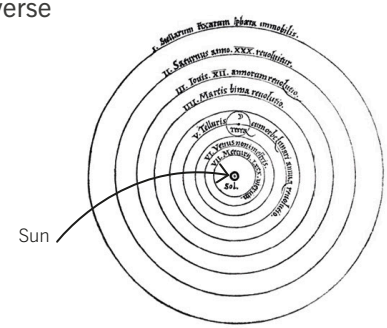
Scientific progress

Scientific methods and theories change over time. For example, the invention of the telescope changed the way people thought about the solar system. As telescopes became more powerful, new ideas about the stars and the Universe became accepted, too.

Key facts

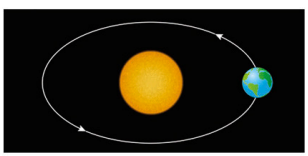
- ✓ **Scientific theories and methods change over time.**
- ✓ **The invention of the telescope led to new discoveries about the planets, moon, and stars.**
- ✓ **As telescope technology improved, new discoveries changed our understanding of the Universe.**

Observing the skies
The first people known to study the night sky were the people of Mesopotamia (now Iraq), around 5,000 years ago. Ancient astronomers used simple instruments like a quadrant to measure the angle stars or planets made with the horizon and to predict when the Sun or Moon would rise and set.



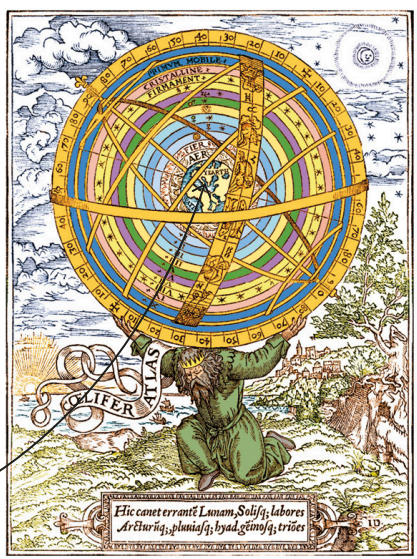
Heliocentric model
Using observations made with the naked eye, the Polish astronomer Nicolaus Copernicus devised a new model. This had the Sun at the center (heliocentric) and planets traveling around it in circular orbits. At first, it wasn't accepted because it didn't match observations perfectly.

Elliptical orbits
About 80 years after Copernicus died, a German astronomer named Johannes Kepler proposed a heliocentric model with elliptical (oval) orbits instead of circular ones. This matched the movements of the planets much better than older models.



140 CE — 1543 — 1609 — 1610

Earth in the middle
The people of the ancient world thought that the Sun moved around Earth and that Earth was the center of the Universe. The Greek astronomer Ptolemy based his "geocentric model" of the solar system on this idea. Geocentric means Earth is in the middle. To make this model fit with the observation that planets sometimes appeared to move backward through the sky, Ptolemy gave each planet a complex system of orbits within orbits (epicycles).

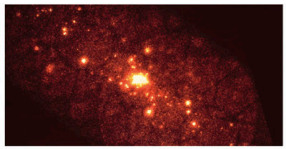


Ptolemy's model is called geocentric because it puts Earth in the center.

Telescopes
After the telescope was invented in the early 1600s, the Italian scientist Galileo Galilei discovered mountains and craters on the Moon and four moons orbiting Jupiter. His observations supported the heliocentric model.

In a different light

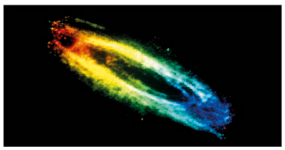
Visible light is just one part of the electromagnetic spectrum. Astronomers can learn more about stars and galaxies by observing the other kinds of electromagnetic wave that they emit. Some of these waves are absorbed by Earth's atmosphere, so X-ray, ultraviolet, and infrared telescopes have to be launched into space. Radio telescopes can be built on the ground. The images here show what the Andromeda Galaxy looks like at different wavelengths.



X-ray

Infrared

Ultraviolet



Radio

Theory of gravity
Inspired in part by Kepler's elliptical orbits, the English scientist Isaac Newton published a book that included his laws of gravity and motion. These mathematical models help explain how the planets orbit the Sun and how moons orbit planets.

Newton also invented the reflecting telescope, which uses a curved mirror instead of lenses.

Andromeda Galaxy

Discovering galaxies
In 1912, the American astronomer Henrietta Swan Leavitt worked out a way of calculating the distance from Earth to variable stars—stars whose brightness varies. In 1923, another American, Edwin Hubble, used her idea to demonstrate the existence of other galaxies beyond our own, revealing that the Universe was far bigger than anyone had realized.

1687 — 1781 — 1908 — Present day

Better telescopes
As telescopes got bigger and better, astronomers discovered more distant objects. The German-born astronomer William Herschel discovered Uranus using a telescope 39 feet (12 meters) long. He also identified lots of nebulas—clouds of glowing material among the stars.

William Herschel constructed his giant telescope with his sister Caroline Herschel.

Modern observation methods
Today, astronomers can launch telescopes into space or build telescopes that detect radio waves or other forms of electromagnetic radiation instead of visible light. The information gathered has helped us explain how stars form and die, how gravity holds them together in galaxies, and how the Universe might have begun.

Radio telescope