Scientific Revolution

The term scientific revolution is used to describe the time period when the modern methods of scientific investigation were established. Although the "revolution" took place over hundreds of years, it is usually associated with the great discoveries of the first modern scientists, including Johannes Kepler, Galileo, and Isaac Newton, in the early-to-late 1600s.

The most remarkable and enduring legacy of that era was the creation of the scientific method. Simply put, the scientific method is a strict set of rules that spell out the proper course of establishing facts. It involves the formulation of a hypothesis, the listing of assumptions, the isolating of variables in any experiment, and the analysis of experimentally observed data to support a conclusion. The scientists before the scientific revolution did not act within those guidelines; their conclusions were thus based on confusing variables and the acceptance of false assumptions about the world that stemmed from the beliefs of their eras.

Science before the 17th Century

The state of science prior to the scientific revolution was a mixture of three unrelated influences: the writings of ancient Greece, the technological advances made by the people of the Middle Ages, and religious policies. Although work was being done in the fields of biology and chemistry, the main thrust of the scientific revolution was centered around astronomy and physics.

The natural philosophers of ancient Greece made great strides in observing and categorizing the world around them, but their writings were highly speculative and were based on the assumptions and beliefs of their time. For example, Aristotle (384–322 BC) and other Greek philosophers believed that a rock thrown into the air would return to the Earth because the rock was composed of the element "earth" and therefore would seek to return to its proper place. In addition, the Greeks believed that the Earth was the center of the universe. These theories were accepted for the next 1400 years with few other advancements in science.

Indeed, the Catholic Church exerted a great influence over everything during the Middle Ages, including education. That meant that all ideas of the time had to conform to the beliefs of the Catholic Church. For example, the Church required a chain of command to exist between heaven and Earth. God, it was thought, existed beyond the sphere of the stars and gave his instructions to angels, who were responsible for the motions of the planets. The hierarchy extended down to humans and then animals, plants, and so forth. That concept was accepted as fact.

The Revolution Begins

Arguably, the "first shot fired" in the scientific revolution was by Nicholas Copernicus with the development of the heliocentric theory at the turn of the 16th century. He realized that the complexity of the solar system could be improved on by placing the Sun at the center of the universe and having the Earth and planets revolve around it in circles. His theory was mathematically simpler, and its central idea was to have far reaching consequences. Placing the Sun at the center of the universe upset the fragile hierarchy between heaven and Earth that was ingrained in Catholic belief. As a result, the supporters of Copernicus's ideas were persecuted by the Church until the mid-1600s, when the idea became widely accepted.

The modern view of the solar system was developed by the work of Tycho Brahe and his disciple Johannes Kepler at the turn of the 17th century. By observing the sky, including the movements of the planets, the stars, and comets, Brahe's and Kepler proposed that the planets moved in elliptical paths around the Sun. From that idea, Kepler derived his three laws of planetary motion. The importance of Kepler's work is twofold. First, it was based on very accurate observations, and second, he was able to derive simple and elegant mathematical equations to explain those observations.

At around the same time, the Italian, Galileo Galilei was performing experiments that had to do with the motion of objects. Galileo's genius lay in his ability to isolate the variables of his experiments, which created "idealized" conditions from which he deduced mathematical constructs. For example, in his experiments with balls rolling down inclined planes, he made sure that all the surfaces were polished smooth so that the motion of the ball itself could be studied. The effects of air resistance and friction on moving objects were well known at the time, but Galileo attempted to ignore them by reducing their influence. By doing so, he was able to collect data and formulate a set of simple equations that governed the motions of projectiles. By timing his experiments, he was able to deduce the acceleration of objects due to gravity, and in doing so, he laid down the fundamental principles of the modern study of mechanics.

Galileo's work was important because his equations were provable by repeated experiment and could be applied to almost any practical situation. Once again, mathematics and observation through experiments took precedence in the formulation of scientific facts.

Newton and Gravity

The Englishman Isaac Newton is credited as the most significant scientist of his time. Aside from developing the calculus, he is known for establishing the universal law of gravity, thus putting to rest the speculations and misconceptions of his predecessors. Newton did not "discover" gravity, but he did make the important connection between Galileo's work on falling objects and Kepler's laws of planetary motion. Using rigorous mathematical proofs, Newton showed that falling objects move under the same influence as the planets. That influence, of course, is gravity. Newton's laws of motion were accepted as uncontested laws of nature for 200 years until Albert Einstein proved him wrong with his special and general theories of relativity.

While the scientific revolution represented an overall break with superstition and religious control, it is important to note that beliefs still play a part in science. What scientists of one era believe to be fact may be disproven by scientists of the next.

1. What is the most important legacy of the scientific revolution?

2. What 3 factors affected scientific beliefs up until the 1700s?

3. What was the role of the Catholic Church in science during the Middle Ages?

4. What was revolutionary about Copernicus' heliocentric theory?

5. What advancements did Galileo make in science?

6. What advancements did Isaac Newton make in science?

7. What are similarities between all of the scientists mentioned in the reading?