

# The Scientific Revolution

CHAPTER 22 Section 1

## THE ROOTS OF

### MODERN SCIENCE *How did modern science begin?*

During the Middle Ages, few scholars questioned beliefs that had been long held. Europeans based their ideas on what ancient Greeks and Romans believed or on the Bible. People still thought that the earth was the center of the universe. They believed that the sun, moon, other planets, and stars moved around it. In the mid-1500s, attitudes began to change. Scholars started what is called the Scientific Revolution. It was a new way of thinking about the natural world. It was based on careful observation and the willingness to question old beliefs. European voyages of exploration helped to bring about the Scientific Revolution. When Europeans explored new lands, they saw plants and animals that ancient writers had never seen. These discoveries led to new courses of study in the universities of Europe. **1. WHAT WAS THE SCIENTIFIC REVOLUTION?**



### A REVOLUTIONARY MODEL OF THE UNIVERSE

*How did new ideas change accepted thinking in astronomy?*

The first challenge to accepted thinking in science came in astronomy. In the early 1500s, Nicolaus Copernicus, a Polish astronomer, studied the stars and planets. He developed a heliocentric theory. Heliocentric meant sun-centered. It said that earth, like all the other planets, revolved around the sun. Copernicus did not publish his findings until just before his death. He had been afraid that his ideas would be attacked. They went against the long accepted geocentric theory. This theory held that the earth was at the center of the universe. In the early 1600s, Johannes Kepler used mathematics to prove that Copernicus's basic idea was correct.

An Italian scientist—Galileo Galilei—made several discoveries that also undercut ancient ideas. He made one of the first telescopes and used it to study the planets. He found that Jupiter had moons, the sun had spots, and Earth's moon was rough. Some of his ideas about the earth, the sun, and the planets went against the teaching of the Catholic Church. Church authorities forced Galileo to take back his statements. Still, his ideas spread.

### **2. WHAT OLD BELIEF ABOUT THE UNIVERSE DID THE NEW DISCOVERIES DESTROY?**



### THE SCIENTIFIC METHOD *Why was the scientific method an important development?*

Interest in science led to a new approach, the scientific method. With this method, scientists ask a question based on something they have seen in the physical world. They form a hypothesis, or an attempt to answer the question. Then they test the hypothesis by making experiments or checking other facts. Finally, they change the hypothesis if needed. The English writer Francis Bacon helped create this new approach to knowledge. He said scientists should base their thinking on what they can observe and test. The French mathematician René Descartes also influenced the use of the scientific method. His thinking was based on logic and mathematics.

### **3. WHAT THINKERS HELPED ADVANCE THE USE OF THE SCIENTIFIC METHOD?**



### NEWTON EXPLAINS THE LAW OF GRAVITY; THE SCIENTIFIC REVOLUTION SPREADS

*What scientific discoveries were made?*

In the mid-1600s, the English scientist Isaac Newton described the law of gravity. Using mathematics, Newton showed that the same force ruled both the motion of planets and the action of bodies on the earth.

Other scientists made new tools to study the world around them. One invented a microscope. Others invented tools for understanding weather. Doctors also made advances. One made drawings that showed the different parts of the human body. Another learned how the heart pumped blood through the body. In the late 1700s, Edward Jenner first used the process called vaccination to prevent disease. By giving a person the germs from a cattle disease called cowpox, he helped that person avoid getting the more serious human disease of smallpox.

Scientists made progress in chemistry as well. One questioned the old idea that things were made of only four elements—earth, air, fire, and water. He and other scientists were able to separate oxygen from air.

### **4. HOW DID THE SCIENCE OF MEDICINE CHANGE?**



#### TERMS AND NAMES

**Scientific Revolution** New way of thinking about the natural world based on careful observation and a willingness to question

**heliocentric theory** Theory that the sun is at the center of the universe

**geocentric theory** View which held that the earth was the center of the universe

**Galileo Galilei** Scientist who was forced by the Catholic Church to take back scientific ideas that disagreed with the church's view

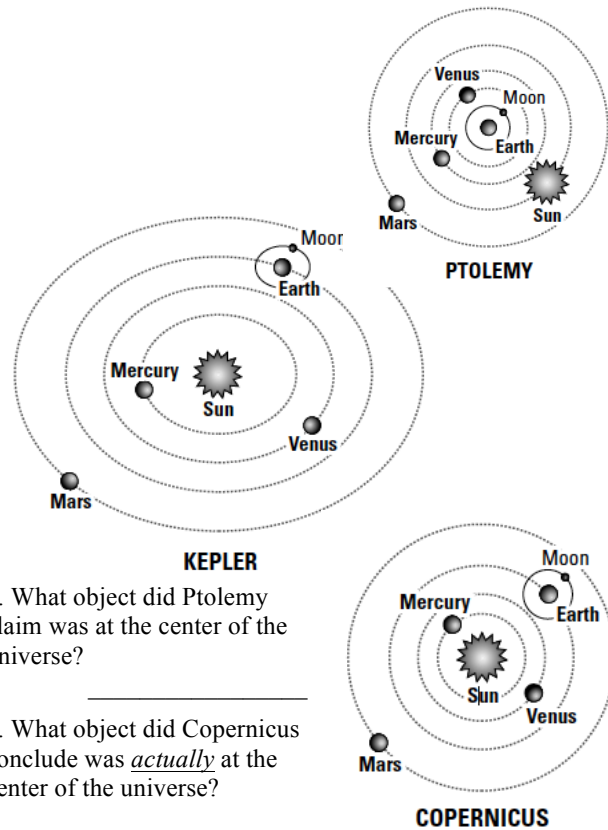
**scientific method** Logical procedure for gathering and testing ideas

**Isaac Newton** Scientist who discovered laws of motion and gravity

# Three Theories of the Solar System

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In the second century A.D., Claudius Ptolemy, an astronomer who lived in Egypt, claimed that the sun, stars, and other planets revolved around the earth. These ideas were unchallenged nearly 1,300 years until Nicolaus Copernicus, a Polish astronomer, discovered his revolutionary theory about the sun. Ptolemy had believed in his geocentric or earth-centered view for several reasons. First, because of gravity all objects were attracted to the earth, which suggested to him that the earth must be the center. Second, he thought that the earth did not move. He showed how an object is thrown in the air and falls in practically the same place. If the earth moved, he theorized, that object should fall in a different place. Even today, these arguments would be difficult to disprove by observation. As a result, Ptolemy's views remained undisputed for centuries. During the 1500s, Copernicus did not accept the Ptolemaic view. He became convinced that a different explanation of the solar system existed. After 25 years of observation, Copernicus concluded that the sun was the center of the solar system and that the planets, including the earth, revolved around the sun in "perfect divine circles." Copernicus's conclusion at first went practically unnoticed. However, in the 1600s a German astronomer, Johannes Kepler, supported Copernicus's belief with mathematics. He also proved that the planets travel in ellipses (ovals), not perfect circles, around the sun. Both Copernicus's and Kepler's breakthroughs laid the foundation of modern day knowledge of the solar system.



1. What object did Ptolemy claim was at the center of the universe?  
\_\_\_\_\_

2. What object did Copernicus conclude was *actually* at the center of the universe?  
\_\_\_\_\_

3. What object is *farthest* from the center in all three systems?  
\_\_\_\_\_

4. What object is closest to the earth in all three systems?  
\_\_\_\_\_

5. According to Ptolemy, where was the sun in relation to Earth and the other planets?

6. According to Copernicus, what planets are located between the sun and the Earth?

7. What is the main difference between Kepler's system and the Copernican system?

8. Compare the way Ptolemy provided proof for his theory with the way Kepler provided proof for his theory.

Do you think Ptolemy's proof of his beliefs would be acceptable today? Why or why not?

# The Enlightenment in Europe

## TWO VIEWS ON GOVERNMENT

### What were the views of Hobbes and Locke?

The **Enlightenment** was an *intellectual* movement. Enlightenment thinkers tried to apply reason and the scientific method to laws that shaped human actions. They hoped to build a society founded on ideas of the Scientific Revolution. Two English writers—Thomas Hobbes and John Locke—were important to this movement. They came to very different conclusions about government and human nature. Hobbes wrote that there would be a war of “every man against every man” if there were no government. To avoid this war, Hobbes said, people formed a **social contract**. It was an agreement between people and their government. People gave up their rights to the government so they could live in a safe and orderly way. The best government, he said, is that of a strong king who can force all people to obey. **John Locke** believed that people have three natural rights. They are life, liberty, and property. The purpose of government is to protect these rights. When it fails to do so, he said, people have a right to overthrow the government.

### 1. How were Hobbes’s and Locke’s views different?

#### TERMS AND NAMES

- Enlightenment** Age of Reason
- social contract** According to Thomas Hobbes, an agreement people make with government
- John Locke** Philosopher who wrote about government
- philosophes** Social critics in France
- Voltaire** Writer who fought for tolerance, reason, freedom of religious belief, and freedom of speech
- Montesquieu** French writer concerned with government and political liberty
- Rousseau** Enlightenment thinker who championed freedom
- Mary Wollstonecraft** Author who wrote about women’s rights

## THE PHILOSOPHES ADVOCATE REASON

### Who were the philosophes?

French thinkers called **philosophes** had five main beliefs: (1) thinkers can find the truth by using reason; (2) what is natural is good and reasonable, and human actions are shaped by natural laws; (3) acting according to nature can bring happiness; (4) by taking a scientific view, people and society can make progress and advance to a better life; and (5) by using reason, people can gain freedom.

The most brilliant of the philosophes was the writer **Voltaire**. He fought for tolerance, reason, freedom of religious belief, and freedom of speech. Baron de **Montesquieu** wrote about separation of powers—dividing power among the separate branches of government. The third great philosophe was Jean Jacques **Rousseau**. He wrote in favor of human freedom. He wanted a society in which all people were equal. Cesare Beccaria was an Italian philosophe. He spoke out against *abuses* of justice.

### 2. Name the types of freedoms that Enlightenment thinkers championed.

## WOMEN AND THE ENLIGHTENMENT; LEGACY OF THE ENLIGHTENMENT

### What were Enlightenment views about individuals?

Many Enlightenment thinkers held traditional views about women’s place in society. They wanted equal rights for all men but paid no attention to the fact that women did not have such rights. Some women protested this unfair situation. “If all men are born free,” stated British writer **Mary Wollstonecraft**, “how is it that all women are born slaves?” Enlightenment ideas strongly influenced the American and French Revolutions. Enlightenment thinkers also helped spread the idea of progress. By using reason, they said, it is possible to make society better. Enlightenment thinkers helped make the world less religious and more worldly. They also stressed the importance of the individual.

Major Ideas of the Enlightenment			Skillbuilder Use the chart to answer these questions.
Idea	Thinker	Impact	
Natural rights—life, liberty, property	Locke	Fundamental to U.S. Declaration of Independence	<b>1. Which Enlightenment thinkers influenced the United States government?</b>  _____  _____
Separation of powers	Montesquieu	France, United States, Latin American nations use separation of powers in new constitutions	
Freedom of thought and expression	Voltaire	Guaranteed in U.S. Bill of Rights and French Declaration of the Rights of Man and Citizen; European monarchs reduce or eliminate censorship	
Abolishment of torture	Beccaria	Guaranteed in U.S. Bill of Rights; torture outlawed or reduced in nations of Europe and the Americas	
Religious freedom	Voltaire	Guaranteed in U.S. Bill of Rights and French Declaration of the Rights of Man and Citizen; European monarchs reduce persecution	
Women’s equality	Wollstonecraft	Women’s rights groups form in Europe and North America	<b>2. Which Enlightenment ideas are in the United States Bill of Rights?</b>  _____  _____

### 3. Explain the influence of Enlightenment ideas.

# The Enlightenment Spreads

## A WORLD OF IDEAS

### *How did ideas spread from individual to individual?*

In the 1700s, Paris was the cultural center of Europe. People came there from other countries to hear the new ideas of the Enlightenment. Writers and artists held social gatherings called **salons**. A woman named Marie-Thérèse Geoffrin became famous for hosting these discussions.

Geoffrin also supplied the money for one of the major projects of the Enlightenment. With her funds, Denis Diderot and other thinkers wrote and published a huge set of books called the *Encyclopedia*. Their aim was to gather all that was known about the world. The French government and officials in the Catholic Church did not like many of the ideas that were published in the *Encyclopedia*. They banned the books at first. Later, however, they changed their minds.

The ideas of the Enlightenment were spread throughout Europe by works like the *Encyclopedia* and through meetings in homes. The ideas also spread to the growing middle class. This group was becoming wealthy but had less social status than nobles. They also had very little political power. Ideas about equality sounded good to them. **1. Why were salons important?**

## NEW ARTISTIC STYLES *How did art and literature change?*

The arts—painting, architecture, music, and literature—moved in new directions in the late 1700s. They used Enlightenment ideas of order and reason.

Earlier European painting had been very grand and highly decorated. It was a style known as **baroque**. Now styles began to change. A new simpler, yet elegant, style of painting and architecture developed. This style borrowed ideas and themes from Classical Greece and Rome. That is the reason it was called **neoclassical**.

In music, the style of the period is called classical. Three important composers of the time were Franz Joseph Haydn, Wolfgang Amadeus Mozart, and Ludwig von Beethoven. They composed music that was elegant and original. New musical forms were developed, including the sonata and the symphony.

In literature, the novel became popular. This new form presented long stories with twisting plots. It explored the thoughts and feelings of characters. A number of European authors, including women, began writing novels. These books were popular with the middle-class. They liked entertaining stories in everyday language. **2. What new styles and forms appeared in art, music, and literature?**

## CHAPTER 22 Section 3

### TERMS AND NAMES

**salon** Social gathering for discussing ideas or enjoying art

**baroque** Grand, ornate style

**neoclassical** Simple style that borrowed ideas from classical Greece and Rome

**enlightened despot** Ruler who supported Enlightenment ideas but did not give up power

**Catherine the Great** Russian ruler who took steps to reform and modernize Russia

## ENLIGHTENMENT AND MONARCHY *Who were the enlightened despots?*

Some Enlightenment thinkers believed that the best form of government was a monarchy. In it, a ruler respected people's rights. These thinkers tried to influence rulers to rule fairly. Rulers who followed Enlightenment ideas in part but were unwilling to give up much power were called **enlightened despots**.

Frederick the Great of Prussia was an enlightened despot. He gave his people religious freedom and improved schooling. He also *reformed* the justice system. However, he did nothing to end *serfdom*, which made peasants slaves to the wealthy landowners. Joseph II of Austria did end serfdom. Once he died, though, the nobles who owned the lands were able to undo this reform.

**Catherine the Great** of Russia was another of the rulers influenced by Enlightenment ideas. She tried to reform Russia's laws but met resistance. She had hoped to end serfdom. But a bloody peasants' revolt persuaded her to change her mind. Instead, she gave the nobles even more power over serfs. Catherine did manage to gain new land for Russia. Russia, Prussia, and Austria agreed to divide Poland among themselves. As a result, Poland disappeared as a separate nation for almost 150 years.

**3. In what way was Frederick the Great typical of an enlightened despot?**