

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?

TAKE A LOOK

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

SECTION 1 Astronomy: The Original Science *continued*

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?

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.

SECTION 1 Astronomy: The Original Science *continued***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. ✓

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.

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.

 **READING CHECK**

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

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?

Section 1 Review

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

SECTION VOCABULARY

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

4. Coastal cities could flood due to increases in global sea level.
5. Burning fossil fuels and trees can increase CO₂ in the atmosphere. Cutting down trees prevents them from removing CO₂ from the atmosphere. Using less electricity that comes from the burning of fossil fuels can help reduce the amount of CO₂ that is added to the atmosphere.

Chapter 18 Studying Space

SECTION 1 ASTRONOMY: THE ORIGINAL SCIENCE

1. by studying the motions of the planets, the moon, and the sun
2. Day: the time it takes the Earth to rotate once on its axis
Month: roughly the time it takes the moon to orbit the Earth once
Year: the time it takes the Earth to orbit the sun once
3. More information has become available to them.
4. The sun is not the center of the universe.
5. Ptolemy: The Earth is the center of the universe, and all other objects orbit the Earth.
Copernicus: The sun is the center of the universe, and the planets orbit the sun.
6. He made detailed astronomical observations.
7. the sun

Review

1. A day is the amount of time required for the Earth to rotate once on its axis. A month is the amount of time required for the moon to orbit around the Earth. A year is the amount of time required for the Earth to orbit around the sun.
2. The movements are predictable and regular.
3. It predicted the motions of the planets more accurately than any other theory. Its predictions matched the observations of scientists living at the time.
4. Brahe gathered data that Kepler was able to analyze to develop the laws of planetary motion.
5. Galileo used a telescope to examine the night sky. Earlier astronomers could only observe the sky with their eyes.

6. Edwin Hubble used data to confirm that the universe is much larger than only our galaxy (the Milky Way).

SECTION 2 TELESCOPES

1. the place where light rays from a lens or mirror come together
2. The objective lens collects and focuses the light. The eyepiece lens magnifies the image.
3. with lenses
4. focuses the light and reflects it to the eyepiece
5. Light may reflect off water vapor in the air, causing images to be blurry.
6. gamma rays
7. Possible answers: radio waves, microwaves
8. using nonoptical telescopes
9. The atmosphere can prevent some kinds of radiation from reaching the Earth's surface.
10. In each image, a feature that is not visible in any of the other images should be circled.

Review

1. A refracting telescope uses lenses to gather and focus light. A reflecting telescope uses a curved mirror to gather and focus light.
2. The size of the objective lens limits the size of the telescope. If the objective lens is too big, it can sag under its own weight. This produces fuzzy images.
3. radio waves, microwaves, infrared, visible, ultraviolet, X rays, gamma rays
4. Radio waves are much longer than optical wavelengths.
5. The atmosphere distorts visible light that travels through it, producing fuzzy images. Also, the atmosphere blocks many forms of invisible radiation, so they can be detected only in space.

SECTION 3 MAPPING THE STARS

1. 88
2. Hydra
3. Different constellations are visible from different points on the Earth.
4. The Earth rotates and makes different parts of the sky visible.
5. The star should be drawn about halfway up the arc.