as pebbles.

Where are most asteroids in our solar system? between Mars and Jupiter

In what ways are asteroids like planets? They are made of solid material and orbit the sun.

In what ways are asteroids different from planets? They are much smaller than even the smallest planet.

Point out the pictures of the asteroids Ida and Dactyl.

What are some theories about how asteroids were formed? Possible answers: Asteroids might be the remains of a planet that was destroyed in a collision. They might be leftover particles from the formation of our solar system. God created them from nothing.

Do we know how asteroids were formed? no

What do we know about their formation? that God formed asteroids

What theory about the formation of asteroids do we know is not true? Any theory that denies that God is the Creator of the universe.

What causes a "shooting star"? a meteoroid that enters Earth's atmosphere

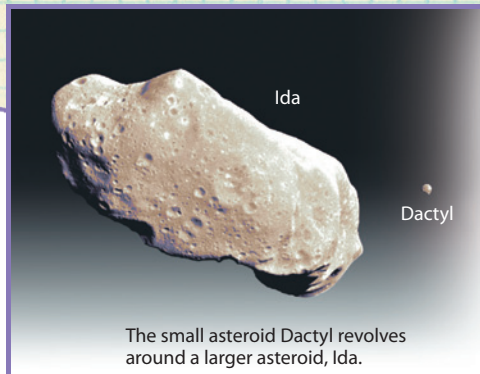
Why does a meteor light up? The friction caused by moving through the Earth's atmosphere causes heat and light.

Explain the relationships between a meteoroid, a meteor, and a meteorite. A meteoroid is a rocky object in space that heads toward our atmosphere. As the friction of our atmosphere causes the rock to light up, we call it a meteor. If it lands on the Earth's surface, it is called a meteorite.

Point out the location of Barringer Crater on a map.

Why has Barringer Crater been preserved while other craters on Earth have eroded? Barringer Crater is in a desert, where there is little water erosion.

How did scientists determine that Barringer Crater was caused by a meteorite? They examined other known meteorite sites and then compared the analyses of those sites to the soil samples from Barringer Crater.



The small asteroid Dactyl revolves around a larger asteroid, Ida.

Other Space Objects

Asteroids

Between Mars and Jupiter is an asteroid belt made of several thousand asteroids that orbit the sun. **Asteroids** are irregularly shaped pieces of rock, metal, and dust. Most asteroids are small, and some are as small as pebbles. Others are huge. One of the largest asteroids, Vesta, is about the size of the state of Arizona.

Most asteroids orbit the sun in a region between Mars and Jupiter. This asteroid belt is made of thousands of asteroids. Some astronomers think that the asteroids are the remains of a planet that was destroyed in a collision. Others think that asteroids are leftover particles from the formation of our solar system. No one can say for sure how God formed asteroids, but we know that any theory that denies God as the Creator of the universe cannot be true.

Meteoroids

A **meteoroid** is a rocky object in space that is smaller than an asteroid. We usually pay very little attention to meteoroids. However, sometimes a meteoroid enters Earth's atmosphere. Have you ever seen a "shooting star"? When the friction caused by a meteoroid's rapid movement through Earth's atmosphere causes it to light up, it is then called a **meteor**. Most meteors burn up in Earth's atmosphere, but a few impact Earth's surface. Those that hit Earth's surface are called **meteorites**.

Scientists believe they have found meteorite craters on Earth. One such crater is Barringer Crater in Arizona. This crater is nearly 1.6 km (1 mi) wide and 174 m (190 yd) deep. Since no one witnessed the formation of Barringer Crater, scientists tried to determine what caused the crater. They analyzed known meteorite impacts as well as the structure and soil of Barringer Crater. Scientists agree that the crater appears to have been formed by a meteorite many years ago. Barringer Crater is one of the few craters on Earth that is still well preserved, probably because it is


Barringer Crater

SCIENCE BACKGROUND

Asteroid satellite
Some asteroids are large enough to have other asteroids orbiting them.

Meteor shower
When a large number of meteors enter the atmosphere at about the same time and from the same area of space, we call it a meteor shower.

LANGUAGE

Asteroid
The word *asteroid* means "starlike."

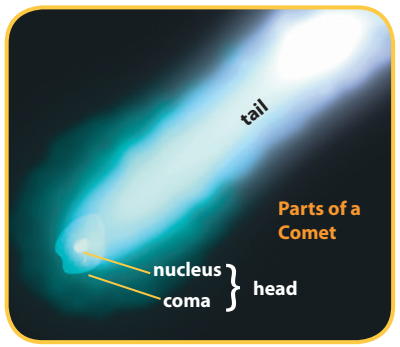
in a desert where there is little water erosion.

Comets

A **comet** is an icy chunk of frozen gases, water, and dust that orbits around the sun over and over again. Some astronomers refer to comets as "dirty snowballs."

Comets have three parts: the coma and nucleus (which make up the head) and the tail. As a comet comes near the sun in its orbit, the sun melts some of the comet's ice, releasing the dust particles that trail behind the comet as its tail.

The time it takes a comet to orbit the sun varies greatly. Some comets, called long-term comets, take thousands of years to orbit. Others, called short-term comets, take only a few years to return to Earth's view. The most famous short-term comet is Halley's Comet. It takes seventy-six years to make its journey around the sun. Halley's Comet was last seen in 1986.



QUICK CHECK

1. How is a globular cluster different from an open star cluster?
2. What is the Local Group?
3. What is a "shooting star"?
4. What are the three parts of a comet?

Barringer Crater
The crater is named for Daniel Barringer, a mining engineer whose research concluded that the crater was made by a meteorite.

Writing from research and a Christian worldview
Encourage the student to research and write about an Earth crater.

Barringer Crater: Arizona
Chicxulub: Yucatán Peninsula, Mexico
Aorounga: Chad, Africa
Wolf Creek: Australia
Manicouagan: Quebec, Canada

Remind the student that he should write from a Christian worldview, which includes that according to the Creation account in the Bible, the earth is not millions of years old as some resources may state.

Discussion

What is a comet? an icy chunk of frozen gases, water, and dust that orbits the sun

What are the three parts of a comet? coma, nucleus, and tail

Which two parts of a comet form the head? coma and nucleus

What causes the tail of a comet to form? The sun melts some of the comet's ices, releasing the dust particles that then trail behind it.

What is the difference between a long-term comet and a short-term comet? A long-term comet takes thousands of years to orbit the sun. A short-term comet takes only a few years to orbit the sun.

When is Halley's Comet expected to return to view from Earth? around the year 2062

Answers

1. A globular cluster is a ball-shaped group of several thousand to a million stars. An open cluster is a less concentrated group of several hundred to a thousand stars.
2. a group of galaxies traveling together, of which the Milky Way is a part
3. a meteor
4. coma, nucleus, and tail

Activity Manual

Bible Connection, page 162

This page explores some of the instances in which the Bible mentions stars.

Review, pages 163–64

These pages review Lessons 118 and 121.

Assessment

Quiz 10-B

The quiz may be given any time after completion of this lesson.

Objectives
- Interpret and use a star chart
- Identify objects in the night sky
- Record observations

Materials
- star charts
- colored pencils or crayons
- copy of *Stargazing* (IA), for display

Introduction
Display the various star charts.

Can a star chart always be used at any location on Earth? no **Why?** Possible answers: The stars seen from Earth change as Earth orbits the sun. Most of the stars seen from the Northern Hemisphere are not seen from the Southern Hemisphere.

Teach for Understanding
Purpose for reading
The student should read all the pages before beginning the exploration.

Discussion
Display and mark *Stargazing* as Activity Manual page 165 is discussed.

Using a star chart is similar to reading a road map.

Why are the stars different sizes? to show the magnitudes of the stars

Draw the symbol for an open star cluster.

What does this symbol stand for? open star cluster

With a yellow colored pencil, circle all the open star clusters. M 35, next to Cassiopeia

Draw the symbol for a globular star cluster.

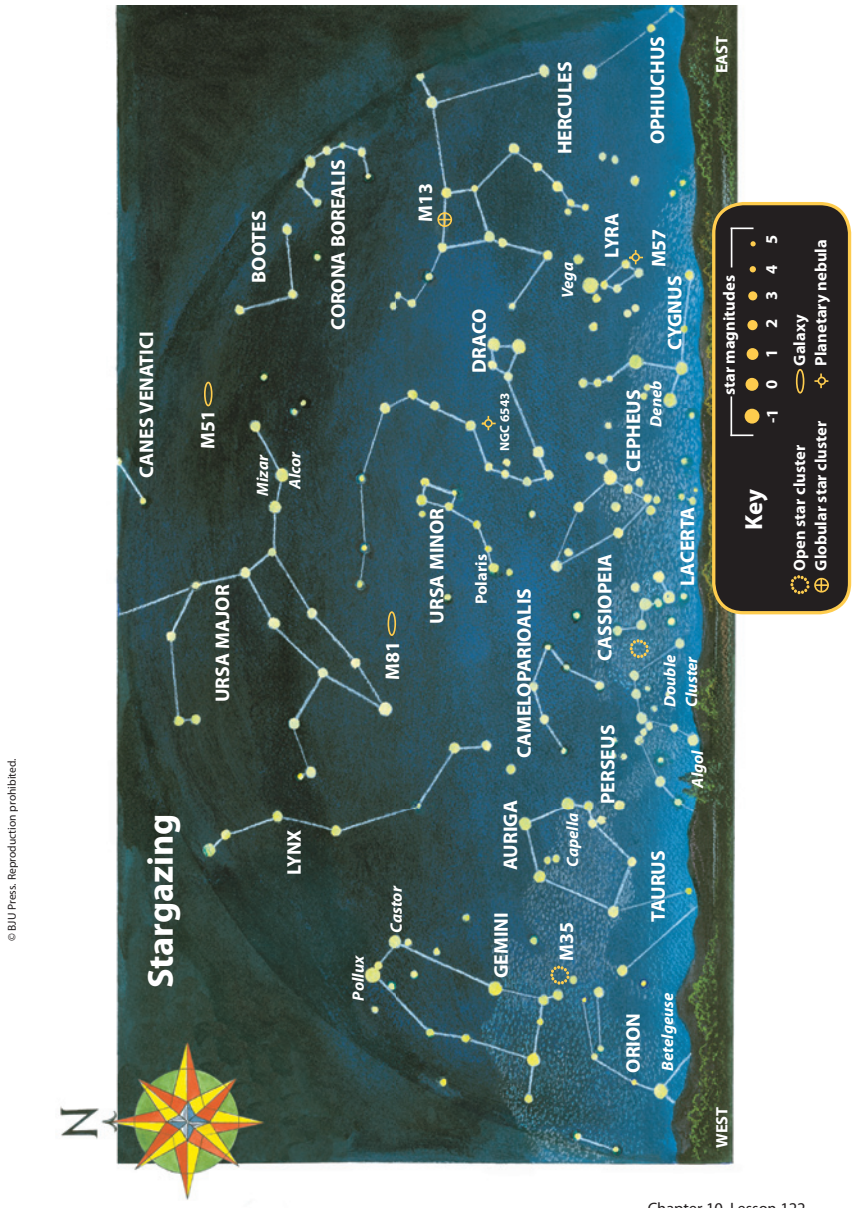
What does this symbol mean? globular star cluster

With an orange colored pencil, circle the globular star cluster. M 13

Draw the symbol for the planetary nebula.

What does this symbol stand for? a planetary nebula

With a green colored pencil, circle the planetary nebulae. NGC 6543, M 57



Star charts
Star charts can be found in many print and electronic resources. The chart on Activity Manual page 165 shows the night sky for the Northern Hemisphere.

Astronomy group
Encourage the student to find out whether there is a local astronomy group in your area. Many areas have amateur astronomers who meet regularly to look at the stars. They usually allow visitors to look through their telescopes.

EXPLORATION

Stargazing

Name _____

This activity is the culmination of your study of the stars. Although looking at pictures of the stars in a textbook is useful, it cannot compare to viewing the splendor of God's creation firsthand. The best conclusion to this chapter is for you to observe the constellations in the evening sky. To get started, you may need to obtain help identifying and locating a constellation. Then try to find the constellation patterns on your own.

Enjoy stargazing!

To be completed by: _____

Suggestions for Stargazing

1. Wear layers of clothing as needed to keep warm.
2. Find a place that is away from city lights.
3. Cover the end of a flashlight with red cellophane. The red light will not disturb your night vision like a white light can.
4. Use the star chart to help you find the constellations.
5. Lie down on a blanket or sit in a chair to steady your arms as you observe the stars with binoculars.

Write the answers.

1. What constellations did you find? _____
2. List anything else you observed in the sky besides the stars and the moon. _____
3. What did you enjoy most about stargazing? _____
4. Create your own constellation. On your own paper sketch it and name it.

SCIENCE BACKGROUND

Twinkling stars

One way to tell the difference between planets and stars at night is by whether the light twinkles. Stars twinkle because of their distance from Earth and how Earth's atmosphere refracts their light. Because planets are nearer to Earth than the stars are and the light does not refract as much, planets appear as solid balls of light and do not twinkle.

Discussion

Choose several specific stars and direct the student to circle them with a white colored pencil. Examples include Mizar, Alcor, Pollux, Castor, Betelgeuse, Algol, Capella, Deneb, Vega, and Polaris.

Choose several constellations and direct the student to circle them with a light-blue colored pencil. Examples of constellations that are complete on this star chart are Lynx, Ursa Major, Bootes, Corona Borealis, Gemini, Auriga, Camelopardalis, Cassiopeia, Cepheus, Ursa Minor, Draco, Lyra, and Hercules.

As time allows, continue asking questions about star magnitude, location of constellations to each other, etc.

Assign a completion date for the stargazing activity and instruct the student write the date on Activity Manual page 166. Direct him to use Activity Manual pages 165–66 to complete the activity.

Activity Manual

Exploration, page 165

This page allows students to experience reading a different kind of map.

Exploration, page 166

This page reinforces the star chapter with a stargazing activity.

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

Lesson 123

Student Text pages 256–57
Activity Manual pages 167–68

Objectives
- Test factors that affect the size and depth of craters
- Measure mass and length
- Use a chart to record information
- Make and test predictions

Materials
- See Student Text page

Introduction

Which space objects have a lot of craters? Possible answers: the moon, Mercury

Why does Earth not have many craters? The friction of Earth's atmosphere burns meteors up before they reach Earth.

Craters have different sizes and depths. Why do you think some craters penetrate deeply into a space object while others leave a smaller print? Accept any answer.

Today you will have the opportunity to make your own craters.

Teach for Understanding

Purpose for reading
The student should read all the pages before beginning the activity.

Procedure
Assist the student in forming his hypothesis as needed. Remind him to include which object he thinks will make the largest crater for each height.

Observe the student's use of materials to ensure accuracy and consistency.

Point out the importance of keeping the measuring device as straight and tall as possible.

Remind the student to assign a different color to each object on the chart on Activity Manual page 167. The student should use these same colors to complete the graph on Activity Manual page 168.

Guide the student in labeling the left and bottom of the graph with numbers in chosen increments and filling in the blanks with the units of measure used.

ACTIVITY

Crater Creations

Process Skills
- Hypothesizing
- Measuring
- Observing
- Recording data
- Identifying and controlling variables
- Communicating

Meteorites do not strike only Earth's surface. Several other planets and moons have many craters formed by meteorites hitting their surfaces. The size, shape, and composition of a meteorite affect the depth of the crater that it causes.

In this activity you will make craters using balls of similar sizes but different masses.

Problem
How does the mass of a dropped object affect the depth of the crater it makes?

Procedure

1. Write a hypothesis in your Activity Manual, stating which object you think will make the largest crater at each height.
2. List the three objects you will drop. Include the color you will use to represent each object on the graph.
3. Weigh each object and record its mass on the table.
4. Lay out newspaper on the floor and place the pan on top of the newspaper. The newspaper should extend approximately a meter beyond the sides of the pan.
5. Pour 8–10 cm of flour into the pan. Shake the pan gently to even the flour. Sprinkle a thin layer of chocolate milk mix on top of the flour. (The chocolate powder will allow you to see the craters better.) Once you begin making craters, do not bump or shake the pan. Disturbing the pan will destroy your craters.

Materials
golf ball
table tennis ball
rubber ball, similar diameter
balance
newspaper
deep foil pan or a dishpan
2–3 bags of flour
powdered chocolate milk mix
meter stick
centimeter ruler
3 colored pens or pencils
Activity Manual

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TEACHER HELPS

Choosing a pan
For best results, choose a deep container that is a minimum of 12 inches wide.

Dropping objects
Any three round objects can be used as long as all three have similar diameter but different masses. Because density is the actual determining factor in how deep a crater forms, it is very important to have balls as close to the same circumference as possible. This allows mass and density to be close to the same.

Chocolate milk mix substitutions
Any nontoxic colored powder may be used to coat the flour, such as powdered tempera paint, powdered soft-drink mix, or colored sand.

Balance
If you do not have a balance available to measure the mass of each of the objects, you can have the students hold the objects and rank each group of three objects from lightest to heaviest.

SCIENCE BACKGROUND

Density or mass
Scientists would actually calculate and use density rather than mass when conducting experiments that are similar to this one. Mass is adequate for the student to use in this activity.

6. Have your partner hold the meter stick so it touches the top of the flour mixture. Drop each "meteorite" from 20 cm above a different area of the pan. Leave the objects in their craters until all are dropped.
7. Carefully remove each object and measure the depth of each crater. Record your results.
8. Repeat steps 6 and 7 by dropping the objects from 60 cm and 1 m above the pan.
9. Graph your results using the colors you have chosen.

Conclusions

- Was there a relationship between the mass of the object and the depth of its crater?
- Did the results change as the height variable changed?

Follow-up

- Compare the results of dropping a different set of objects, such as a baseball, an orange, and a tennis ball.
- Compare the depths of the craters of three objects that have the same mass but are different sizes.

SCIENCE PROCESS SKILLS

Recording data

What did you use to record your data? a chart

Do you think that this is an effective way to record data for this activity? yes **Why?** Answers will vary, but elicit that the chart allows you to see all the information in one place.

What is the advantage of making the graph? It is easier to see the relationships between the data collected from each object.

Conclusions

Provide time for the student to evaluate his hypothesis and answer the questions.

Was there any connection between the mass of the object and the depth of the crater made? Explain your answer. Answers should include the idea that the greater the mass of the object dropped, the deeper the crater will be.

What were your results when the height variable was changed? Answers should include the idea that the greater the height from which objects are dropped, the deeper the crater will be.

Use the questions in the Science Process Skills to discuss recording data.

Activity Manual

Activity, pages 167–68

Assessment

Rubrics

Select the prepared rubric, or design a rubric to include your chosen criteria.

Student Text page 258
Activity Manual pages 169–70

Objectives
- Recall concepts and terms from Chapter 10
- Apply knowledge to everyday situations

Introduction
Material for the Chapter 10 Test may be taken from Student Text page 258 and Activity Manual pages 160, 163–64, and 169–70. You may review any or all of the material during the lesson. Questions similar to Solve the Problem or the ones in Thinking It Through, Activity Manual pages 169–70, may appear on the test.

You may choose to review Chapter 10 by playing "Constellations" or a game from the Game Bank on the Teacher's Toolkit CD.

Teach for Understanding
Diving Deep into Science
Information on this page reflects the vocabulary and concepts the student should know for the test.

Solve the Problem
In order to solve the problem, the student must apply material he has learned. The student should attempt the problem independently. The answer for this Solve the Problem is based on the material on Student Text page 245. Answers will vary and may be discussed.

Activity Manual
Review, pages 169–70
These pages require written responses to application questions.

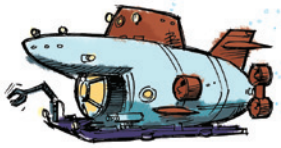
Lesson 125

Objective
- Demonstrate knowledge of concepts taught in Chapter 10

Assessment
Tests, Chapter 10

DIVING DEEP INTO SCIENCE

Words to Know
magnitude
apparent magnitude
absolute magnitude
light-year
parallax
variable star
nebula
neutron star
pulsar
black hole
constellation
circumpolar constellation
astronomy
redshift
binary system
multiple star group
star cluster
galaxy
asteroid
meteoroid
meteor
meteorite
comet



Key Ideas
How stars produce their own light
Relationship between a star's color and its temperature
Types and sizes of stars
Contrast a pulsating variable star and an eclipsing variable star
Causes of novas and supernovas
Recognize and name some star groups and constellations
Problems with practicing astrology
Identify and describe instruments used to study stars
Relationship of the Milky Way to the Local Group

Solve the Problem
You have a friend who tells you that when she is unsure about making a decision, she likes to look at a horoscope to get advice about what she should do. She claims to be a Christian, but she thinks that since the Bible was written long ago, it cannot help her with the decisions of today. She asks you what you think about her ideas. What will you tell her?

Answers will vary, but emphasize that the Bible is the Word of God and that God is unchangeable. God tells us in His Word that the Bible should be "a lamp unto [our] path" (Ps. 119:105). Christians should not look for guidance from sources that do not agree with God's Word.

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Review Game
Constellations
Divide the class into two teams. Choose two constellations with the same number of stars in each. Give each team an unlabeled picture of one of the constellations. When a team member answers a review question correctly, he then draws a star to represent one of the stars in the constellation. Alternate questions between teams. The first team to draw all of the stars in its constellation wins. Bonus points may be given if the team can correctly identify the constellation. Use other constellations and continue playing as time allows.

Suggested constellations
5 stars: Lyra, Cassiopeia, Cancer
7 stars: Andromeda, Ursa Minor
8 stars: Lacerta, Lepus, Crater