

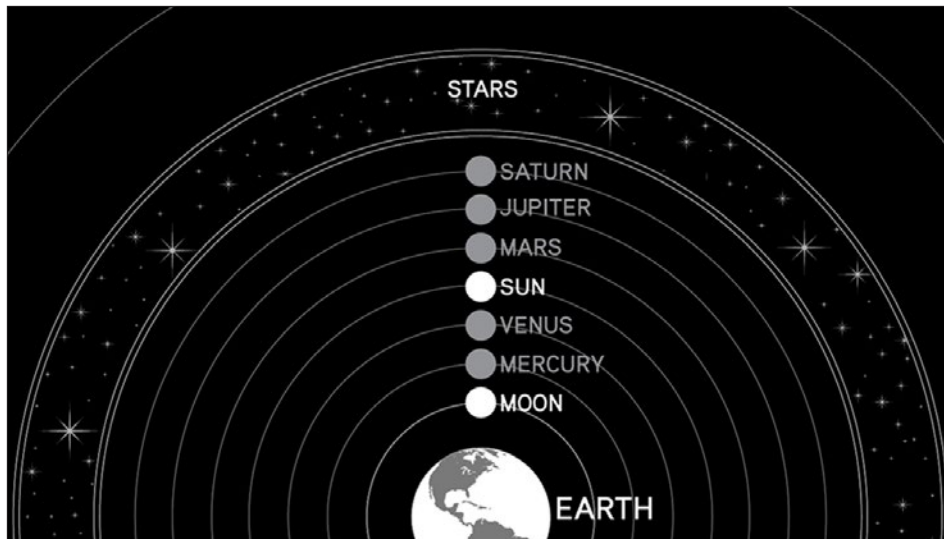
## TEXT 01

# THE GEOCENTRIC VIEW

How did the Universe appear to our ancestors before the invention of the telescope? Most people thought the Earth was the center of the Universe. For them, the Earth did not move in the sky and it did not rotate on its axis. Rather, all the planets and stars rotated around the Earth. Historians and scientists call this Earth-centered view of the Universe *geocentric* (“geo” referring to the Earth and “centric” meaning in the center) and *geostatic* (“static” meaning unmoving).

The Greek astronomer Ptolemy (ca. 90–168 CE) described the geocentric view of the Universe in the *Almagest*, a book he wrote in about 150 CE. For more than 1,500 years, people accepted this view (pictured below) as the correct one. Why would an astronomer like Ptolemy hold a geocentric and geostatic view of the Universe? Why did so many of our ancestors accept this view? In the excerpt below, Carl Sagan, an American astronomer and cosmologist, explains.

Ptolemy believed that the Earth was at the center of the Universe and that the Sun, Moon, planets and stars went around the Earth. This is the most natural idea in the world. The Earth seems steady, solid, immobile, while we can see the heavenly bodies rising and setting each day. Every culture leaped to the geocentric hypothesis.



### Sources

Carl Sagan, *Cosmos* (New York: Ballantine, 1985) 38–39.

Illustration by the Big History Project.



### THINGS TO THINK ABOUT

Why would most of our ancestors have believed in this view of the Universe? Can you figure out why their model of the Universe did not include Neptune and Uranus?

## TEXT 02

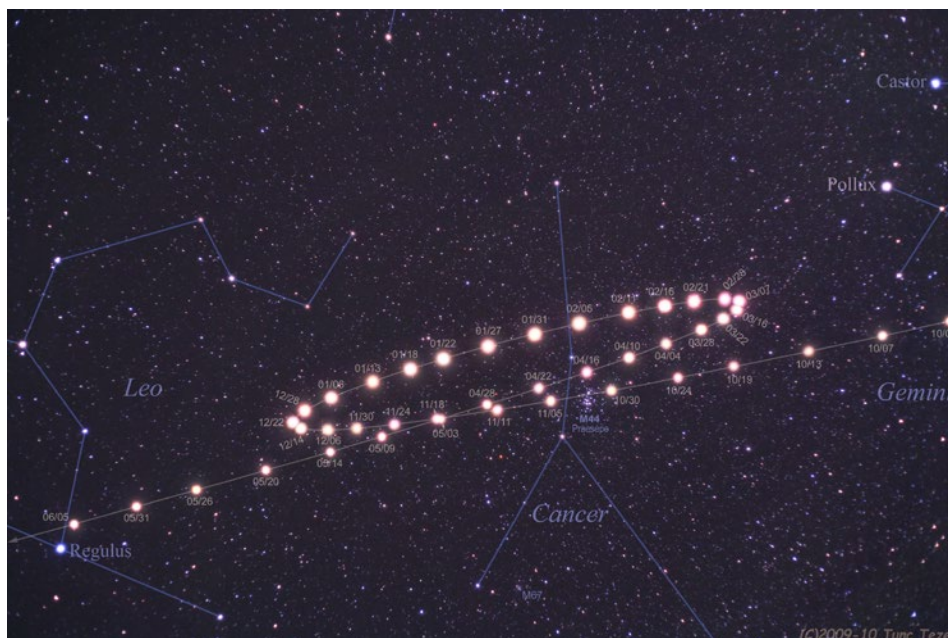
# PATH OF THE PLANETS

With only their eyes, our ancestors observed the heavenly bodies moving across the night sky. The Greeks called these heavenly bodies “planets,” which means wandering stars.

They also noticed that sometimes the planets appear to go backward in the sky and even to do loop-de-loops. The picture below, a composite photo of shots taken of Mars from the same spot on the Earth once a week from early autumn 2009 to late spring 2010, shows how Mars appeared to reverse its course and then circle back on track.

From the first picture, taken on October 2, 2009, Mars is the white dot on the far right-hand side of the photograph. About three months later (December 22, 2009), Mars appears to go backward in the sky and moves in that direction until about mid-March, when it looks as if it is going forward again.

Scientists call this movement of the planets “retrograde motion.” “Retrograde” means backward. What do you think explains this unusual motion? How would our ancestors explain it?



### Image credit

Tunç Tezel (TWN), <http://apod.nasa.gov/apod/ap100613.html>

## TEXT 04

# COPERNICUS'S HELIOCENTRIC VIEW

In 1543, Copernicus (1473–1543) published a revolutionary book that challenged the geocentric view of the Universe. The texts below explain some of what we know about why Copernicus changed his mind and suggested that the heliocentric view was better than the geocentric view.

Cynthia Stokes Brown, an educator and historian who taught at Dominican University of California at San Rafael, writes:

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In 1492, Copernicus went to study at a university. He was 19 years old. At school, he began to question what his teachers were teaching. Even though his professors believed that the Earth was in the center of the Universe and did not move, Copernicus began to question those ideas. His professors also taught about Ptolemy's views of the Universe, but Copernicus found mathematical errors in Ptolemy's use of epicycles that did not allow accurate predictions about the movement of the planets. These predictions would be more accurate, he thought, if the Earth revolved around the Sun instead of the other way around.

After graduating, Copernicus continued his observations of the heavens. To observe the planets, he used devices that looked like wooden yardsticks joined together. He used these to measure the altitude of stars and planets and to calculate the angles between two distant bodies in the sky. He could not use a telescope because no one had invented the telescope yet.

By 1514 Copernicus wrote a short report, called the *Little Commentary*, that explained his heliocentric theory. In this report, he confidently claimed that the Earth both revolved on its axis and orbited around the Sun. For Copernicus, putting the Sun in the center of the Universe solved many of the problems he found with Ptolemy's model. He gave this book, however, to only a few of his friends.

Copernicus waited over 20 years before he published his ideas on the heliocentric Universe. He was afraid of creating controversy. Finally, Copernicus agreed to have the book, *On the Revolutions of the Celestial Spheres*, published in 1543, the year he died.

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Paul Murdin, an astronomer at Cambridge in the United Kingdom and the author of many books on astronomy, writes:

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Copernicus put forward the concept that planets revolved around the Sun in outward order: Mercury, Venus, Earth, Mars, Jupiter and Saturn; while the Moon revolved around the Earth. The book is regarded as the foundation of the heliocentric (Sun-centered) theory of the solar system.... Copernicus showed that the puzzling retrograde motion of the outer planets, particularly Mars, was a natural consequence of the way that the

inner planets revolved around the Sun more quickly than the outer ones — and athlete running quickly on the inside track of a racecourse would see an athlete in front on an outer track moving ahead, but then as he overtook him he would see him apparently falling behind.

Copernicus’s model asked people to give up thinking that they lived in the center of the Universe. For him, the thought of the Sun illuminating all of the planets as they rotated around it had a sense of great beauty and simplicity.

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**Sources**

Modified from Cynthia Stokes Brown’s biography of Copernicus that appears in Unit 2 of the Big History Project course.

Paul Murdin, *Mapping the Universe* (London: Carlton Books, 2011).

## TEXT 05

# GALILEO'S LETTER TO KEPLER

Galileo (1564–1642) explains his support for Copernicus in a letter, written in 1597, to Johannes Kepler, a fellow scientist. He wrote the letter 54 years after Copernicus had died.

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I accepted the view of Copernicus many years ago. And from this standpoint I have discovered many natural phenomena, which cannot be explained on the basis of the more commonly accepted hypothesis [that the Earth is the center of the Universe].

I have written many direct and indirect arguments for the Copernican view. But until now I have not dared to publish them, alarmed by the fate of Copernicus himself, our master. He has won for himself undying fame in the eyes of a few, but he has been mocked and hooted at by an infinite multitude... I would dare to come forward publicly with my ideas if there were more people of your way of thinking.

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### Source

Modified from *The Portable Renaissance Reader*, ed. James Bruce Ross and Mary Martin McLaughlin (New York: Viking Press, 1953).

## TEXT 06

# GALILEO'S TELESCOPE

Galileo invented many things, and though he did not invent the telescope, he did, in 1609, devise a telescope that had more power than previous ones. And he was the first person to *use* the telescope to study the heavens. With it, he saw that the Moon was not smooth, observed sunspots and a supernova, and discovered the four moons of Jupiter. Did these discoveries support, extend, or challenge the geocentric or the heliocentric view of the Universe?



**Image credit**

Telescopes owned by Galileo © Gustavo Tomsich/CORBIS

## TEXT 08

# THE HELIOCENTRIC VIEW GROWS IN POPULARITY

Before Copernicus and Galileo, most people and most powerful organizations, such as the Roman Catholic Church in Europe, thought the geocentric view was correct. Therefore, both Copernicus and Galileo were afraid to publish their new ideas and with good reason. Copernicus waited until near his death to allow his book to be published and the Roman Catholic Church eventually tried and found Galileo guilty of holding heliocentric views that went against the Bible.

As you think about why and when people should change their minds, is it important to think about social pressure? Is it easier to change your mind when others are doing so?

Take a look at this timeline below. We have included some key dates in the change in collective learning from the geocentric to heliocentric views. How does this brief timeline support, extend, or challenge your ideas about when and why people should change their minds?

### **1633 Roman Catholic Church Outlaws Heliocentric View**

The Roman Catholic Church bans the teaching of heliocentric theories: "The proposition that the Sun is the center of the world and does not move from its place is absurd and false.... The proposition that the Earth is not the center of the world and...that it moves...is equally absurd and false...and at least an error in faith."

### **1661 Newton Studies Heliocentric View in College**

Among the books that Isaac Newton reads at Trinity College, Cambridge is Galileo's *Dialogue*, which challenges the geocentric idea.

### **1686 Popular Book Promotes Heliocentric View**

Bernard de Fontenelle, a French thinker, publishes *Conversations on the Plurality of Worlds*. In it he accepts the heliocentric view. The book becomes very popular and is published in many languages.

### **1687 Newton Publishes a Scholarly Book Improving on Heliocentric View**

Newton publishes his *Principia Mathematica*, offering more proof and many corrections for Copernicus and Galileo's heliocentric view.

### **1758 Roman Catholic Church Drops Its Heliocentric Ban**

The Catholic Church drops the prohibition of books advocating heliocentric theory.

### **1774 Roman Catholic Church Opens its First Observatory**

### **1891 Roman Catholic Church Opens the Vatican Observatory**

### **1992 Roman Catholic Church Expresses Regret for Treatment of Galileo**

### **2008 Catholic News Reports on Roman Catholic Church Plans to Honor Galileo with a Statue in the Vatican Gardens**

These plans, however, are later put on hold.