Mathematical Principles of Natural Philosophy

Sir Isaac Newton

The greatest scientific synthesis of the seventeenth century was made by Isaac Newton (1642–1727), who was born in England and attained a post as professor of mathematics at Cambridge University. Newton made his most important discoveries early in life. By the beginning of the eighteenth century he was the most admired scientific figure in Europe. He made fundamental discoveries concerning gravity, light, and differential calculus. Most important, he synthesized various scientific findings and methods into a description of the universe as working according to measurable, predictable mechanical laws. Newton's most famous work, Mathematical Principles of Natural Philosophy *(1687), contains his theory of universal gravitation. In the following selection from that work, Newton describes his four rules for arriving at knowledge.*

CONSIDER: *Why Newton's rules might be particularly useful for the experimental sciences; ways these rules differ from those of Descartes.*

RULE I

We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.

To this purpose the philosophers say that Nature does nothing in vain, and more is in vain when less will serve; for Nature is pleased with simplicity, and affects not the pomp of superfluous causes.

RULE II

Therefore to the same natural effects we must, as far as possible, assign the same causes.

As to respiration in a man and in a beast; the descent of stones in *Europe* and in *America*; the light of our culinary fire and of the sun; the reflection of light in the earth, and in the planets.

RULE III

The qualities of bodies, which admit neither intensification nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever.

For since the qualities of bodies are only known to us by experiments, we are to hold for universal all such as universally agree with experiments; and such as are not liable to diminution can never be quite taken away.

RULE IV

In experimental philosophy we are to look upon propositions inferred by general induction from phenomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time as other phenomena occur, by which they may either be made more accurate, or liable to exceptions.

This rule we must follow, that the argument of induction may not be evaded by hypotheses.

SOURCE: Sir Isaac Newton, *Mathematical Principles of Natural Philosophy*, trans. Andrew Motte, rev. Florian Cajori (Berkeley, CA: University of California Press, 1947), pp. 398, 400. Reprinted by permission of the University of California Press.

Visual Sources

A Vision of the New Science

One of the most important figures of the Scientific Revolution was the astronomer and mathematician Johannes Kepler (1571–1630). Figure 6.1 shows a page from the front of one of his works, first printed in Nuremberg in 1627, in which the "edifice" of astronomy is presented allegorically. The older but still respectable pillars of astronomy of Hipparchus and Ptolemy give way to the new, sturdy pillars of Kepler's immediate predecessors, Copernicus and Tycho Brahe. In the lower left panel Kepler is pictured in his study; in the center panel is a map of the island where Brahe's observatory was located; in the right-hand panel is a picture of two people working on a printing press. Throughout are various instruments used in astronomy.

The picture reveals much about the Scientific Revolution. The instruments emphasize how important measurement and observation were to the new science. The depiction of the old and new pillars suggests that the new scientists were replacing if not necessarily challenging the old, accepted scientific authorities by building on the work of their immediate predecessors—here Brahe on Copernicus, and Kepler on Brahe and Copernicus. The importance of communication among scientists is indicated by tribute to the printing press.

CONSIDER: *How this picture illustrates the ways in which seventeenth-century scientists were breaking with earlier scientific assumptions.*

The Anatomy Lesson of Dr. Tulp

Rembrandt van Rijn

This 1632 painting by Dutch artist Rembrandt van Rijn (1606–1669; figure 6.2) shows Dr. Nicholass Tulp using the body of a hanged criminal to give an anatomy lesson.