The Scientific Revolution

Introduction

The phrase "the Scientific Revolution" was first used in the nineteenth century to refer to the transformational developments in the study of nature that took place during the sixteenth and seventeenth centuries in Europe.[1] These developments included not only new discoveries but also new approaches to the acquisition of knowledge, including the formulation of new philosophies for how knowledge should or could be acquired and how the natural world should be approached.

The Scientific Revolution was not a "revolution" in the usual sense of the term. It did not occur violently or all at once. Rather, it developed over the course of a century and drew from the achievements and contributions of earlier thinkers, including the ancient Greeks, Islamic thinkers of the Middle Ages, and various late-medieval and early-Renaissance Europeans.

The developments of the Scientific Revolution were spurred on in part by utilitarian concerns, including the need for improvements in navigation and locomotion. Many of the major thinkers of the Scientific Revolution justified their work on the basis of its actual or potential usefulness.

The Transformations of Natural Philosophy

During the sixteenth and seventeenth centuries, what we refer to today as "science" was conducted under the rubric of "natural philosophy." Natural philosophy had always been treated as a branch of philosophy more generally, and in some ways, this did not change during the Scientific Revolution.

Yet during this period natural philosophy underwent transformations in both theory and practice, diverging from the ancient and medieval philosophy, dominated as they were by the systems of Aristotle. These transformations—which depended upon the emergence of the modern scientific method for approaching the natural world, new divisions of labor, and the founding of major institutions for the study of nature[2]—resulted in major developments in astronomy, mechanics, motion, and mathematics.

The new natural philosophy took on many of the characteristics that we recognize as features of modern science, including an emphasis on the experimental method, the expression of natural phenomena in mathematical terms, a mechanistic approach aimed at reducing complex phenomena to their constituent parts, and the

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[1] Some historians and philosophers of science have since referred to a second and sometimes even additional scientific revolutions thought to have occurred in the nineteenth and twentieth centuries.

[2] New institutions devoted to the study of nature included the Royal Society in England, founded in 1660 and the French Academy of Sciences, founded in 1666.

attempt to avoid both *a priori* and teleological assumptions about the natural world. The natural philosophers of the period generally attempted to approach nature without preconceived ideas drawn from either Aristotelian metaphysics or medieval theology.

While natural philosophy became more developed and specialized than in the past, nothing like modern specialization and science professionalization took place during the period. Science professionalism as we know it today did not occur in any great degree until the nineteenth century. Like their contemporaries in the arts, the new natural philosophers relied on patronage to support them while they pursued their work. Patronage for those studying nature still came from the Church and various courts.

The Growth in Natural Knowledge

The new approach to nature yielded many results, some of which are still recognized as valid by modern science.

In the field of astronomy, Nicolaus Copernicus introduced a heliocentric universe with planets revolving in perfect circles around the sun. Johannes Kepler conceived of the elliptical orbit of the planets around the sun. Galileo Galilei's telescopic observations of the moon, planets, and stars introduced the notion of material similarity throughout the universe. Using the telescope, Galileo was also able to make observations that contributed to knowledge of the planetary motions.

In the area of motion itself, Galileo applied empirical observation and mathematical expression to the rate of falling bodies. He postulated that all bodies, regardless of weight, fall at the same rate, and that the rate of falling bodies increases in a specific proportion with distance.

In mathematics, Rene Descartes invented what we call "algebra," and Galileo and Descartes recommended and applied mathematics for the study and ultimate expression of all natural phenomena. Galileo applied mathematics to the results of experimentation.

In what we now call the "philosophy of science," Francis Bacon developed a system of open-ended induction as a method for making scientific claims, as well as introducing the notion that inductive claims could be made false by a single counter instance. Galileo applied an inductive method to the study of nature through experimentation. Descartes also emphasized induction, but considered knowledge to be ultimately based on deductive reasoning.

In what we now call "physics," the culmination of the Scientific Revolution came with Isaac Newton's formulation of universal gravity and the three laws of motion. Because the laws of motion were central to the new natural philosophy, the Scientific Revolution was not complete until the work of Isaac Newton.

Religion and the Scientific Revolution

The relationship between science and religion is not so simple as common conceptions would have it. The commonly held image of the scientist as relentlessly persecuted by religious authorities represents a caricature, even where the most

controversial figures of the Scientific Revolution are concerned.[3] As noted above, the Church was a major patron of the natural philosophers and remained so throughout the period. Natural philosophers generally retained their belief in Christianity and the Catholic Church, even though their theology was sometimes considered suspect. The issue of unbelief was not as general as it had become by the nineteenth century, and science was not seen as continually encroaching upon a retreating religion. These are images given to us by subsequent writers and thinkers, but they are generally inapt characterizations of the period itself.

The conflict model (science versus religion) is belied by the historical evidence, which reveals more complex interactions. Natural philosophers often saw scientific controversies as debates between factions within natural philosophy or theology, rather than in terms of an opposition between science and religion as such. Natural philosophers presented their work as the search for order in a universe regulated by an intelligent Creator. The premise of an ordered universe itself was based on a presupposition provided by a God-ordained cosmology. Despite attempts to rid their inquiries of preconceptions, the particular views of the universe held by the natural philosophers of the period were nevertheless sometimes informed by their theological presuppositions. For example, Copernicus's conception of perfectly circular planetary revolutions around the sun was premised on his belief that God's creations were necessarily perfect. When the natural philosophers referred to the "laws of nature," they chose the words with a divine legislator in mind—a Creator who established said laws. Furthermore, the ability of the human mind to comprehend the laws of nature was seen as evidence of an affinity between human and divine intelligence, and as a form of communication of the latter to the former. Finally, the proponents of natural philosophy often presented their work in terms of the obligation to study God's revelations in the book of Nature, the most important of God's books after the Bible.

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[3] For example, the placement, in 1616, of Copernicus's *On the Revolutions of the Celestial Spheres* (1543) on the Index of Forbidden Books was conditional. It was eligible for removal upon corrections. Galileo's *Dialogue Concerning the Two Chief World Systems* (1632) was similarly banned in 1633, although in this case, unconditionally. It remained proscribed well into the nineteenth century, and Galileo was placed on house arrest for the remainder of his life.