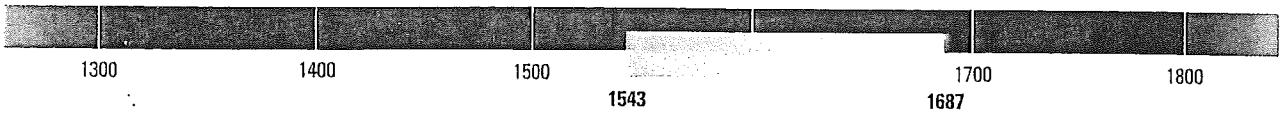


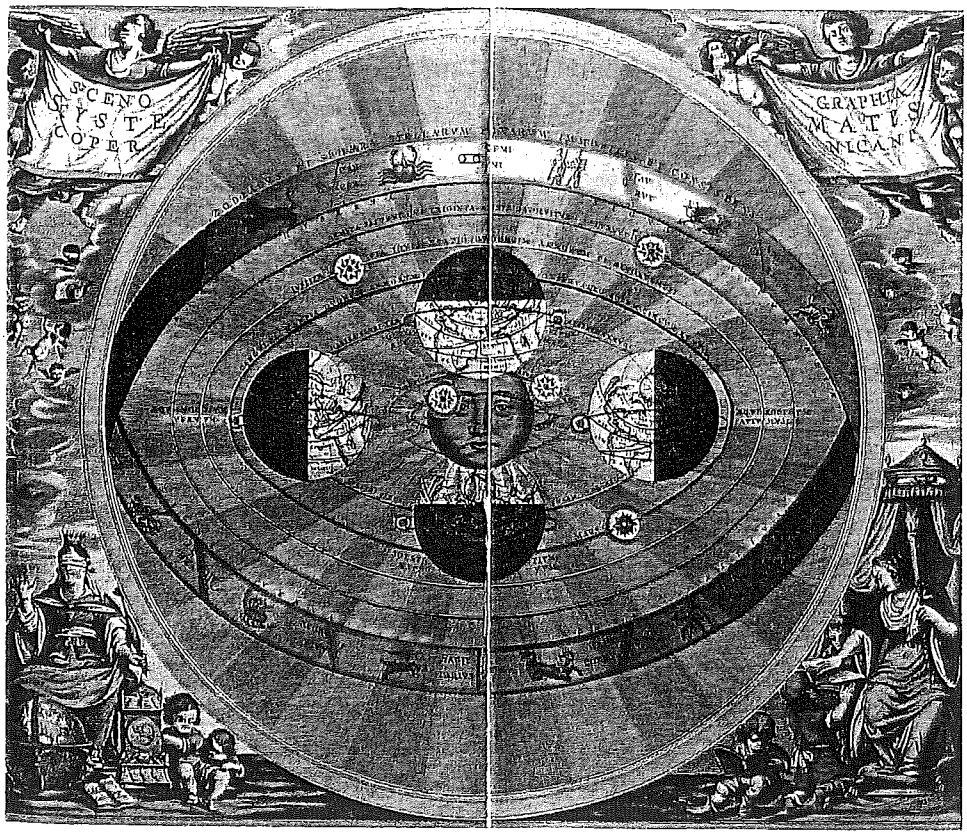
LESSON 4

Scientific Revolution

Clearly, by 1543, Nicolaus Copernicus, the Polish physician and astronomer, did not have much longer to live. For years, Georg Joachim, his young assistant, had begged Copernicus to publish his revolutionary theories on planetary motion. Copernicus theorized that the sun, not the earth, was the center of the universe. Copernicus claimed he needed more time to provide mathematical and factual support for these theories. But, on his deathbed, he agreed to publish.

Copernicus died later that year. But on the day he died, Joachim brought him the first copy of his work, *On the Revolution of the Celestial Spheres*.

The publication of Copernicus's theory began a movement that would change people's view of the world. Theories that had been accepted for hundreds of years would be challenged by scientific experiment and observation.



◄ *In Ptolemy's system, the earth is circled by water, air, fire, and seven planets—including the moon and sun. The plan shown here illustrates Copernicus's sun-centered theory.*

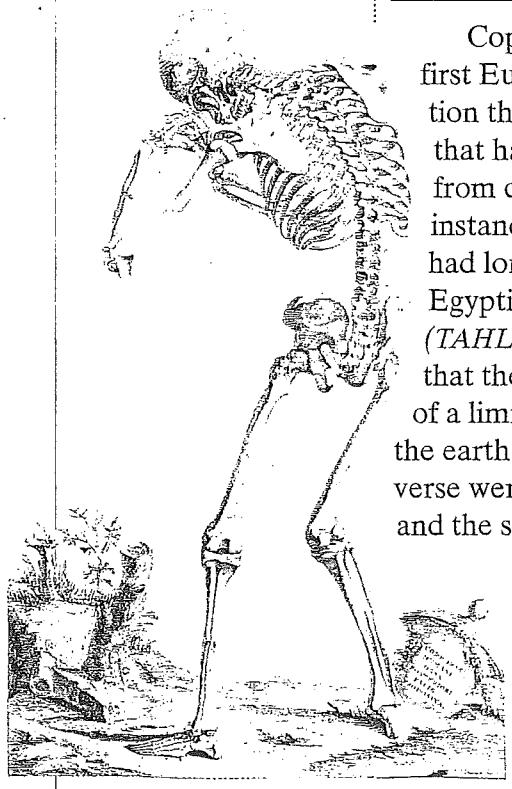
THINKING FOCUS

What was the Scientific Revolution?

Key Terms

- Scientific Revolution
- scientific method
- hypothesis

New Visions of the Natural World



In order to carry out his experiments and make drawings such as this, Vesalius sometimes stole the bodies of people who had been hanged.

■ *How did the scientific discoveries of Copernicus offer a new view on the world?*

Copernicus was one of the first European scientists to question theories about the universe that had been handed down from classical philosophers. For instance, educated Europeans had long accepted the theory of Egyptian astronomer Ptolemy *(TAHL uh mee),* which stated that the earth was at the center of a limited universe. Between the earth and the limits of the universe were the moon, the planets, and the sun.

The Universe

After years of observation and mathematical research, Copernicus concluded that the universe was sun-centered. Drawings demonstrating Copernicus's theory appear on the preceding page and on page 516 of the Minipedia. According to this theory, the planets, including earth, revolve around the sun in circular orbits. The German astronomer Johannes Kepler later proved that the planets' orbits were oval.

Protestant and Catholic leaders alike opposed Copernicus's theory. The Protestants claimed that the Bible said the earth stood still. The Catholics claimed that the earth and its human beings—not the sun—held the central place in th universe. In 1610, the Catholic church declared that all followe of Copernicus were heretics.

The Human Body

While Copernicus and Kepl explored the universe, Flemish physician Andreas Vesalius explored the human body. His obs vations challenged the works of Galen, a second-century physici whose theories based on the dissection of animals were widely accepted. Vesalius's thorough di section of the human body enab him to write a much more accur description of human anatomy. Vesalius's book stimulated new r search in the field of anatomy. Some results stemming from co tinued research are discussed in Making Decisions on pages 358 and 359.

Vesalius and Copernicus bot dared to question and reevaluat accepted theories. Their empha on careful observation of the na ral world marked a new era in s entific thinking, a period that became known as the **Scientific Revolution.** ■

Galileo and the Church

The Italian astronomer and physicist Galileo continued the work of Copernicus. He greatly admired the Polish astronomer's genius. Like Copernicus and Vesalius, Galileo recognized the importance of relying on observation rather than blindly trusting classical authorities.

Through observation and ex perimentation, Galileo tested th theory of falling bodies. This the ory, which held that heavy objec fall faster than lighter objects, h been accepted since about 300 B Galileo made his own observati by dropping objects of various weights and shapes from differe

heights. He then developed a mathematical formula showing that all bodies—no matter what their shape or weight—would fall at the same speed.

Galileo also applied his method of observation to astronomy. In 1609, he developed a telescope that was larger and more powerful than any made before. Galileo was the first person to observe sunspots, Jupiter's moons, and Saturn's rings. He also provided new information about the rough, crater-marked surface of our moon, which had previously been considered smooth.

Galileo's observations of one planet, Venus, provided strong support for Copernicus's theory. But when Galileo argued the point in his *Dialogue Concerning the Two Chief World Systems,* the Catholic church reacted. Because the idea of a sun-centered universe went against Catholic beliefs, the publication was placed on the *Index of Prohibited Books*. The inquisition in Rome condemned Galileo in 1616. Threatened with torture, Galileo, now an old man, denied his belief in Copernicus's ideas.

But his spirit was not broken. Upon leaving his trial, he is believed to have said of the earth, "but still it moves." Galileo spent the remaining eight years of his life under house arrest on his estate near Florence, where he continued his scientific activities.

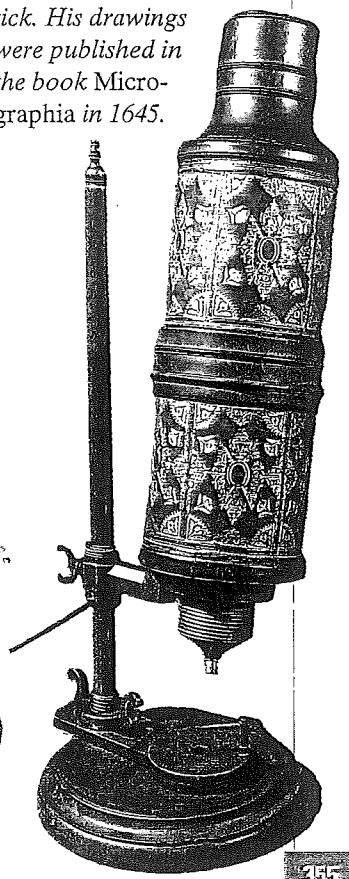
The church's victory was short-lived. By the late 1630s, the theory of the sun-centered universe was well established, and the age of science was under way. ■

How Do We Know?

HISTORY *Church officials banned books whose ideas threatened the church's power and authority. By reading the books listed in the* Index of Prohibited Books, *modern scholars have determined which ideas the church considered to be most dangerous.*

■ *Why was the Catholic church threatened by Galileo's ideas?*

Using this compound microscope, Robert Hooke examined cork, snowflakes, and tiny organisms, such as the tick. His drawings were published in the book Micrographia *in 1645.*



The Scientific Method

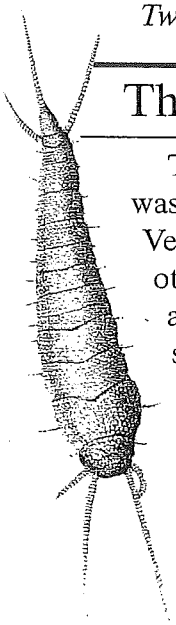
The Scientific Revolution was pioneered by Copernicus, Vesalius, and Galileo. Many other thinkers and writers also contributed to its success.

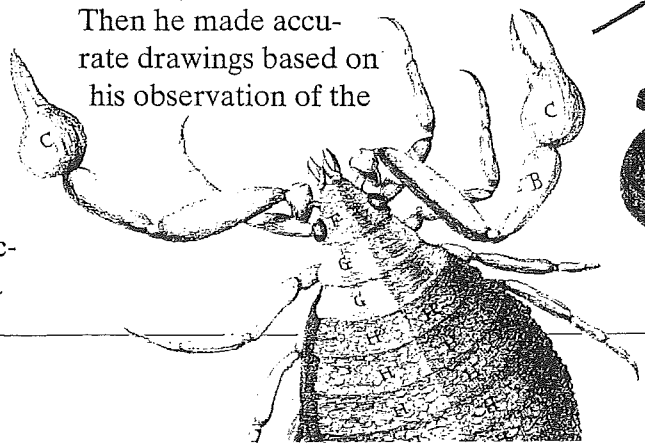
Francis Bacon

One such thinker was Francis Bacon, an English philosopher. In his book *Novum Organum,* published in 1620, Bacon stressed the importance of observation and experimentation leading to the statement of general principles about the natural world. This way of doing scientific research is now known as the **scientific method.**

A key part of this process, according to Bacon, was forming a hypothesis. A **hypothesis** is an assumption that can be tested by investigation. For example, Robert Hooke, an Englishman who developed the compound microscope in 1665, hypothesized that a microscope with two lenses could produce a clearer image of a magnified object.

This hypothesis was then tested by an experiment, and the results were recorded. Hooke experimented by adjusting and readjusting the placement of the lenses. Then he made accurate drawings based on his observation of the





Isaac Newton was praised by the English poet Alexander Pope in the following rhyme: "Nature, and nature's laws lay hid in night/ God said, 'Let Newton be!' and all was light."

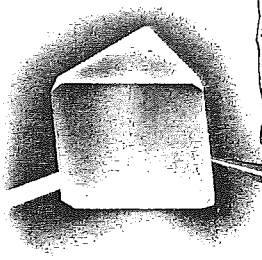
magnified objects. Finally, the collected data were analyzed and a conclusion was drawn. Hooke's data indeed revealed that objects could be more closely observed using a microscope with two lenses.

Bacon's method helped others in the Scientific Revolution organize and formulate their research. The scientific method is still at the core of scientific research.

Isaac Newton

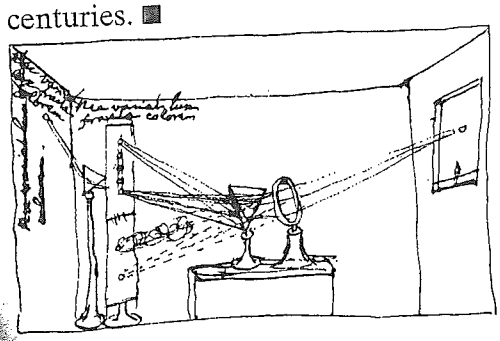
Sir Isaac Newton, English scientist, astronomer, and mathematician, also used the scientific method. Many scientists before Newton made observations and recorded data. However, Newton's biggest contribution was in providing an explanation for the universe that was very large in scope. His great ability lay in interpreting data and drawing accurate conclusions about the nature of the universe.

Newton's studies of how light passes through a prism helped explain how rainbows are formed.



Born in 1642, the year Galileo died, Newton expanded and perfected many of Galileo's theories. Like Galileo, Newton was fascinated by falling objects. According to the story, while in the country one day, Newton saw an apple fall from a tree branch. He hypothesized that there must be some force pulling the apple to the ground. He further hypothesized that the same force that pulls an object to earth keeps the moon and planets in orbit around the sun. After much observation and many experiments, Newton announced that a force called gravity holds the universe together. He described this theory and many others in the *Mathematical Principles of Natural Philosophy* published in 1687.

During the Reformation and the Scientific Revolution, people began to reexamine their spiritual and physical worlds. Freed from having to rely on accepted theories and beliefs, they sought new answers to old questions. This searching set the stage for further reformation in the 18th and 19th centuries. ■



■ *What was revolutionary about the scientific method?*

REVIEW

1. **FOCUS** What was the Scientific Revolution?
2. **CONNECT** What did the new scientific thinkers and the leaders of the Reformation have in common?
3. **BELIEF SYSTEMS** Why was the publication of Vesalius's findings considered revolutionary?
4. **SCIENCE** How did Newton use the scientific method?
5. **CRITICAL THINKING** Which scientific achievements do you think were more important, those of Copernicus or those of Galileo? Explain.
6. **ACTIVITY** Use Bacon's scientific method to answer the following question: Which weighs more, a pound of apples or a pound of lettuce?