

## Module 5: The Scientific Revolution and the Enlightenment

### Topic 1: The Scientific Revolution

#### Laying the Basis for Modern Science

*"I do not feel obliged to believe that the same God who has endowed us with sense, reason, and intellect has intended us to forgo their use."*

-Galileo

Turn the page to explore how scientists changed the world during the Scientific Revolution.




# Middle Ages and Science

Laying the Basis for Modern Science

## Middle Ages and Science

- Middle Ages - scientists followed ideas based on untested ideas of the ancient Greeks and Romans and the Bible
- End of the Age of Absolutism - Science and scientific laws as the basis of decisions and actions
- Scientific Revolution - New emphasis on reason, observation, and systematic measurement

*Image: The Ptolemaic geocentric model of the Universe according to the Portuguese cosmographer and cartographer Bartolomeu Velho.*

The image shows a historical diagram of the Ptolemaic geocentric model of the universe. It consists of two circular diagrams side-by-side, each with Earth at the center. Concentric circles represent celestial spheres, with various celestial bodies and constellations labeled. The diagrams are framed by decorative borders. A small magnifying glass icon is visible in the bottom right corner of the image.

## **Narration**

During the Middle Ages, many scientists followed old ways of thinking which were based on the Bible and the work of the ancient Greeks and Romans. However, few people actually tested the ideas proposed by these two sources.

Toward the end of the Age of Absolutism, the idea that science and scientific laws should be the basis of our decisions and actions started to become popular in Europe. These ideas replaced established ideas about how religion should be the basis for all decisions and actions in the world.

The new emphasis on reason, observation, and systematic measurement became known as the Scientific Revolution. Many of the theories that were developed during the Scientific Revolution overturned some of the most basic beliefs of society. It was not easy for scientists to convince leaders that their discoveries were true, and some even had to risk their lives to do so.

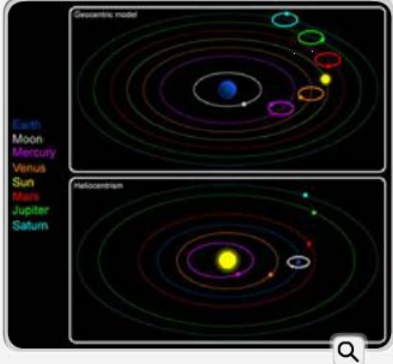
# Nicolaus Copernicus

Laying the Basis for Modern Science

## Nicolaus Copernicus

- From the country now known as Poland
- Developed heliocentric theory with the sun is the center of the Universe
- Did not promote his theory because it went against the views of the Catholic Church

*Image: Original image by Niko Lang, Licensed under Creative Commons Attribution-Share Alike 2.5 Generic license.*



The diagram consists of two panels. The top panel, labeled 'Geocentric model', shows Earth at the center with concentric circles representing the orbits of the Moon, Mercury, Venus, Earth, Mars, Jupiter, and Saturn. The bottom panel, labeled 'Heliocentric', shows the Sun at the center with concentric circles representing the orbits of the planets, including Earth. A legend on the left lists the celestial bodies: Earth (blue), Moon (grey), Mercury (purple), Venus (orange), Sun (yellow), Mars (red), Jupiter (green), and Saturn (brown). A magnifying glass icon is located at the bottom right of the diagram.

## ***Narration***

Early scientists believed that the Earth was the center of the universe. This is known as the geocentric theory.


After studying planetary motion for 30 years, Nicolaus Copernicus came to believe that the Sun was the center of the Universe. In 1543, he published his book, *On the Revolutions of the Heavenly Bodies*, which presented a heliocentric theory. His heliocentric theory proposed that the Earth and the other planets revolved around the Sun. This was in conflict with the Catholic Church's position that the Earth was the center of the Universe. Copernicus' heliocentric model challenged a 2,000 year old view of the Universe.

# Johannes Kepler

Laying the Basis for Modern Science

## Johannes Kepler

- From the Holy Roman Empire
- Developed the Laws of Planetary Motion
- Used observation and mathematics to prove Copernicus' theory was correct.

A black and white engraving of Johannes Kepler, showing him from the chest up. He has a full beard and is wearing a dark, buttoned-up garment with a white ruffled collar. The portrait is framed by a simple border with small decorative elements in the corners. Below the portrait, there is a small magnifying glass icon and the text "Photo: iStock".

## ***Narration***

For years, Johannes Kepler observed and recorded the movements of planets and stars. In the early 1600's, he developed the three laws of planetary motion. These laws supported the heliocentric theory, providing more evidence for Copernicus' views. Kepler proved that the planets orbited the sun in an elliptical path rather than a perfect circle.

# Galileo Galilei

## Laying the Basis for Modern Science

### Galileo Galilei

- Italian scientist
- Developed the telescope.
- Proved Aristotle's ideas about motion to be false
- Catholic Church declared him a heretic

*Image: Giuseppe Bertini (1825-1898) Galileo Galilei showing the Doge of Venice how to use the telescope*



### ***Narration***

Galileo Galilei studied and tested Aristotle's ideas about motion. Using observation and reason, he was able to prove that many of Aristotle's ideas were false. According to legend, Galileo dropped different weights off of the leaning tower of Pisa to disprove Aristotle's theory that heavier objects fall faster than lighter objects.

He is also credited with developing the telescope. He used this new tool as a way to observe the planets and stars. Galileo's telescope was used to give accurate descriptions of the moon and sun. The telescope would also help prove the heliocentric theory.

Some of the new ideas from the Scientific Revolution were not so readily accepted. Church leaders from both Protestant and Catholic churches believed that the heliocentric theory made Earth seem less important. Because Galileo was a Catholic living near the center of the Catholic Church in Rome, church leaders banned Copernicus' ideas and put Galileo on trial. They accused him of heresy. In 1633, Galileo was threatened with being burned at the stake and forced to recant, or take back, his ideas. He was placed under house arrest for the rest of his life.

# Isaac Newton


Laying the Basis for Modern Science

Isaac Newton

English scientist

Discovered

- Laws of Gravity
- Laws of Motion
- Calculus
- Physics



## **Narration**

Isaac Newton was an English scientist who laid out the laws of gravity and the three laws of motion, which described how the physical world worked.

According to legend, after observing an apple fall from a tree, Newton theorized that the same force which pulled the apple to the ground also controlled the movements of planets. Over the next twenty years, he perfected his theory using mathematics to show that a single force called gravity keeps the planets in their orbits around the sun, thereby proving that the heliocentric model of the universe was correct.

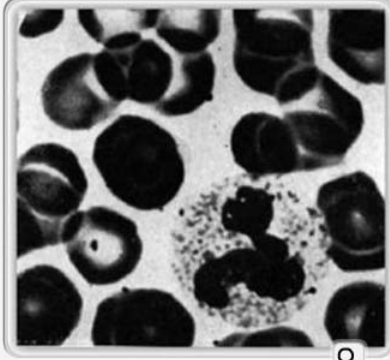
Newton's most famous publication was *Principia Mathematica*. In this book, he stated his three laws of motion and gained international recognition for himself. He also is known for developing a new type of telescope and for his ideas about light obtained through the use of optical lenses.

## Medical Advancements

Laying the Basis for Modern Science

### Medical Advancements

- 1628: William Harvey discovers how blood circulates in the body
- 1650's: Anton van Leeuwenhoek improves microscope and uses it to discover bacteria and red blood cells

A black and white microscopic image showing numerous red blood cells. The cells are roughly spherical and have a darker, denser center, characteristic of biconcave discs. They are scattered across the field of view, with some overlapping. A small magnifying glass icon is visible in the bottom right corner of the image frame.

### ***Narration***

The Scientific Revolution also brought a number of medical advancements which laid the foundations for many of the techniques and technologies in use today.

William Harvey was an English scientist who was the first to accurately describe how the blood circulation system worked, with the heart acting as the pump which pushes blood through the body's veins and arteries.

Another contributor to the field of medicine was Anton van Leeuwenhoek, a Dutch inventor who perfected the microscope and was first person to see cells and microorganisms that cannot be seen with the naked eye.




# Scientific Method

Laying the Basis for Modern Science

## Scientific Method

- Developed by Francis Bacon, English scientist
- Uses reason, logic, and observation to prove theories
- No basis in superstition or church beliefs

A black and white portrait of Francis Bacon, an English philosopher, statesman, and scientist. He is depicted from the chest up, wearing a dark, high-collared garment and a black hat. The portrait is framed within a white border, and a small magnifying glass icon is visible in the bottom right corner of the frame.

## ***Narration***

One of the major developments of the Scientific Revolution was the creation of a step-by-step process for scientists to use when testing their work.

In the 1600s, Francis Bacon developed the modern scientific method, a system that requires a scientist to create a hypothesis, test the hypothesis, and analyze the data that they collect in order to form conclusions. The scientific method also required scientists to test and challenge their findings to gain an accurate understanding of the world. New inventions like the microscope and telescope helped scientists follow the scientific method.




## Scientific Method - Impact

Laying the Basis for Modern Science

### Scientific Method - Impact

- New ideas about the world and government
- The Enlightenment
- Political Revolutions
- The Industrial Revolution



Fermi National Particle Accelerator Laboratory

### ***Narration***

The Scientific Revolution that took place in the 1500s and 1600s resulted in rapid advancements in science and technology that continue to this day. From that point on, scientists applied the scientific method in their pursuit of knowledge. This rational approach to the world opened the door for many of the ideas of the Enlightenment, including the application of scientific thinking to how governments should work.

The resulting new ideas led to revolutions in the Americas and Europe. In addition, Scientific Revolution thinkers inspired others to use reason and experimentation to develop new technologies. These new technologies resulted in the Industrial Revolution during the 1800s into the early part of the 1900s and the rapid pace at which technology advances today.