Distance Learning for
World History (11th Grade)
Week #1 April 6 - 10

Essential Question:
Who were the key figures and concepts in the Scientific Revolution and what did they contribute that changed the world?

Instructions:
1. (Packet users) Using the reading packet given to you (Chapter 17: Revolution and Enlightenment) answer the following questions on your own paper. Hold your written answers until time to return all your work.
(Google Classroom users) Read the information on each slide. On the last slide, number and answer each question listed below. When you are finished you can submit your work on Google Classroom.
2. Please put your completed work in a safe place where you can easily find it when the time comes to collect the work.
3. Each question should be answered in 2 or 3 sentences.

Questions:
Read pages 511 to 517 and answer the following questions:
1. How did Copernicus and Galileo prove their theories that the Sun was the center of the Universe? (2 to 3 sentences)
2. Explain how Newton’s “universal law of gravitation” further confirmed what Galileo and Copernicus had discovered. (2 to 3 sentences)
3. Explain the contribution of Vesalius to the world of medicine. (2 to 3 sentences)
4. What were some of the early contributions of women to the scientific revolution? (2 to 3 sentences)
5. In your own words, explain what Rationalism is. (2 to 3 sentences)
6. Explain what the scientific method is and who created the process. How do we use this process today? (2 to 3 sentences)
7. Summation Question: Who or what do you think fought against Galileo and other scientists in this time period?
CHAPTER 17

Revolution and Enlightenment
1550–1800

Key Events
As you read this chapter, look for the key events in the history of the Scientific Revolution and the Enlightenment.

• The ideas of the Scientific Revolution and the Enlightenment laid the foundation for a modern worldview based on rationalism and secularism.
• Enlightenment thought led some rulers to advocate such natural rights as equality before the law and freedom of religion.
• The American colonies formed a new nation and ratified the Constitution of the United States.

The Impact Today
The events that occurred during this time period still impact our lives today.

• Scientists use research techniques that are based on the scientific method.
• The intellectuals of the Enlightenment advocated the rights of the individual, paving the way for the rise of democracy.
• Montesquieu’s idea of separation of powers strongly influenced the writing of the Constitution of the United States.


1620
Francis Bacon publishes the Novum Organum

1633
The Church condemns Galileo’s teachings

1687
Isaac Newton publishes the Principia

1543
Nicholas Copernicus presents a new view of the universe

1550 1575 1600 1625 1650 1675

1666
Royal Academy of Science founded in France

Engraving of Copernican system, 1661
Galileo on Trial

The Italian scientist Galileo found himself in trouble with the authorities of the Catholic Church. Galileo believed in a new worldview. He explained to a friend, “I hold the Sun to be situated motionless in the center of the revolution of the celestial bodies, while . . . Earth rotates on its axis and revolves about the Sun.” Moreover, “nothing physical that sense-experience puts before our eyes . . . ought to be called in question (much less condemned) upon the testimony of passages from the Bible.”

The Catholic Church had a different view. In 1632, Galileo, 68 years old and in ill health, was called before the dreaded Inquisition in Rome. He was kept waiting for two months before he was tried and found guilty of heresy and disobedience. The report of the Inquisition said: “The view that the Sun stands motionless at the center of the universe is foolish, philosophically false, and utterly heretical, because contrary to Holy Scripture.”

Completely shattered by the experience, Galileo recanted in 1633: “With a sincere heart I curse and detest the said errors contrary to the Holy Church, and I swear that I will nevermore in future say or assert anything that may give rise to a similar suspicion of me.” Legend holds that when he left the trial room, Galileo muttered to himself, “And yet it [Earth] does move!”

Why It Matters

Galileo was one of the scientists of the seventeenth century who set the Western world on a new path. That path, known as the Scientific Revolution, developed a new way of viewing the universe.

In the eighteenth century, a group of intellectuals used the ideas of the Scientific Revolution to reexamine all aspects of life and began what came to be called the Age of Enlightenment. The ideas of the Enlightenment helped foster the American and French Revolutions.

History and You The philosopher Adam Smith used Enlightenment ideas to identify economic laws. Read the front page, business section, and classifieds of a newspaper. Create a poster with articles and advertisements reflecting Smith’s economic principles.
Main Idea
- The Scientific Revolution gave Europeans a new way to view humankind's place in the universe.

Key Terms
geocentric, Ptolemaic system, heliocentric, universal law of gravitation, rationalism, scientific method, inductive reasoning

People to Identify
Ptolemy, Nicholas Copernicus, Galileo Galilei, Isaac Newton, Robert Boyle, Margaret Cavendish, Maria Winkelmann, René Descartes, Francis Bacon

Places to Locate
Poland, Padua

Preview Questions
1. How did the Scientific Revolution begin?
2. What is the scientific method?

Reading Strategy
Summarizing Information Use a table like the one below to identify the contributions of Copernicus, Kepler, Galileo, and Newton to the development of a new concept of the universe.

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copernicus</td>
<td>1545</td>
</tr>
<tr>
<td>Kepler</td>
<td>1575</td>
</tr>
<tr>
<td>Galileo</td>
<td>1590</td>
</tr>
<tr>
<td>Newton</td>
<td>1605</td>
</tr>
</tbody>
</table>

Preview of Events
- 1543: Vesalius publishes *On the Fabric of the Human Body*
- 1545: Vesalius publishes *On the Fabric of the Human Body*
- 1560: Galileo's discoveries are published
- 1575: Harvey publishes *On the Motion of the Heart and Blood*
- 1590: Galileo is expelled from the university of Padua
- 1605: Galileo is arrested by the Inquisition
- 1620: Descartes publishes *Discourse on Method*
- 1635: Galileo is released from prison

Voices from the Past
In 1610, Galileo described what he had observed with his newly devised telescope:

> Now let us review the observations made during the past two months. . . . Let us speak first of that surface of the Moon which faces us. For greater clarity I distinguish two parts of this surface, a lighter and a darker. . . . The darker part makes the Moon appear covered with spots. . . . From observation of these spots . . . I have been led to the opinion and conviction that the surface of the Moon is not smooth, uniform, and precisely spherical as a great number of philosophers believe it and the other heavenly bodies to be, but is uneven, rough, and full of cavities, not unlike the face of . . . Earth, relieved by chains of mountains and deep valleys.

— *Discoveries and Opinions of Galileo*, Stillman Drake, ed., 1957

Galileo's observations helped to create a new view of the universe in the seventeenth century.

Background to the Revolution
In the Middle Ages, many educated Europeans took an intense interest in the world around them. However, these "natural philosophers," as medieval scientists were known, did not make observations of the natural world. These scientists relied on a few ancient authorities—especially Aristotle—for their scientific knowledge. A number of changes in the fifteenth and sixteenth centuries caused
the natural philosophers to abandon their old views and develop new ones.

Renaissance humanists had mastered Greek as well as Latin and thus had access to newly discovered works by Ptolemy (TAH-luh- mee), Archimedes, and Plato. These writings made it obvious that some ancient thinkers had disagreed with Aristotle and other accepted authorities of the Middle Ages.

Other developments also encouraged new ways of thinking. Technical problems that required careful observation and accurate measurements, such as calculating the amount of weight that ships could hold, served to stimulate scientific activity. Then, too, the invention of new instruments, such as the telescope and microscope, made fresh scientific discoveries possible. Above all, the printing press helped spread new ideas quickly and easily.

Mathematics played a very important role in the scientific achievements of the sixteenth and seventeenth centuries. The study of mathematics was promoted in the Renaissance by the rediscovery of the works of ancient mathematicians. Nicholas Copernicus, Johannes Kepler, Galileo Galilei, and Isaac Newton were all great mathematicians who believed that the secrets of nature were written in the language of mathematics. After studying and, sometimes, discarding the ideas of the ancient mathematicians, these intellectuals developed new theories that became the foundation of the Scientific Revolution.

**Reading Check** Evaluating: What changes in the fifteenth and sixteenth centuries helped the natural philosophers develop new views?

### A Revolution in Astronomy

Especially significant in the Scientific Revolution were discoveries in astronomy. These discoveries would overturn the conception of the universe held by Westerners in the Middle Ages.

**The Ptolemaic System** Ptolemy, who lived in the second century A.D., was the greatest astronomer of antiquity. Using his ideas, as well as those of Aristotle and of Christianity, the philosophers of the Middle

---

**Ptinging History**

These astronomers, Ptolemy (left) and Copernicus (shown on page 513), were separated in time by approximately 1,400 years. Both men had a major impact on the way people viewed their place in the universe. What elements do you see in the two illustrations that help to convey to the viewer the importance of the two men and their scientific discoveries?
Ages had constructed a model of the universe known later as the Ptolemaic (TAH-uh-MAY-ik) system. This system is called geocentric because it places Earth at the center of the universe.

In the Ptolemaic system, the universe is a series of concentric spheres—spheres one inside the other. Earth is fixed, or motionless, at the center of these spheres. The spheres are made of a crystal-like, transparent substance, in which the heavenly bodies—pure orbs of light—are embedded. For example, the Moon is embedded in the first sphere, Mercury in the second, Venus in the third, and the Sun in the fourth. The rotation of the spheres makes these heavenly bodies rotate around the earth and move in relation to one another.

The tenth sphere in the Ptolemaic system was the "prime mover," which moved itself and gave motion to the other spheres. Beyond the tenth sphere was Heaven, where God and all the saved souls resided. God was at one end of the universe, then, and humans were at the center. Humans had been given power over the earth, but their real purpose was to achieve salvation.

**Copernicus and Kepler** In May 1543, Nicholas Copernicus, a native of Poland, published his famous book, *On the Revolutions of the Heavenly Spheres*. Copernicus, a mathematician, felt that the geocentric system was too complicated. He believed that his heliocentric, or sun-centered, conception of the universe offered a more accurate explanation than did the Ptolemaic system.

Copernicus argued that the Sun, not Earth, was at the center of the universe. The planets revolved around the Sun. The Moon, however, revolved around Earth. Moreover, according to Copernicus, the apparent movement of the Sun around Earth was really caused by the daily rotation of Earth on its axis and the journey of Earth around the Sun each year.

The next step in destroying the Ptolemaic system was taken by the German mathematician Johannes Kepler. Kepler used detailed astronomical data to arrive at his laws of planetary motion. His observations confirmed that the Sun was at the center of the universe and also added new information. In his first law, Kepler showed that the orbits of the planets around the Sun were not circular, as Copernicus
The Church ordered Galileo to abandon the Copernican idea. The Copernican system threatened the Church’s entire conception of the universe and seemed to contradict the Bible. In the Copernican view, the heavens were no longer a spiritual world but a world of matter. Humans were no longer at the center of the universe, and God was no longer in a specific place.

In spite of the Church’s position, by the 1630s and 1640s, most astronomers had come to accept the heliocentric conception of the universe. However, the problem of explaining motion in the universe had not been solved, and the ideas of Copernicus, Kepler, and Galileo had yet to be tied together. This would be done by an Englishman who has long been considered the greatest genius of the Scientific Revolution.

**Newton** Born in 1642, **Isaac Newton** showed few signs of brilliance until he attended Cambridge University. Later, he became a professor of mathematics at the university and wrote his major work, *Mathematical Principles of Natural Philosophy*. This work is known simply as the *Principia*, by the first word of its Latin title.

In the first book of the *Principia*, Newton defined the three laws of motion that govern the planetary bodies, as well as objects on Earth. Crucial to his whole argument was the **universal law of gravitation**. This law explains why the planetary bodies do not go off in straight lines but instead continue in elliptical orbits about the Sun. The law states, in mathematical terms, that every object in the universe is attracted to every other object by a force called gravity.
Newton had shown that one universal law, mathematically proved, could explain all motion in the universe. At the same time, Newton's ideas created a new picture of the universe. It was now seen as one huge, regulated, uniform machine that worked according to natural laws. Newton's world-machine concept dominated the modern worldview until the twentieth century, when Albert Einstein's concept of relativity created a new picture of the universe.

**Reading Check**  Identifying  Name the four great mathematicians who had a profound impact on astronomy.

**Breakthroughs in Medicine and Chemistry**

A revolution in medicine also began in the sixteenth century. Medicine in the Late Middle Ages was dominated by the teachings of the Greek physician Galen, who had lived in the second century A.D. Galen had relied on animal, rather than human, dissection to arrive at a picture of human anatomy, and he was wrong in many instances.

The new anatomy of the sixteenth century was based on the work of Andreas Vesalius. In his 1543 book, *On the Fabric of the Human Body*, Vesalius discussed what he had found when dissecting human bodies while he was a professor of surgery at the University of Padua.

Vesalius presented a careful and accurate examination of the individual organs and general structure of the human body. His "hands-on" approach enabled him to overthrow some of Galen's theories. Nevertheless, Vesalius still clung to Galen's erroneous idea that two kinds of blood flowed in the veins and arteries.

William Harvey's reputation rests on his book *On the Motion of the Heart and Blood*, published in 1628. Harvey's work was based on close observations and experiments. Harvey showed that the heart—not the liver, as Galen had thought—was the beginning point for the circulation of blood in the body. He also proved that the same blood flows in both veins and arteries. Most important, he showed that the blood makes a complete circuit as it passes through the body.

A science of chemistry also arose in the seventeenth and eighteenth centuries. Robert Boyle was one of the first scientists to conduct controlled experiments. His pioneering work on the properties of gases led to Boyle's Law. This generalization states that the volume of a gas varies with the pressure exerted on it. In the eighteenth century, Antoine Lavoisier invented a system of naming the chemical elements, much of which is still used today. He is regarded by many as the founder of modern chemistry.

**Reading Check**  Describing  How did Vesalius and Harvey disprove many of Galen's theories?

**Women and the Origins of Modern Science**

Women as well as men were involved in the Scientific Revolution. One of the most prominent female scientists of the seventeenth century, Margaret Cavendish, came from an aristocratic family. She wrote a number of works on scientific matters, including *Observations Upon Experimental Philosophy*.

In her work, Cavendish was especially critical of the growing belief that humans, through science, were the masters of nature: "We have no power at all over natural causes and effects . . . for man is but a small part, his powers are but particular actions of Nature, and he cannot have a supreme and absolute power."

In Germany, many of the women who were involved in science were astronomers. These women had received the opportunity to become astronomers from working in family observatories, where they had been trained by their...
fathers or husbands. Between 1650 and 1710, women made up 14 percent of all German astronomers.

The most famous of the female astronomers in Germany was Maria Winkelmann. She received training in astronomy from a self-taught astronomer. Her chance to be a practicing astronomer came when she married Gottfried Kirch, Prussia’s foremost astronomer, and became his assistant.

Winkelmann made some original contributions to astronomy, including the discovery of a comet. Her husband described the discovery:

*Early in the morning (about 2:00 A.M.) the sky was clear and starry. Some nights before, I had observed a variable star, and my wife (as I slept) wanted to find and see it for herself. In so doing, she found a comet in the sky. At which time she woke me, and I found that it was indeed a comet. . . . I was surprised that I had not seen it the night before.*

When her husband died, Winkelmann applied for a position as assistant astronomer at the Berlin Academy. She was highly qualified, but as a woman—

with no university degree—she was denied the post. Members of the Berlin Academy feared that they would set a bad example by hiring a woman. “Mouths would gape,” they said.

Winkelmann’s problems with the Berlin Academy reflect the obstacles women faced in being accepted as scientists. Such work was considered to be chiefly for males. In the view of most people in the seventeenth century, a life devoted to any kind of scholarship was at odds with the domestic duties women were expected to perform.

**Reading Check** **Summarizing** What did Margaret Cavendish and Maria Winkelmann contribute to the Scientific Revolution?

**Descartes and Reason**

The new conception of the universe brought about by the Scientific Revolution strongly influenced the Western view of humankind. Nowhere is this more evident than in the work of the seventeenth-century French philosopher René Descartes (day•KAHRT). Descartes began by thinking and writing about the doubt and uncertainty that seemed to be everywhere in the confusion of the seventeenth century. He ended with a philosophy that dominated Western thought until the twentieth century.

The starting point for Descartes’s new system was doubt. In his most famous work, Discourse on Method, written in 1637, Descartes decided to set aside all that he had learned and to begin again. One fact seemed to him to be beyond doubt—his own existence:

*But I immediately became aware that while I was thus disposed to think that all was false, it was absolutely necessary that I who thus thought should be something; and noting that this truth I think, therefore I am, was so steadfast and so assured . . . I concluded that I might without scruple accept it as being the first principle of the philosophy I was seeking.*

Descartes emphasized the importance of his own mind and asserted that he would accept only those things that his reason said were true.

From his first principle—“I think, therefore I am”—Descartes used his reason to arrive at a second principle. He argued that because “the mind cannot be doubted but the body and material world can, the two must be radically different.”

From this idea came the principle of the separation of mind and matter (and of mind and body).
Descartes's idea that mind and matter were completely separate allowed scientists to view matter as dead or inert—as something that was totally detached from themselves and that could be investigated independently by reason.

Descartes has rightly been called the father of modern rationalism. This system of thought is based on the belief that reason is the chief source of knowledge.

**Reading Check** Explaining What is the significance of Descartes's principle of the separation of mind and matter?

### The Scientific Method

During the Scientific Revolution, people became concerned about how they could best understand the physical world. The result was the creation of a scientific method—a systematic procedure for collecting and analyzing evidence. The scientific method was crucial to the evolution of science in the modern world.

The person who developed the scientific method was actually not a scientist. Francis Bacon, an English philosopher with few scientific credentials, believed that instead of relying on the ideas of ancient authorities, scientists should use inductive reasoning to learn about nature. In other words, scientists should proceed from the particular to the general. Systematic observations and carefully organized experiments to test hypotheses (theories) would lead to correct general principles.

Bacon was clear about what he believed his scientific method could accomplish. He stated that "the true and lawful goal of the sciences is none other than this: that human life be endowed with new discoveries and power." He was much more concerned with practical matters than pure science.

Bacon wanted science to benefit industry, agriculture, and trade. He said, "I am laboring to lay the foundation, not of any sect or doctrine, but of human utility and power."

How would this "human power" be used? Bacon believed it could be used to "conquer nature in action." The control and domination of nature became an important concern of science and the technology that accompanied it.

**Reading Check** Summarizing What are the characteristics of the scientific method?
Type your answers in the textbox below

Click here to type