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Abstract:	Chapter 8 of the book "Everyday Life: Renaissance" is presented. It discusses scientific discoveries during the Renaissance period. Among scientists the Renaissance produced were Roger Bacon, Nicolaus Copernicus and Galileo Galilei. Galileo is remembered most for the telescope and for confirming Copernicus' heliocentric theory that the sun, and not Earth, was the center of the universe.
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CHAPTER 8: Scientific Discoveries

While the people of the Renaissance were improving their manners and behavior, they took few steps to improve their knowledge of the universe and their physical world. Except for Leonardo da Vinci and others who learned much of anatomy by dissecting cadavers, little scientific progress was made until the latter part of the Renaissance period.

Early Renaissance scientists continued to look to the ancient Greeks and Romans for guidance, accepting the errors those who lived long ago had made in their studies of both the world and the people who occupied it. Take their concept of the solar system, for example. Everyone accepted the geocentric theory put forth by the Greek scientist Ptolemy about A.D. 150. Ptolemy maintained that Earth was the center of the universe and that the sun and everything else revolved around it. After all, he erroneously pointed out, Earth did not move. And because it stood still, it must be the center of all creation.

People of the Middle Ages and the early years of the Renaissance cannot be faulted for believing Ptolemy. This was a time of religious fervor and, because God had placed people on Earth, then Earth had to be the center of the universe. So reasoned learned men of the times, even though a Greek scientist named Aristarchus had concluded some 300 years before Ptolemy that the sun was the center of the universe and all other bodies revolved around it. But Aristarchus's ideas were rejected, and humankind continued to be mired in ignorance for another 1,700 years.

The gap between medieval and Renaissance science was bridged by an English monk named Roger Bacon. Bacon, who lived in the 1200s, believed that knowledge could only be arrived at through observation and experimentation. His ideas, like those of Aristarchus centuries earlier, were also rejected. Bacon, in fact, spent more than 14 years of his life in prison for being so brazen as to challenge time-honored beliefs. Almost 200 years passed before his ideas were adopted and put into effect.

One of the first to emulate Bacon in his quest for scientific knowledge was a Polish astronomer named Nicolaus Copernicus. Copernicus was born in 1473 and was educated

as a doctor and lawyer. He also was an ordained official of the Catholic Church. But his great love was astronomy, and he spent more than 30 years studying the heavens and formulating his theories.

Even as late as the 1500s, any scientific inquiry that contradicted the teachings of the Catholic Church resulted in punishment for the guilty party. Copernicus knew this and kept his thoughts to himself. To go against the established teachings of the Church made one a heretic and subject to scrutiny by the Inquisition, a special Church court that searched out and brought to trial any person who openly questioned Church doctrine. Torture (to extract confessions) and burnings at the stake were common punishments of this much-feared court.

In 1543, when he was almost 70 and had kept his ideas to himself for many years, Copernicus published On the Revolutions of the Heavenly Spheres. A copy was said to have been placed in his hands just before he died. In the book, Copernicus advanced the heliocentric theory that the sun--and not Earth--was the center of the universe. But because he did not have the wherewithal to test and prove his theory, his ideas were scoffed at and rejected. Both the educated and the uneducated laughed at the notion that Earth rotated on its axis. How silly, they thought! If Earth spun as Copernicus claimed, what kept people from simply flying off into space, never to be seen or heard from again?

Another century passed before Copernicus's theory could be proven. In the interval, the geocentric theory continued to be sanctioned by both the Church and leading scientists of the day. And woe to anyone who thought otherwise! There were always the rack, the thumbscrew, and the stake to convince any heretic of the error of his ways.

It was left to an Italian scientist named Galileo Galilei to prove that Copernicus was right. Galileo (1564-1642) had planned to become a doctor, but his interest in astronomy and mathematics got in the way. Through careful observation and study, he discovered both the principle of the pendulum and the law of falling bodies. You have probably studied in your science class how Galileo proved that if he dropped cannonballs of different weights from the top of the Leaning Tower of Pisa, they would touch the ground at about the same time.

Galileo, however, is remembered most for the telescope and for confirming the theories of Copernicus. Galileo didn't really invent the telescope; he made an improved model of one discovered by accident earlier by a Dutch optician named Johannes Lippershey. Lippershey was sometimes more interested in playing around with lenses than in making spectacles for his clients. In so doing, he found that he could arrange two lenses in such a way that he could make distant objects appear closer. Lippershey, however, viewed his spyglass as a toy with little practical use. It never occurred to him to aim his invention at the heavens.

When Galileo heard of Lippershey's device, he went to work to fashion an improved model. He ground lenses until they were better and stronger. In a short time he had a telescope that magnified eight diameters, making it possible for him to see ships at sea several hours before they were visible to the naked eye. Eventually, he came up with a telescope that would magnify 32 times. With this, he was ready to take a closer look at the night sky.

What Galileo saw when he first peered through his telescope was startling. The moon was not the smooth, flat body everyone supposed it to be. Instead, it was marked by valleys and craters. Galileo also marveled at the Milky Way and the rings of Saturn. His most remarkable discovery, however, concerned Jupiter. Through his telescope, Galileo could

clearly see that the four moons of Jupiter revolved around that planet itself and not Earth. This was proof that all heavenly bodies did not circle Earth as was believed for centuries. Therefore, Galileo concluded that Earth could not be at the center of the universe.

Urban VIII, who became pope after Galileo proved Copernicus's heliocentric theory, authorized the astronomer to publish his findings. But there was a catch. He was ordered to present both his and Ptolemy's geocentric views as theories only. This, you will remember, was the official position held by the Church for centuries.

Galileo complied, and in 1632 he published his Dialogue on the Two Chief World Systems. But there was such an uproar over its contents that the bewildered author was arrested and brought before the dreaded Inquisition. Under threat of torture, he was forced to withdraw his theories and was placed under house arrest until his death in 1642.

In spite of continued opposition, Galileo's theories in time took root. They were supported by the work of a German mathematician and astronomer named Johannes Kepler (1571-1630), who had earlier explained the motion of the planets around the Sun. Kepler's calculations showed that the planets followed an oval path in their orbit, rather than a circular one as Copernicus had supposed. His laws of planetary motion proved essential to scientists in their study of the solar system.

As mentioned at the beginning of the chapter, few advancements in science were made during the Renaissance. Even the knowledge and theories advanced by Copernicus and Galileo did not occur until the later stages of the era. But there were several other achievements worthy of note. Johannes Gutenberg's printing press with movable type made it possible to print more books at a lower cost and, as a result, encouraged reading and education throughout Europe. Peter Henlein's "pocket" watch, although it was so heavy it had to be worn on a belt around the waist, relieved its carriers of the necessity of looking for a larger clock to learn the time. And Evangelista Torricelli's barometer in 1643 made it possible for the first time to measure air pressure, which is important in weather forecasting.

Although the Renaissance produced few scientific wonders, the groundwork for future discoveries had been laid. Roger Bacon's emphasis on experimentation and observation, coupled with the determination of such astronomers as Copernicus and Galileo, paved the way for the birth of modern science.

Name ____

Date ____

Rank the Discoveries

In this chapter you studied several important achievements that stand out in an age not noted for its scientific progress. Which, in your opinion, was the most important? Which was the second in importance?

Rank these achievements 1 to 5 in the order of importance you assign them, with 1 being the most important and 5 being the least.

____ Galileo's telescope

____ Copernicus's heliocentric theory

____ Gutenberg's printing press with movable type

____ Roger Bacon's emphasis on observation and experimentation

____ Leonardo da Vinci's anatomical discoveries

On the lines below, explain why you ranked the discoveries as you did.

____

Name ____

Date ____

Research the Solar System

You can imagine how astounded people were when Galileo and Kepler proved that the sun was center of the universe. Their work paved the way for the study of the solar system, which is made up of the sun and all the heavenly bodies that revolve around it.

Review the solar system in your science book or in an encyclopedia. Then answer the questions below.

1. List the names of the nine planets. ____
2. Which planet is nearest the sun? ____
3. Our solar system is part of a giant galaxy called ____

In the space below, make a drawing of the solar system showing all of the planets in the order of their distance from the sun. Color your drawing for effect.

Name ____

Date ____

Make False Statements True

All the statements at right are false. Change the word(s) in italics to make them true. Write the replacement word(s) on the line following the statement.

1. An astronomer named Aristarchus advanced the geocentric theory of the universe almost 2,000 years ago. ____
2. The geocentric theory holds that the sun is the center of the universe. ____
3. The Roman Catholic Church during the Middle Ages and the Renaissance upheld the heliocentric theory. ____
4. Roger Bacon believed that knowledge could only be arrived at by an extensive study of the Bible. ____
5. Nicolaus Copernicus was a German astronomer. ____
6. Copernicus published his theories about the universe in a book entitled Dialogue on the Two Chief World Systems. ____
7. A Dutch optician named Peter Henlein made the world's first crude telescope. ____
8. The telescope used by Galileo to study the heavens would magnify objects eight times. ____
9. The Inquisition was a special court established by the rulers of the various Italian city-states. ____

10. Johannes Kepler discovered that the planets followed a circular path in their movements around the sun. ____
11. Johannes Gutenberg is most remembered for inventing the pocket watch. ____
12. An Italian named Evangelista Torricelli devised an instrument to measure temperature. ___

Name ____

Date ____

Create a Dialogue

You have learned that Galileo, like Copernicus before him, expounded the theory that the sun was the center of the universe. His support of the heliocentric theory brought him into conflict with the authorities of his day, who erroneously continued to maintain that Earth was the center of the universe and that all things revolved around it. By disregarding Ptolemy's geocentric theory, Galileo ran afoul of the Church and consequently spent the last 10 years of his life under house arrest.

Today you probably find it easy to support Galileo's theories in any discussion or debate. But how do you think you would fare if asked to defend the opposite view, that Galileo was a troublemaker and the geocentric theory was the correct explanation of the universe?

On the lines provided, create a dialogue between two Italian scientists of the 1600s as they point out reasons why Galileo's ideas are false.

PHOTO (BLACK & WHITE): The Polish astronomer Copernicus, who discovered that the sun was the center of the universe.

PHOTO (BLACK & WHITE): Nobles of Venice react with astonishment after gazing through Galileo's telescope.

PHOTO (BLACK & WHITE): Johannes Kepler working at his desk. Kepler's calculations explained the laws of planetary motion.

