Name _____ Date _____

CHAPTER 22

Section 1

GEOGRAPHY APPLICATION: LOCATION

Three Theories of the Solar System

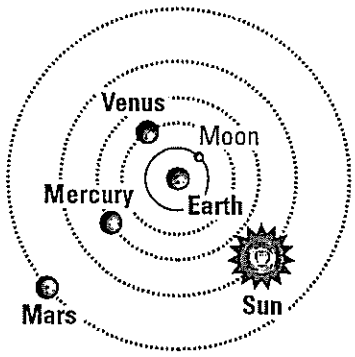
Directions: Read the paragraphs below and study the illustrations carefully. Then answer the questions that follow.

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.



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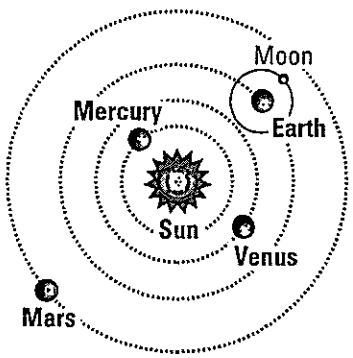
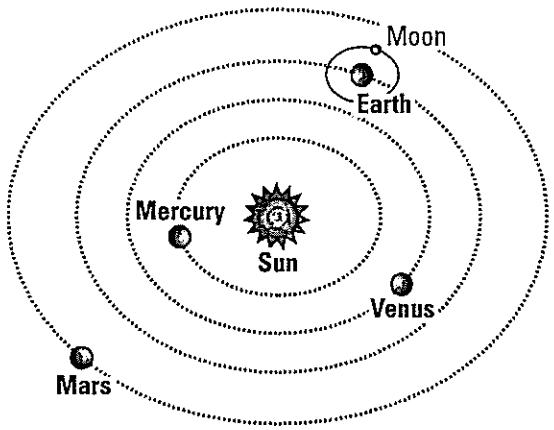


COPERNICUS



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Name _____ Date _____

CHAPTER 22
Section 1

HISTORYMAKERS

Nicolaus Copernicus

Earth-Shaking Scientist

"We revolve about the sun like any other planet." —Copernicus,* A Commentary on the Theories of the Motions of Heavenly Objects *(1514)

Watching the sun travel through the sky each day and seeing the stars and planets glide across the sky each night, Europeans concluded that these heavenly bodies revolved around the earth. As a result, they made the logical conclusion that the earth was the center of the universe and did not move. This view also became part of the teaching of the Catholic Church. Nicolaus Copernicus changed all this.

Born in 1473, Copernicus became a learned man. He was trained in Church law, medicine, and mathematics. His main interest, though, was astronomy. After more than 25 years of observations, he reached a startling conclusion: the earth itself moved and revolved around the sun.

In 1514, Copernicus wrote a pamphlet outlining his ideas and passed it around to friends, but he delayed making it widespread. In the 1530s, his views were presented to Pope Clement VII, who had no objection to this new theory. Finally, a former student of Copernicus's persuaded him to publish his ideas. As a result, *On the Revolutions of Heavenly Bodies* became available in 1543, the year its author died.

Copernicus argued that the earth moved in three ways. It spun on its axis every day, it rotated around the sun over the course of a year, and it moved up and down on its axis to cause the change of seasons. His new system put the planets in their proper order: sun, Mercury, Venus, Earth and moon, Mars, Jupiter, and Saturn.

Copernicus's bold idea solved several problems. The order of Mercury and Venus had always been disputed, and his new system settled that. His idea also gave a simpler explanation of the motion of the planets. Because the planets sometimes seem to stop and move backward, the old theory had required a complex structure of circles within circles. Copernicus reasoned that these movements occurred because the earth also orbits the sun. Furthermore, the earth and the other planets orbit at different speeds. His view was not perfect, though. He believed the planets moved in circles around the sun, but it was later proven that they move in ellipses, or ovals.

Copernicus's theory raised two questions. If the earth moves, why do the stars not appear in different positions? The stars, he said, were so far away that their changes in position could not be noticed. In other words, he suggested that the universe was vast. Copernicus was right, although his argument could not be proven for three centuries. Only then did scientists have telescopes powerful enough to detect that the stars did indeed move.

The second question asked why objects in the air tend to fall to the ground. When the universe was seen as moving around the earth, it was logical to think that objects would fall to the center of the universe. Now that the earth moved, it was no longer the center. However, Copernicus believed that an object tended to fall to the center of its home. Thus, articles on Earth would be pulled to Earth, and those on the moon would be pulled to the moon. He suggested the basics of gravity about 100 years before Isaac Newton.

Copernicus's views did not cause much of a stir at first. Although his idea challenged Catholic teaching about the universe, the Church did not object to the new theory. However, Martin Luther and John Calvin, leaders of the Reformation, both objected strongly. Calvin asked, "Who will venture to place the authority of Copernicus above that of the Holy Spirit?" Over time, though, Catholics objected as well. By 1616, the Church officially called his idea false. The work of later astronomers, however, showed that Copernicus drew an accurate picture of the solar system.

Questions

1. ***Determining Main Ideas*** According to Copernicus, what were the ways in which the earth moved?
2. ***Making Inferences*** Since Copernicus's theory was not perfect and could not explain all observations of the heavens, why did some people accept it?
3. ***Clarifying*** How did Copernicus use the idea of bodies tending toward different centers to support his theory?

Name _____ Date _____

CHAPTER 22
Section 1

SKILLBUILDER PRACTICE *Clarifying*

You can clarify information you read by looking up the meaning of unfamiliar terms and summarizing the main ideas in your own words. As you read the passage below, make notes of the main ideas. Look up any unfamiliar or technical terms you do not understand. Then complete the activities that follow. (See Skillbuilder Handbook)

Galileo Galilei was an Italian mathematician, astronomer, and physicist. As a physicist, he began a whole new field of scientific investigation—the modern science of dynamics.

As a youth of 18, Galileo watched the movements of a cathedral's chandelier as it swung back and forth on its chain. Aristotle had written that a pendulum swings more slowly as it approaches its resting point. Galileo tested this idea and found it incorrect. Feeling his pulse to keep time, he found that each oscillation of the pendulum took exactly the same amount of time.

Galileo's observation led to a new method of measuring time. In the 1200s and 1300s European inventors had built clocks that were driven by weights. In the 1400s, they turned to spring-driven clocks. But none of these timepieces were very accurate. In 1656, a Dutch astronomer built a clock using a pendulum. It proved to be more accurate than earlier ways of measuring time. In fact, pendulum clocks were not surpassed in accuracy until the introduction of electricity.

In addition to discovering the law of the pendulum, Galileo performed other experiments in physics. For days he rolled balls down a slope and measured the speed at which they moved. His data led him to conclude that freely falling bodies, heavy or light, had the same, constant acceleration. He also discovered that an object moving on a perfectly smooth horizontal surface would neither speed up or slow down.

1. Define each of the following terms:

Physicist: _____

Dynamics: _____

Oscillation: _____

2. Identify the main idea of the passage. _____

_____

_____

_____

3. Write a paragraph summarizing the main idea and key details in this passage. Remember to restate information in your own words.

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CHAPTER 22

Summary

CHAPTERS IN BRIEF

Enlightenment and Revolution, 1550–1789

CHAPTER OVERVIEW Starting in the 1500s, European thinkers overturned old ideas about the physical world with a new approach to science. Thinkers of the Enlightenment hoped to use reason to make a better society in which people were free. Enlightenment ideas spread throughout Europe. They had a profound effect in North America, forming the basis of the new government of the United States.

❶ The Scientific Revolution

***KEY IDEA** In the mid-1500s, scientists began to question accepted beliefs and make new theories based on experimentation.*

During the Middle Ages, few scholars questioned ideas that had always been accepted. Europeans based ideas about the physical world on what ancient Greeks and Romans believed or what was said in the Bible. Therefore, people still thought that the earth was the center of the universe. To them, the sun, moon, other planets, and stars moved around it.

In the mid-1500s, however, attitudes changed. Scholars now started a scientific revolution drawn from a spirit of curiosity. One factor was the new focus on careful observation. Another was the willingness to question old beliefs. European explorations were a third factor. When they reached new lands, Europeans saw new plants and animals never seen by ancient writers. These discoveries led to the opening of new courses of study in universities.

The first challenge came in astronomy. In the early 1500s, Nicolaus Copernicus studied the stars and planets for many years. He concluded that the earth, like the other planets, revolved around the sun, and the moon revolved around the earth. Fearing attack, he did not publish his findings until just before his death. In the early 1600s, Johannes Kepler used mathematics to confirm Copernicus's basic idea.

An Italian scientist—Galileo Galilei—made several discoveries that 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. These statements went against church teaching, and Galileo was forced to deny their truth. Still, his ideas spread.

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 foster this new approach to knowledge by telling scientists they should base their ideas on what they can see and test in the world. The French mathematician René Descartes also had great influence. His thinking was based on logic and mathematics.

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

Scientists made new tools to study the world around them. One invented a microscope to study creatures too small for the naked eye to see. 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 advances in chemistry as well. One challenged 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.

❷ The Enlightenment in Europe

***KEY IDEA** A revolution in intellectual activity changed Europeans' view of government and society.*

New ways of thinking arose in other areas. In the intellectual movement called the