Legacy of the Scientific Revolution

Directions: Read about three influential figures of the Scientific Revolution and answer the questions.

The Scientific Method: The revolution in scientific thinking that Copernicus, Kepler, and Galileo began eventually developed into a new approach to science called the **scientific method**. The scientific method is a logical procedure for gathering and testing ideas. It begins with a problem or question arising from an observation. Scientists next form a hypothesis, or unproved assumption. The hypothesis is then tested in an experiment or on the basis of data. In the final step, scientists analyze and interpret their data to reach a new conclusion. That conclusion either confirms or disproves the hypothesis.

The scientific method did not develop overnight. The work of two important thinkers of the 1600s, Francis Bacon and René Descartes, helped to advance the new approach.

Francis Bacon, an English politician and writer, had a passionate interest in science. He believed that by better understanding the world, scientists would generate practical knowledge that would improve people's lives. In his writings, Bacon attacked medieval scholars for relying too heavily on the conclusions of Aristotle and other ancient thinkers. He also criticized the way in which both Aristotle and medieval scholars arrived at their conclusions. They had reasoned from abstract theories. Instead, he urged scientists to **experiment**. Scientists, he wrote, should **observe** the world and gather information about it first. Then they should draw conclusions from that information. This approach is called **empiricism**, or the **experimental method**.

In France, **René Descartes** (day•KAHRT) also took a keen interest in science. He developed analytical geometry, which linked algebra and geometry. This provided an important new tool for scientific research. Like Bacon, Descartes believed that scientists needed to reject old assumptions and teachings. As a mathematician, however, his approach to gaining knowledge differed from Bacon's. Rather than using experimentation, Descartes relied on **mathematics and logic**. He believed that everything should be doubted until proved by **reason**. The only thing he knew for certain was that he existed—because, as he wrote, "I think, therefore I am." From this starting point, he followed a train of strict reasoning to arrive at other basic truths.

Modern scientific methods are based on the ideas of Bacon and Descartes. Scientists have shown that observation and experimentation, together with general laws that can be expressed mathematically, can lead people to a better understanding of the natural world.

"…Seeing that our senses sometimes deceive (trick) us… when I considered that the very same thoughts which we experience when awake may also be experienced when we are asleep (in dreams), [and none of those thoughts are true], I supposed that all the objects that had ever entered into my mind when awake, had in them no more truth than the illusions of my dreams. But immediately upon this I observed that, [while I was ready] to think that all was false, it was absolutely necessary that I, who [had this thought, must be something]; and as I [realized] that this truth, **I think, therefore I am**, was so certain and of such evidence that no… doubt… could be [suggested] by the skeptics capable of shaking it. [I decided to] accept it as the first principle of the philosophy of which I was in search."

Source: René Descartes, *Discourse on the Method*, 1637

Newton Explains the Law of Gravity: By the mid-1600s, the accomplishments of Copernicus, Kepler, and Galileo had shattered the old views of astronomy and physics. Later, the great English scientist **Isaac Newton** helped to bring together their breakthroughs under a single theory of motion.

Newton studied mathematics and physics at Cambridge University. By the time he was 24, Newton was certain that all physical objects were affected equally by the same forces. Kepler had worked out laws for a planet's motion around the sun. Galileo had studied the motion of pendulums. Newton's great discovery was that the same force ruled the motions of the planets, the pendulum, and all matter on earth and in space. He disproved the idea of Aristotle that one set of physical laws governed earth and another set governed the rest of the universe.

The key idea that linked motion in the heavens with motion on the earth was the law of universal gravitation. According to this law, every object in the universe attracts every other object. The degree of attraction depends on the mass of the objects and the distance between them.

In 1687, Newton published his ideas in a work called Mathematical Principles of Natural Philosophy—one of the most important scientific books ever written. The universe he described was like a giant clock. Its parts all worked together perfectly in ways that could be expressed mathematically. Newton believed that God was the creator of this orderly universe based on **natural laws**, the clockmaker who had set everything in motion.

As in Mathematicks, so in natural philosophy, the investigation of difficult things by the method of analysis [scientific method], ought ever to precede the method of composition. This analysis consists in making experiments and observations, and in drawing general conclusions from them by induction [reason], and admitting of no objections against the conclusions, but such as are taken from experiments, or other certain truths. For hypotheses [theories] are not to be regarded in experimental philosophy. And although the arguing from experiments and observations by induction be no demonstration of general conclusions; yet it is the best way of arguing which the nature of things admits of, and may be looked upon as so much the stronger, by how much the induction is more general. And if no exception occur from phenomena [facts], the conclusion may be pronounced generally. But if at any time afterwards any exception shall occur from experiments, it may then begin to be pronounced with such exceptions as occur. By this way of analysis we may proceed from compounds to ingredients, and from motions to the forces producing them; and in general, from effects to their causes, and from particular causes to more general ones, till the argument end in the most general. This is the method of analysis [scientific method]: and the synthesis [combination of parts] consists in assuming the causes discovered, and established as principles, and by them explaining the phenomena proceeding from them, and proving the explanations

Source: Sir Isaac Newton, *Opticks*, 1718