Name _____ Class _____ Date _____

CHAPTER 18 Studying Space

SECTION 1

Astronomy: The Original Science

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How do astronomers define a day, a month, and a year?
- What is the difference between the Ptolemaic and Copernican theories about the universe?
- What contributions did Brahe, Kepler, Newton, Galileo, and Hubble make to astronomy?

National Science Education Standards

ES 3a, ES 3b, ES 3c

How Does Astronomy Affect Our Calendar?

Imagine that it is 5,000 years ago. You do not have a modern clock or calendar. How can you know what day it is? How can you know what month it is? One way is to study the movement of the moon, the planets, and the stars.

People in ancient cultures used the movements of the stars, planets, and moon to mark the passage of time. People observed that the objects in the solar system move in regular and predictable ways. Farmers used these cycles to figure out the best time of year to plant and harvest. Sailors used the stars to navigate their ships. ☑

The early observations of the night sky led to the first calendars. Our modern calendar is also based on the movements of the bodies in our solar system. In our modern calendar, a **year** is the amount of time it takes the Earth to orbit the sun once. A **month** is about the same amount of time that the moon takes to orbit the Earth once. A **day** is the time it takes for the Earth to rotate once on its axis.

Unit	Description
Day	
Month	
	the time it takes the Earth to orbit the sun once

Over time, the study of the night sky became the science of astronomy. **Astronomy** is the study of the universe. Scientists who study astronomy are called *astronomers*. Modern astronomy is based partly on the work of early astronomers.

STUDY TIP

Compare As you read, make a chart comparing the different scientists that are mentioned in this section. In your chart, describe each scientist's contributions to astronomy.

READING CHECK

1. Explain How did people in ancient cultures mark the passage of time?

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_____

TAKE A LOOK

2. Identify Fill in the blank spaces in the table.

How Did Early Astronomers Affect Astronomy?

Almost everything that early astronomers knew came from what they could observe with their eyes. Therefore, most early astronomers thought the universe was made only of the moon, the planets, and the sun. They thought that all the stars were at the edge of the universe.

Early theories about the universe were incorrect in many ways. However, over time, more data became available to astronomers. As a result, theories about the universe began to change. ☑

READING CHECK

3. Explain Why have astronomers changed their theories about the universe over time?

_____

_____

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PTOLEMY: AN EARTH-CENTERED UNIVERSE

Claudius Ptolemy was a Greek astronomer. In 140 CE, he wrote a book that brought together many ancient astronomical observations. He used these observations, together with careful calculations, to develop what is known as the *Ptolemaic theory*. According to this theory, the Earth is the center of the universe. The Ptolemaic theory also states that all other objects in the universe orbit the Earth.

Today, we know that the Ptolemaic theory is incorrect. However, Ptolemy's calculations predicted the motions of the planets better than any other theory at the time. The predictions fit the observations that other astronomers made. Therefore, the Ptolemaic theory was accepted as correct for more than 1,500 years.

COPERNICUS: A SUN-CENTERED UNIVERSE

In 1543, a Polish astronomer named Nicolaus Copernicus published a new theory. His theory stated that the sun is the center of the universe and that the planets revolve around the sun.

Scientists did not accept Copernicus's theory immediately. However, when it was accepted, it caused major changes in science and society. These changes were called the *Copernican revolution*.

Critical Thinking

4. Compare Today, scientists know that only part of Copernicus's theory is correct. Which part of Copernicus's theory is not correct?

_____

_____

TAKE A LOOK

5. Describe Fill in the blank spaces in the table.

Astronomer	Description of theory
Ptolemy	
	The sun is the center of the universe, and the planets orbit the sun.

TYCHO BRAHE: A WEALTH OF DATA

In the late 1500s, a Danish astronomer, Tycho Brahe, made the most detailed astronomical observations so far. Brahe thought the sun and moon revolved around the Earth, and the other planets revolved around the sun. Although his theory was incorrect, his precise observations helped future astronomers. ☑

READING CHECK

6. Explain How did Tycho Brahe's work help astronomers?

_____

_____

JOHANNES KEPLER: LAWS OF PLANETARY MOTION

Johannes Kepler was Brahe's assistant. He continued to analyze Brahe's data after Brahe died. Kepler determined that the planets revolve around the sun in *elliptical*, or oval-shaped, orbits. He also developed three laws that describe planetary motion. These laws are still used today.

GALILEO: TURNING A TELESCOPE TO THE SKY

Galileo Galilei was one of the first people to use a telescope to observe objects in space. Before his time, astronomers observed space using only their eyes. Galileo made many important observations about the solar system. Some of these observations are listed below.

- There are craters and mountains on the surface of the Earth's moon.
- Jupiter has at least four moons.
- Dark spots sometimes appear on the surface of the sun.

These discoveries were important because they showed that the planets are physical bodies like the Earth. Until Galileo, people thought that the planets were stars that moved quickly through the sky.

STANDARDS CHECK

ES 3a The earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets. The sun, an average star, is the central and largest body in the solar system.

7. Identify What is the most massive object in the solar system?

_____

ISAAC NEWTON: THE LAWS OF GRAVITY

In 1687, Sir Isaac Newton showed that all objects in the universe attract each other through a force called gravity. Heavy objects and objects that are close together have the strongest force of gravity. This explains why all the planets orbit the sun. The sun has more mass than any other object in the solar system.

EDWIN HUBBLE: BEYOND THE MILKY WAY

In 1924, Edwin Hubble used detailed observations to prove that other galaxies existed beyond the edge of our galaxy. His data confirmed that the universe is much larger than our own galaxy, the Milky Way.

Name _____ Class _____ Date _____

Section 1 Review

NSES ES 3a, ES 3b, ES 3c

SECTION VOCABULARY

astronomy the scientific study of the universe **day** the time required for Earth to rotate once on its axis	**month** a division of the year that is based on the orbit of the moon around the Earth **year** the time required for the Earth to orbit once around the sun

1. **Compare** What is the difference between a day, a month, and a year in terms of astronomy?

2. **Describe** What did people in ancient cultures observe about the motions of the planets, the moon, and the sun?

3. **Explain** Why was the Ptolemaic theory accepted for a long time?

4. **Infer** How did Tycho Brahe's work help Kepler develop his laws of planetary motion?

5. **Evaluate** What advantage did Galileo have over other, earlier astronomers?

6. **Identify** What did Edwin Hubble prove about the size of the universe?

Name _____ Class _____ Date _____

CHAPTER 18 Studying Space

SECTION 2

Telescopes

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- What are telescopes?
- How can telescopes help scientists study space?

How Can a Telescope Help Us Make Observations?

How much of the sky can you see when you gaze up at night? At most, you can see 3,000 stars. With a telescope, you can see millions of stars, as well as many other objects. A **telescope** is a tool that scientists use to study objects, such as stars, that are far away. A telescope collects light and other kinds of radiation from the sky and makes it brighter. In this way, telescopes make distant objects more visible.

An *optical telescope* is used to study visible light from objects in the universe. Simple optical telescopes, such as the one in the figure below, have two lenses. The *objective lens* collects light from distant objects. The objective lens focuses the light and forms an image at a focal point. A *focal point* is where rays of light that pass through a lens or reflect from a mirror come together. ☑

The second lens in a simple optical telescope is in the eyepiece. This lens *magnifies*, or makes bigger, the image that forms at the focal point.

This simple refracting telescope has an objective lens that collects light and a lens in the eyepiece to magnify the image.

STUDY TIP

Learn New Words As you read, underline words you don't know. When you figure out what they mean, write the words and their definitions in your notebook.

READING CHECK

1. Define What is a focal point?

_____

_____

_____

TAKE A LOOK

2. Compare How is the objective lens different from the lens in the eyepiece?

_____

_____

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_____

REFRACTING TELESCOPES

Refracting telescopes are simple optical telescopes that use lenses to gather and focus light. The figure on the previous page shows a drawing of a refracting telescope. Refracting telescopes are the simplest telescopes, so they are usually easy to use. ☑

READING CHECK

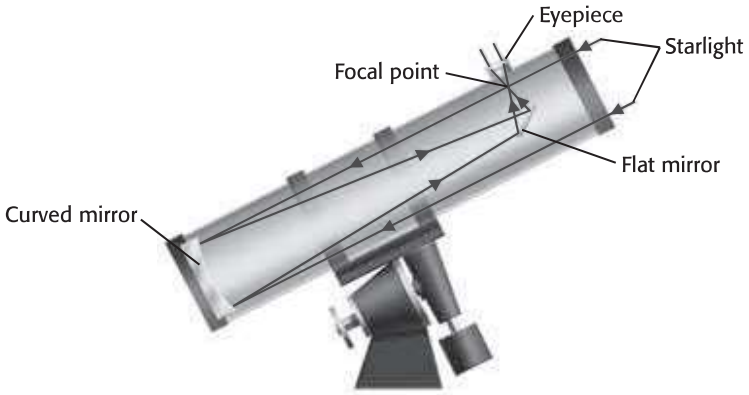
3. Explain How do refracting telescopes gather and focus light?

_____

There are two disadvantages to refracting telescopes. First, lenses focus different colors of light at slightly different distances. This means that images cannot be focused well. Second, refracting telescopes cannot be very large. Large telescopes have large objective lenses. The bigger the objective lens, the more light the telescope can gather. However, if the lens is too large, it can bend under its own weight. This causes the image to look fuzzy.

REFLECTING TELESCOPES

Reflecting telescopes use curved mirrors to gather and focus light. Light enters the telescope and reflects off a large, curved mirror. The light then travels to a flat mirror near the eyepiece. The flat mirror focuses the image and reflects it to the eyepiece.



This reflecting telescope uses mirrors to collect and focus light.

TAKE A LOOK

4. Describe What does the flat mirror in a reflecting telescope do?

_____

_____

_____

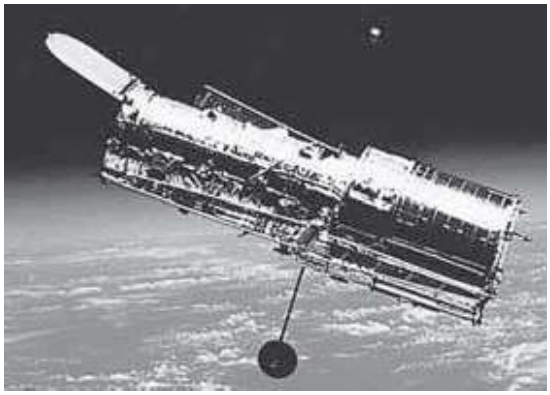
There are some advantages to reflecting telescopes. First, the mirrors can be large. This allows the reflecting telescope to gather a lot of light. Second, the light reflects off the mirrors instead of passing through them. This means that problems with the glass in the mirrors do not affect the image. Third, mirrors can focus all colors of light to the same focal point. Therefore, the images can be better focused than with refracting telescopes.

LARGE TELESCOPES AND CLEAR IMAGES

Some very large reflecting telescopes use several mirrors to collect and focus light. For example, the Keck Telescopes in Hawaii each use 36 mirrors to collect and focus light. However, even very large reflecting telescopes must be in a good location if they are to form clear images.

The light gathered by telescopes on the Earth is affected by the atmosphere. The motion of the air in the Earth's atmosphere causes starlight to shimmer and blur. Therefore, astronomers may place telescopes on mountain tops, where the air is thinner. There may also be less air and light pollution in these areas.

In order to avoid interference from the atmosphere, scientists have put telescopes in space. These telescopes can detect very faint objects because there is no air to blur the image.



The mirrors in the Hubble Space Telescope are smaller than the mirrors in many telescopes on the Earth. However, the Hubble Telescope can produce images of very faint objects because the Earth's atmosphere does not blur the images.

Critical Thinking

5. Apply Concepts Scientists may place telescopes in deserts or other areas where the air is dry. This is because dry air often produces less blurry images than moist air. What is the most likely reason that dry air produces less blurry images than moist air?

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What Is Light?

Optical telescopes make the visible light from objects in space easier for us to see. Visible light is a form of electromagnetic radiation. However, visible light is not the only form of electromagnetic radiation. Other examples of electromagnetic radiation are gamma rays, X rays, and radio waves. The **electromagnetic spectrum** is made up of all the kinds of electromagnetic radiation.

Electromagnetic radiation travels in waves. Each kind of radiation has a different wavelength. Gamma rays have the shortest wavelengths. Radio waves have the longest wavelengths. ☑

Most of the electromagnetic spectrum is invisible. For example, we cannot see gamma rays or radio waves. The figure on the top of the next page shows some of the different kinds of electromagnetic radiation.

READING CHECK

6. Identify Which kind of electromagnetic radiation has the shortest wavelength?

_____

Say It

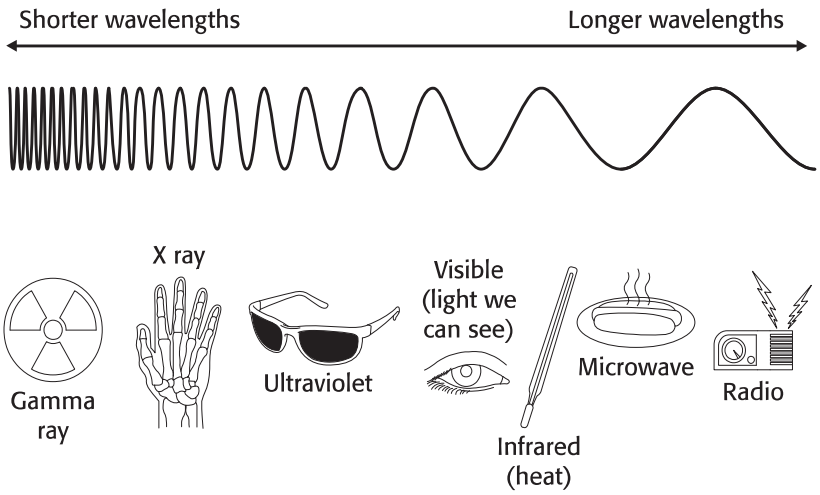
Discuss You may have heard or seen the terms "X ray," "infrared," and "ultraviolet" in other places. In a small group, talk about the ways that these words are used in other situations.

TAKE A LOOK

7. Identify Give two kinds of electromagnetic radiation that are invisible.

_____

_____



The electromagnetic spectrum is made up of all the kinds of electromagnetic radiation. Visible light is light that we can see. However, most electromagnetic radiation is invisible.

DETECTING ELECTROMAGNETIC RADIATION

The atmosphere acts as a shield around the Earth. It blocks most kinds of invisible radiation that come from objects in space. However, some types of radiation, such as radio waves and microwaves, can pass through the atmosphere.

Scientists can study invisible radiation using *nonoptical telescopes*. These telescopes can detect invisible radiation and focus it to produce an image. Astronomers study the entire electromagnetic spectrum because each type of radiation reveals different clues about an object. ☑

READING CHECK

8. Explain How do scientists study invisible radiation from objects in space?

_____

_____

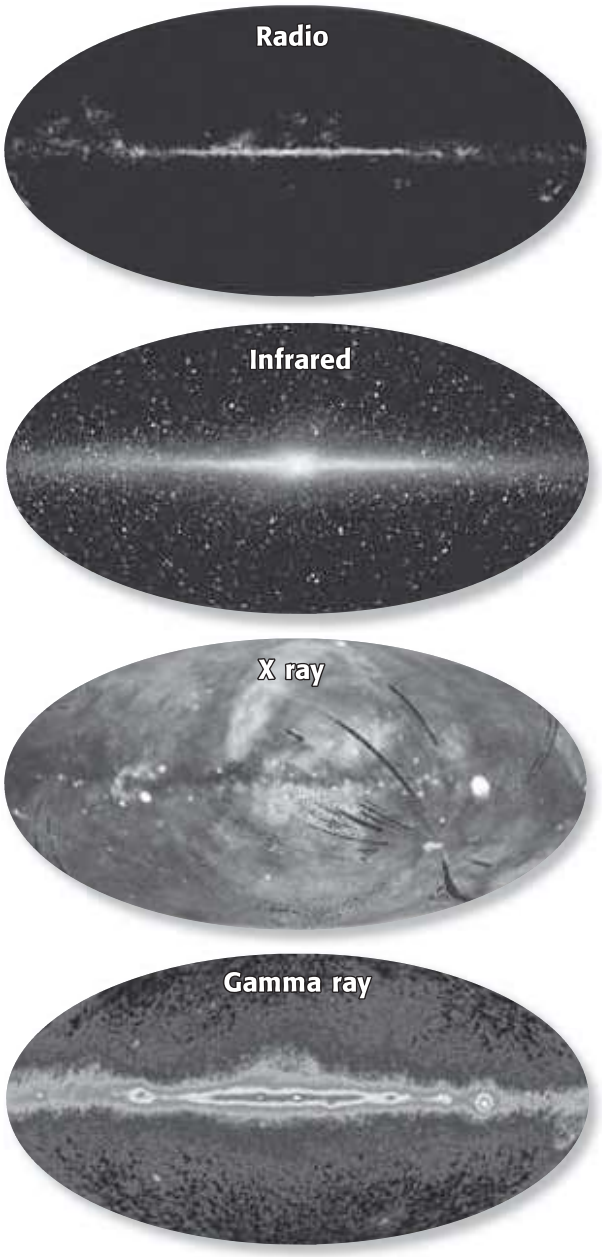
RADIO TELESCOPES

Radio telescopes detect radio waves. Radio wavelengths are much longer than visible wavelengths. Therefore, radio telescopes have to be much larger than optical telescopes. However, the reflecting surfaces of radio telescopes do not have to be as smooth as those in optical telescopes. In addition, radio waves can be detected at night and during the day. Therefore, radio telescopes can be very useful, even though they are large.

Astronomers can use many radio telescopes together to get more detailed images. When radio telescopes are linked together, they work like a single giant telescope. The Very Large Array (VLA) consists of 27 radio telescopes spread over 30 km. Together, the VLA telescopes act as a single telescope that is 30 km across.

NONOPTICAL TELESCOPES IN SPACE

Most electromagnetic waves are blocked by the Earth's atmosphere. Therefore, scientists have placed some kinds of nonoptical telescopes in space. These telescopes produce images of objects in space using different kinds of electromagnetic radiation. For example, each figure below shows an image of our galaxy. The images look different because they were recorded from different types of electromagnetic radiation. ☑



Each of these images shows our galaxy, the Milky Way. Different features of the galaxy are visible at different wavelengths of electromagnetic radiation.

READING CHECK

9. Explain Why have scientists placed some nonoptical telescopes in space?

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_____

_____

_____

TAKE A LOOK

10. Compare On each image, circle a feature that is not found in any of the other images.

Name _____ Class _____ Date _____

Section 2 Review

SECTION VOCABULARY

electromagnetic spectrum all of the frequencies or wavelengths of electromagnetic radiation **reflecting telescope** a telescope that uses a curved mirror to gather and focus light from distant objects	**refracting telescope** a telescope that uses a set of lenses to gather and focus light from distant objects **telescope** an instrument that collects electromagnetic radiation from the sky and concentrates it for better observation

1. **Compare** What is the main difference between a refracting telescope and a reflecting telescope?

2. **Describe** What limits the size of a refracting telescope? Explain your answer.

3. **Identify** List five types of electromagnetic radiation. Put them in order, from the longest wavelengths to the shortest.

4. **Explain** Why do radio telescopes have to be larger than optical telescopes?

5. **Explain** Why do astronomers place telescopes in space? Give two reasons.