

Historical Models of the Solar System

ESSENTIAL QUESTION

How have people modeled the solar system?

By the end of this lesson, you should be able to compare various historical models of the solar system.



The Earth-centered model of the solar system was accepted for almost 1,400 years. It was replaced by the sun-centered model of the solar system, which is shown in this 17th-century illustration.

Lesson Labs

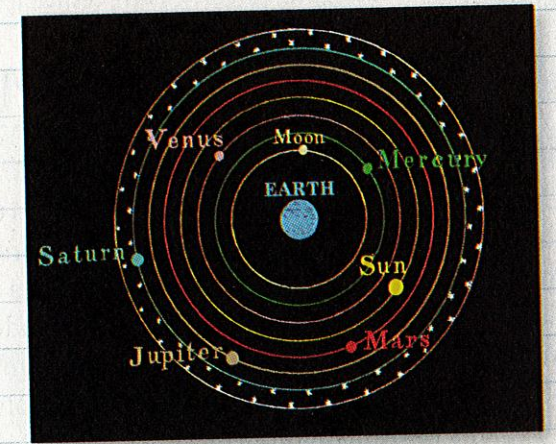
- Quick Labs**
- The Geocentric Model of the Solar System
 - The Heliocentric Model of the Solar System
 - Orbital Ellipses
- Field Lab**
- Investigating Parallax

Engage Your Brain

1 Predict Check T or F to show whether you think each statement is true or false.

- | | | |
|--------------------------|--------------------------|--|
| T | F | |
| <input type="checkbox"/> | <input type="checkbox"/> | The sun and planets circle Earth. |
| <input type="checkbox"/> | <input type="checkbox"/> | Most early astronomers placed the sun at the center of the solar system. |
| <input type="checkbox"/> | <input type="checkbox"/> | The planets orbit the sun in ellipses. |
| <input type="checkbox"/> | <input type="checkbox"/> | The telescope helped to improve our understanding of the solar system. |

2 Evaluate What, if anything, is wrong with the model of the solar system shown below?



Active Reading

3 Synthesis You can often define an unknown word if you know the meaning of its word parts. Use the word parts and sentence below to make an educated guess about the meaning of the word *heliocentric*.

Word part	Meaning
helio-	sun
-centric	centered

Example sentence
The heliocentric model of the solar system was first proposed by Aristarchus.

heliocentric:

Vocabulary Terms

- solar system
- geocentric
- heliocentric
- parallax

4 Apply As you learn the definition of each vocabulary term in this lesson, create your own definition or sketch to help you remember the meaning of the term.

What is the Center of the Solar System?

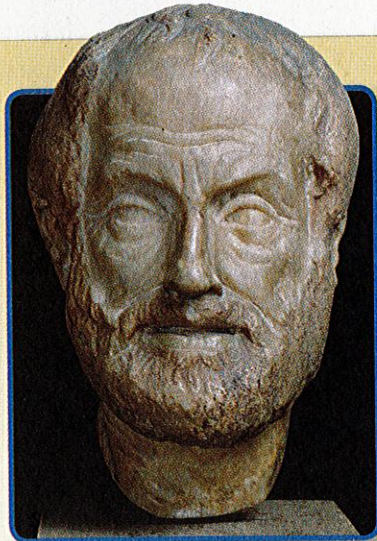
What is the solar system?

The **solar system** is the sun and all of the bodies that orbit the sun. Our current model of the solar system is the *sun-centered* or *heliocentric* (hee•lee•oh•SEN•trik) model. In the **heliocentric** model, Earth and the other planets orbit the sun. The earliest models for the solar system assumed that the Earth was at the center of the solar system, with the sun, moon, and planets circling it. These models, which used Earth as the center, are called *Earth-centered* or **geocentric** (jee•oh•SEN•trik) models. The heliocentric model was not generally accepted until the work of Copernicus and Kepler in the late 16th to early 17th centuries.

Who proposed some early models of the solar system?

Until Galileo improved on the telescope in 1609, people observed the heavens with the naked eye. To observers, it appeared that the sun, the moon, the planets, and the stars moved around Earth each day. This caused them to conclude that Earth was not moving. If Earth was not moving, then Earth must be the center of the solar system and all other bodies revolved around it.

This geocentric model of the solar system became part of ancient Greek thought beginning in the 6th century BCE. Aristotle was among the first thinkers to propose this model.



Aristotle (384–322 BCE)

Aristotle

Aristotle (AIR•ih•stah'tl) was a Greek philosopher. Aristotle thought Earth was the center of all things. His model placed the moon, sun, planets, and stars on a series of circles that surrounded Earth. He thought that if Earth went around the sun, then the relative positions of the stars would change as Earth moves. This apparent shift in the position of an object when viewed from different locations is known as **parallax** (PAIR•uh•laks). In fact, the stars are so far away that parallax cannot be seen with the naked eye.

Active Reading

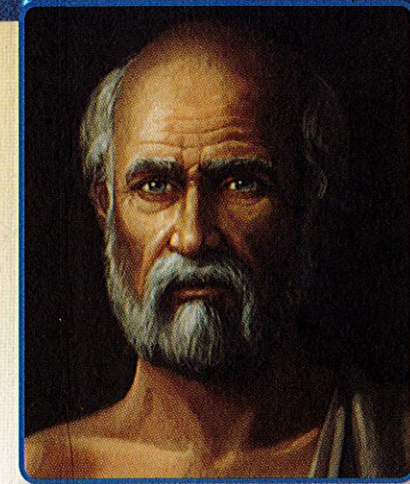
5 Identify As you read the text, underline the definitions of geocentric and heliocentric.

Think Outside the Book

6 Research Use different sources to research a geocentric model of the solar system from either ancient Greece, ancient China, or Babylon. Write a short description of the model you choose.

Aristarchus

Aristarchus (air•i•STAHHR•kuhs) was a Greek astronomer and mathematician. Aristarchus is reported to have proposed a heliocentric model of the solar system. His model, however, was not widely accepted at the time. Aristarchus attempted to measure the relative distances to the moon and sun. This was a major contribution to science. Aristarchus's ratio of distances was much too small but was important in the use of observation and geometry to solve a scientific problem.



Aristarchus (about 310–230 BCE)

Aristotle thought that if Earth were moving, the positions of the stars should change as Earth moved. In fact, stars are so far away that shifts in their positions can only be observed by telescope.

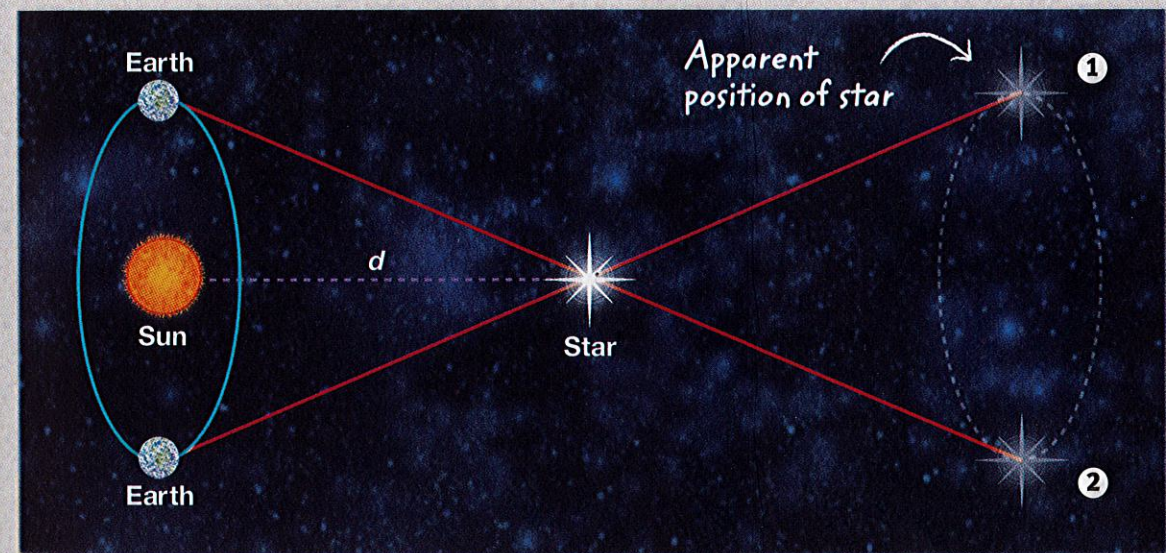


Diagram showing the shift in apparent position of a star at two different times of year seen from a telescope on Earth. A star first seen at point 1 will be seen at point 2 six months later.

Visualize It!

7 Predict If a star appears at position 1 during the summer, during which season will it appear at position 2?



Ptolemy (about 100–170 CE)

Ptolemy

Ptolemy (TOHL•uh•mee) was an astronomer, geographer, and mathematician who lived in Alexandria, Egypt, which was part of ancient Rome. His book, the *Almagest*, is one of the few books that we have from these early times. It was based on observations of the planets going back as much as 800 years. Ptolemy developed a detailed geocentric model that was used by astronomers for the next 14 centuries. He believed that a celestial body traveled at a constant speed in a perfect circle. In Ptolemy's model, the planets moved on small circles that in turn moved on larger circles. This "wheels-on-wheels" system fit observations better than any model that had come before. It allowed prediction of the motion of planets years into the future.

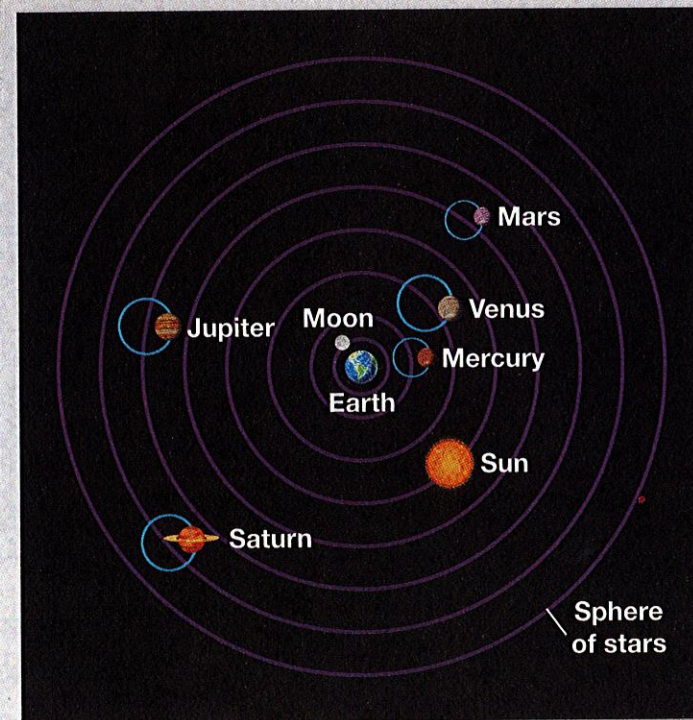
Visualize It!

8 Describe Use the diagram at the right to describe Ptolemy's geocentric model of the solar system.

Think Outside the Book Inquiry

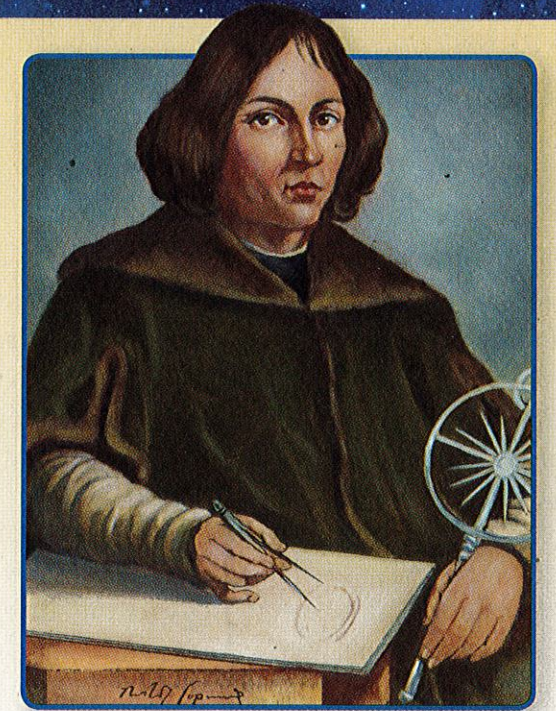
9 Defend As a class activity, defend Ptolemy's geocentric model of the solar system. Remember that during Ptolemy's time people were limited to what they could see with the naked eye.

Ptolemaic Model



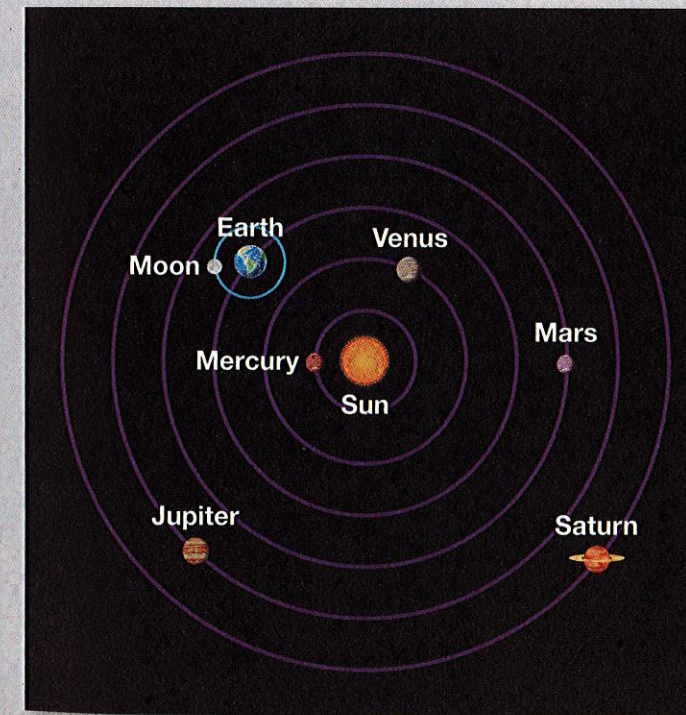
Copernicus

The Polish astronomer Nicolaus Copernicus (nik•uh•LAY•uhs koh•PER•nuh•kuhs) felt that Ptolemy's model of the solar system was too complicated. He was aware of the heliocentric idea of Aristarchus when he developed the first detailed heliocentric model of the solar system. In Copernicus's time, data was still based on observations with the naked eye. Because data had changed little since the time of Ptolemy, Copernicus adopted Ptolemy's idea that planetary paths should be perfect circles. Like Ptolemy, he used a "wheels-on-wheels" system. Copernicus's model fit observations a little better than the geocentric model of Ptolemy. The heliocentric model of Copernicus is generally seen as the first step in the development of modern models of the solar system.



Nicolaus Copernicus (1473–1543)

Copernican Model



10 Compare How does Copernicus's model of the solar system differ from Ptolemy's model of the solar system?

Ptolemaic model	Copernican model

Active Reading

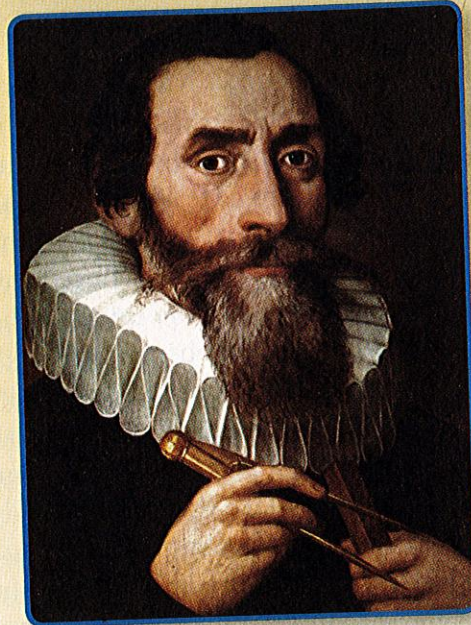
11 Identify Underline text that summarizes Kepler's three laws.

Kepler

Johannes Kepler (yoh•HAH•nuhs KEP•luhr) was a German mathematician and astronomer. After carefully analyzing observations of the planets, he realized that requiring planetary motions to be exactly circular did not fit the observations perfectly. Kepler then tried other types of paths and found that ellipses fit best.

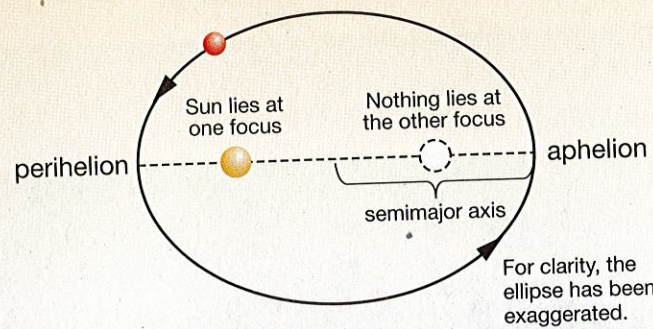
Kepler formulated three principles, which today are known as Kepler's laws. The first law states that planetary orbits are ellipses with the sun at one focus. The second law states that planets move faster in their orbits when closer to the sun. The third law relates the distance of a planet from the sun to the time it takes to go once around its orbit.

12 Analyze How did Kepler's first law support the idea of a heliocentric solar system?



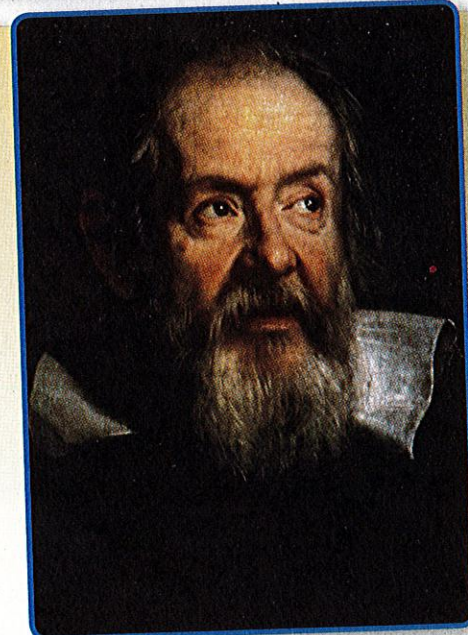
Johannes Kepler (1571–1630)

Kepler's First Law



Galileo

Galileo Galilei (gahl•uh•LAY•oh gahl•uh•LAY) was a scientist who approached questions in the fashion that today we call *scientific methods*. Galileo made significant improvements to the newly invented telescope. He then used his more powerful telescope to view celestial objects. Galileo observed the moons Io, Europa, Callisto, and Ganymede orbiting Jupiter. Today, these moons are known as the Galilean satellites. His observations showed that Earth was not the only object that could be orbited. This gave support to the heliocentric model. He also observed that Venus went through phases similar to the phases of Earth's moon. These phases result from changes in the direction that sunlight strikes Venus as Venus orbits the sun.



Galileo Galilei (1564–1642)

Why It Matters

Galileo

Galileo Galilei was an Italian mathematician, physicist, and astronomer who lived during the 16th and 17th centuries. Galileo demonstrated that all bodies, regardless of their mass, fall at the same rate. He also argued that moving objects retain their velocity unless an unbalanced force acts upon them. Galileo made improvements to telescope technology. He used his telescopes to observe sunspots, the phases of Venus, Earth's moon, the four Galilean moons of Jupiter, and a supernova.



Galileo's Telescopes

This reconstruction of one of Galileo's telescopes is on exhibit in Florence, Italy. Galileo's first telescopes magnified objects at 3 and then 20 times.

The Galileo Spacecraft

The *Galileo* spacecraft was launched from the space shuttle *Atlantis* in 1989. *Galileo* was the first spacecraft to orbit Jupiter. It studied the planet and its moons.

Extend

13 Identify What were Galileo's most important contributions to astronomy?

14 Research Galileo invented or improved upon many instruments and technologies, such as the compound microscope, the thermometer, and the geometric compass. Research one of Galileo's technological contributions.

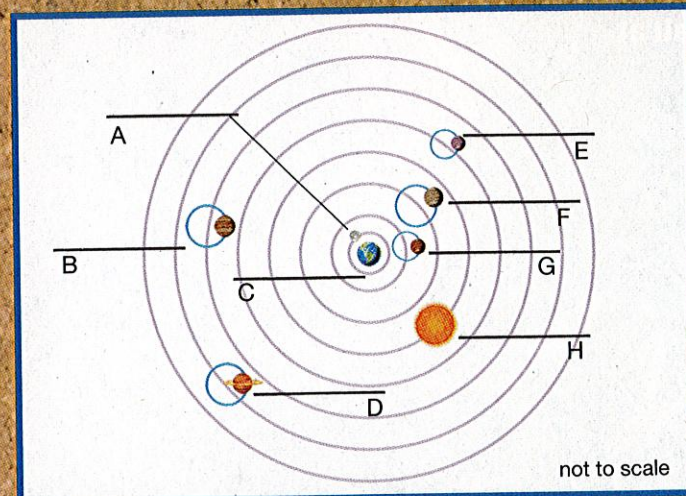
15 Create Describe one of Galileo's experiments concerning the motion of bodies by doing one of the following:

- make a poster
- recreate the experiment
- draw a graphic novel of Galileo conducting an experiment

Visual Summary

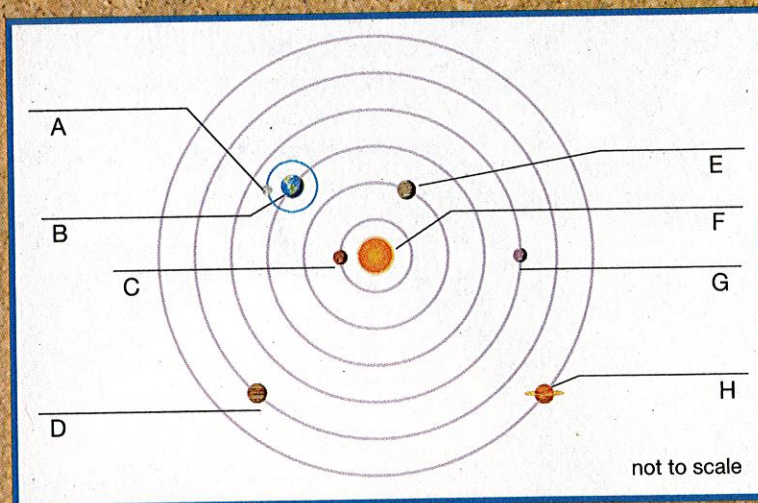
To complete this summary, fill in the blanks with the correct word or phrase. Then use the key below to check your answers. You can use this page to review the main concepts of the lesson.

Models of the Solar System



Early astronomers proposed a geocentric solar system.

- 16 Label the solar system bodies as they appear in the geocentric model.
- 17 Which astronomers are associated with this model of the solar system?



The heliocentric solar system is the current model.

- 18 Label the solar system bodies as they appear in the heliocentric model.
- 19 Which astronomers are associated with this model of the solar system?

Answers: 16 A. moon, B. Mercury, C. Venus, D. Earth, E. Mars, F. Jupiter, G. Saturn, H. Sun; 17 Aristotle, Ptolemy; 18 A. moon, B. Earth, C. Mercury, D. Jupiter, E. Venus, F. sun, G. Mars, H. Saturn; 19 Aristarchus, Copernicus, Kepler, Galileo

- 20 **Compare** How does the geocentric model of the solar system differ from the heliocentric model of the solar system?

Lesson Review

Vocabulary

Fill in the blank with the term that best completes the following sentences.

- The _____ is the sun and all of the planets and other bodies that travel around it.
- Until the time of Copernicus, most scientists thought the _____ model of the solar system was correct.
- An apparent shift in the position of an object when viewed from different locations is called _____.

Key Concepts

In the following table, write the name of the correct astronomer next to that astronomer's contribution.

Contribution	Astronomer
4 Identify Who first observed the phases of Venus?	
5 Identify Who attempted to measure the relative distances to the moon and the sun?	
6 Identify Who replaced circles with ellipses in a heliocentric model of the universe?	
7 Identify Whose geocentric model of the solar system was accepted for 1,400 years?	
8 Identify Whose heliocentric model is seen as the first step in the development of modern models of the solar system?	

Critical Thinking

Use the illustration to answer the following question.



- 9 **Appraise** How did data gathered using Galileo's early telescope support the heliocentric model?

- 10 **Explain** How did Aristotle's inability to detect parallax lead him to propose a geocentric model of the solar system?