

The Scientific Revolution of the Seventeenth Century

On Yedinci Yüzyılda Bilimsel Devrim

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ABSTRACT After discussing the value of scientific inquiry in response to the questioning of its validity by some contemporary historians, the author briefly reviews the history of the scientific revolution of the seventeenth century.

Key Words: Scientific revolution, medical history, social factors, seventeenth

ÖZET Yazar, bazı çağdaş tarihçiler tarafından geçerliliğini sorgulamaya yanıt olarak bilimsel so-
ruşturmanın değerini tartıştıktan sonra kısaca onyedinci yüzyıldaki bilimsel devrimin tarihini in-
celemektedir.

Anahtar Kelimeler: Bilimsel devrim ,tıp tarihi , sosyal faktörler ,onyedinci yüzyıl

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Some contemporary historians of science have questioned the validity of scientific knowledge for the description and understanding of reality. A few remarks underlying the importance of science and the scientific method as a mean to acquire knowledge are therefore necessary before discussing the Scientific Revolution.

A) SCIENCE

As we have mentioned before on several occasions,ⁱ in spite of the large amount of literature on the subject and of the many differing opinions,ⁱⁱ science can be defined as the acquisition of knowledge by the scientific method, the latter being a tool consisting of three elements: observation, development of a hypothesis, verification of the hypothesis by experimentation.ⁱⁱⁱ

Until fairly recently it was universally accepted that science consisted in a growing body of truths about nature. As a consequence, progress was seen as characteristic of it. Although lately this idea has been challenged as “old fashioned” and science is considered by new-wave historians to be a “social construct,”^{iv} anybody with scientific training and experience knows

that the old fashioned idea is correct. Historians with no training in science seem to confuse the affirmation that science consists in a growing accumulation of objective knowledge (which is the case) with the idea that the accumulation proceeds in a straight line and is uninfluenced by social factors (which is not the case). The view that science is totally uncontaminated by human interests and passions is obviously extreme and naïve; the opposite view, however, that it is the contingent product of social and historical forces with only a loose and unreliable connection with external reality is absurd.

It is evident that social factors (e.g., fashion, customs, financial support) influence the rate of scientific development, which therefore proceeds very unevenly as a result of the constant discarding and correction of old theories in the light of new experimental evidence. Science, therefore, while in a fluid state at any given period, it accumulates with time a core of knowledge that can be considered as “true.”^v

As we have noted before,^{vi} while philosophers may doubt the reliability of sense-data, the existence of natural “truth,” and even the reality of the universe, scientists conduct their research as if there were a perfect correspondence between sense-data and reality and assume that there is a natural “truth” that they are striving to discover. What we call “science,” in fact, is the ongoing process of discovering such “truth.” The process brings us closer and closer to the goal even if, it is assumed, never quite up to it (as if it followed an asymptotic curve). For this reason, any accepted scientific explanation is considered a temporary hypothesis ready to be replaced by another that is closer to the “truth.”^{vii} This, of course, constitutes what we call scientific progress. We have also mentioned^{viii} that this is defined “Whiggism”^{ix} or “Whiggish history”^x by post-modern and deconstructionist historians of science.^{xi} For example, a historian discussing the contributions to science of Robert Boyle states:

A discussion of how a retrieval of Boyle’s ideas can make a contribution to today’s philosophical concerns is different from such decidedly “Whiggish” prac-

tices as claiming that Boyle’s concerns were the same as ours or that his experimental program was successful because it was in some sense the right way in which to initiate modern science.^{xii}

It is evident that if Boyle’s “concerns” were related to the requirement that interpretation of reality be based on experimental verification indeed they were the same as ours. It is also evident that when his experimental program was successful it was so because he did things the right way and that in so doing he contributed to the initiation of modern science.

Accusations of “whiggism” are usually the manifestation of an anti-science prejudice that even accuses science of damaging the ecology:

... science in the Western world has been characterized by a theoretical confidence that has resulted in the diminishing of alternative models of thought, and a technological hubris that has resulted in the near devastation of crucial parts of the earth’s delicate ecosystem.^{xiii}

Ultimately, non-scientists discussing history of science are in the same position as somebody discussing the extent and limitations of the expressive capacity of, let’s say, Sanskrit without knowing the language. It is quite evident that they can make contributions concerning some of aspects of science (e.g., sociology, economics, politics) but they do not have the competence to discuss others (e.g., epistemological value and capacity, progress).

The idea that science is a “social construct” with only a loose relation with reality may be due, at least in part, to the failure of our educational system: our scientists, by and large, are ignorant about everything outside their specialty and non-scientists (e.g., historians) know little or nothing about science and even less about scientific research. As a result, most often scientists ignore history of science and historians misunderstand what science is all about. As for philosophers of science, they are usually not scientists and therefore have no direct knowledge of scientific inquiry. In other words they discuss and analyze something of which they have fuzzy knowledge at best. The re-

sults are not helpful in understanding science and its history.^{xiv}

The “truth” investigated by science is in quotation marks because science is a human endeavor and nothing human is eternal or absolute. Nevertheless some scientific facts are sufficiently proven to eventually deserve the label “true.” For example, although there are unsolved astronomical problems debated among astronomers, nobody doubts the reality of the earth revolving around the sun. Similarly, the fact that a molecule of water is composed of two atoms of hydrogen and one of oxygen is considered certain in spite of the existence of many theories on various chemical problems. In medicine, although uncertainty and lack of knowledge abound, certain data, like the impermeability of the interventricular septum, are to be considered part of our definitive knowledge of anatomy. Perhaps, to avoid philosophical complication, we should substitute “true” with “certain” and state that science accumulates knowledge that is to be considered certain.

B) THE SCIENTIFIC REVOLUTION

The term “revolution” in the expression “Scientific Revolution” should be understood not as “sudden change” “or overthrow of previous beliefs” but as a change in the approach of the study of nature that, with its roots in previous historical periods (*scientia, sicut natura, non facit saltus*),^{xv} reached a critical level. This resulted in an accelerated sequence of discoveries that led to dramatic progress in the sciences in a relatively short period, and proceeded to the development of modern science. The period immediately preceding the Scientific Revolution, the period in which such roots became particularly vigorous was the Renaissance. In other words, concerning science, the term “revolution” simply means “dramatic change in the rate of acquisition of knowledge of the external world.”

The *primum movens*, the *cupiditas cognoscendi* (“the longing to know”),^{xvi} relentlessly pushes man toward the investigation of the external world and therefore the human quest for knowledge is as old as man. It was around the sixteenth and seventeenth centuries, however, that, as a result of the

systematic application of the scientific method and of mathematics, the rate at which such knowledge was acquired increased dramatically.^{xvii}

This increase in scientific knowledge has been considered a “revolution” since the eighteenth century. In the 1720’s Bernard Le Bovier de Fontenelle (1657-1757), Secretary of the Académie Royale des Sciences, underlined the importance of the development of infinitesimal calculus by Newton, Leibniz, Bernoulli, and others and called it “an epoch of almost total revolution occurring in geometry.” In the 1750s, Diderot and d’Alembert, the two editors of the *Encyclopédie*, described the revolution in science that had been initiated in the previous century and which they saw as continuing.^{xviii}

As is to be expected, the meaning and even the very existence of a scientific revolution has been contested by some historians. The following illustrates the point and the confusion resulting, we believe, from lack of any knowledge of science:

As our understanding of science in the seventeenth century has changed in recent years, so historians have become increasingly uneasy with the very idea of “the Scientific Revolution.” Even the legitimacy of each word making up that phrase has been individually contested. Many historians are now no longer satisfied that there was any singular and discrete event, localized in time and space, that can be pointed to as “the” Scientific Revolution. Such historians now reject even the notion that there was any single coherent cultural entity called “science” in the seventeenth century to undergo revolutionary change. There was, rather, a diverse array of cultural practices aimed at understanding, explaining, and controlling the natural world, each with different characteristics and each experiencing different modes of change. We are now much more dubious of claims that there is anything like “a scientific method” – a coherent, universal, and efficacious set of procedures for making scientific knowledge – and still more skeptical of stories that locate its origin in the seventeenth century, from which time it has been unproblematically passed onto us. And many historians do not now accept that the changes wrought on scientific beliefs and practices during the seventeenth century were as “revolutionary” as has been widely portrayed.^{xix}

The “old fashion” view of the Scientific Revolution and its importance is still held, however, by some:

The Scientific Revolution is the name given by historians of science to the period in European history when, arguably, the conceptual, methodological and institutional foundations of modern science were first established. The precise period in question varies from historian to historian, but the main focus is usually held to be the seventeenth century, with varying periods of scene-setting in the sixteenth and consolidation in the eighteenth. Similarly, the precise nature of the Revolution, its origins, causes, battlegrounds and results vary markedly from author to author. Such flexibility of interpretation clearly indicates that the Scientific Revolution is primarily a historian’s conceptual category. But the fact that the notion of the Scientific Revolution is a term of convenience for historians does not mean that it is merely a figment of their imaginations with no basis in historical reality.^{xx}

History consists in the record and analysis of past events. It is obvious that it should be objective, that is, *sine ira et studio*,^{xxi} but it is also obvious that the term “objective” should be considered as meaning “as objective as possible” because each historian sees events through the prism of his beliefs and background. This, however, does not mean that, for example, the importance of the Roman Empire to the history of the West is a “social construct” or that Caesar, in reality, lived to a happy old age.

Whereas the natural philosophy of the Middle Ages did not avail itself of mathematics and experimentation, during the Scientific Revolution those tools became widely used in the analysis of nature, which gave rise to what we call science. Newton’s *Principia Mathematica* was, in fact, regarded as the model of the new mathematical approach to physics.^{xxii}

We have mentioned elsewhere^{xxiii} that a phenomenon that played a significant role in the re-birth of objective inquiry at the end of the Middle Ages was a weakening of religious beliefs. This should not be interpreted as meaning that agnosticism

or atheism became prevalent, but only that traditional religious belief were questioned with increased frequency rather than unquestionably accepted. This phenomenon, which we have seen developing throughout the Renaissance, continued in the seventeenth century and the Scientific Revolution.

This way of thinking about religion did not develop in a smooth, progressive way over time but showed considerable variation in different authors and scientists at various times. The difficulty Galileo had in accepting the literal truth of the Bible and his problems with the Church are well known. Kepler still accepted traditional beliefs, whereas Descartes expressed skepticism at least concerning some (e.g., the belief in miracles), and Newton tended toward Arianism. It is to be underlined, however, that they all professed to be Christians and religious. Giordano Bruno, on the other hand, rejected traditional religious beliefs.

The weakening of religious beliefs should be interpreted, therefore, as meaning that the absolute certitude offered by religion concerning nature and the universe was not automatically accepted and that man started to look for explanations based on verifiable empirical data.

Part of the Scientific Revolution consisted in the creation of academies and scientific societies, especially in the sixteenth, seventeenth and eighteenth centuries. Although few are famous (e.g., the Accademia del Cimento, the Accademia della Crusca and the Accademia dei Lincei in Italy, the Royal Society in England, the Académie Française in France), their number was very large. In Italy alone, Maylender lists well over two thousand distributed in about one thousand large and small communities.^{xxiv}

The establishment of these societies was the result of the new spirit characteristic of the Scientific Revolution.^{xxv}

The content of this essay will be found in Volume VII (Seventeenth Century Medicine) of: Plinio Prioreshi, A History of Medicine, Omaha, Horatius Press, scheduled to be published in 2011.

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- ⁱ See, for example, Plinio Prioreshi, *A History of Medicine*, Omaha, Horatius Press, Volume I, Second Edition, MCMXCVI, Foreword.
- ⁱⁱ See: David C. Lindberg, *The Beginning of Western Science*, Chicago, The University of Chicago Press, 1992, pp. 1-4.
- ⁱⁱⁱ In this discussion we will often use science and scientific knowledge interchangeably.
- ^{iv} See Plinio Prioreshi, *A History of Medicine*, Omaha, Horatius Press, Volume V, Second Edition, MMIII, General Conclusions. Also: "The belief that science was inevitably progressive was given canonical formulation by George Sarton in *The Study of the History of Science*, first published in 1936.... This naive view was echoed by philosophers of science who pointed out that consensus was possible in science but a forlorn hope elsewhere. They claimed this was the case because science dealt with matters of fact (as opposed to armchair theories) and resolved its disputes by invoking appropriate rules of inference instead of mere rhetoric.... The pendulum swung from high-minded logical rigour to trendy sociological determination. Science once the pure light of rationality, became a garish sign that was turned on and off by concealed pulsations in society." William Shea, "Dubious Revolution," book review of Steven Shapin's, *The Scientific Revolution*, in *Nature*, 385, p. 312, 1997. "...Shapin [Steven Shapin, *The Scientific Revolution*, Chicago, The University of Chicago Press, 1996] sees science as a system of provisional beliefs and not a growing body of truths about nature." William Shea, "Dubious Revolution," book review of Steven Shapin's, *The Scientific Revolution*, *Nature*, 385, p. 312, 1997. The postmodernists believe "that such phenomena as science, knowledge, evidence and truth are social constructions, in some sense or other which implies that one should reject the idea that scientific practices achieve an approximate representational fit, of some sort or other, between the content of scientific theories and the world or reality".... "the findings of work in the sciences are determined exclusively, or in large measure, not by the "facts," but instead by relations of social power within the scientific community and the broader community within which research is conducted." Richard Boyd, "Scientific Realism", *The Stanford Encyclopedia of Philosophy* (Summer 2002 Ed.), Edward N. Zalta (ed.), URL= <http://plato.stanford.edu/archives/sum2002/entries/scientific-realism/>.
- ^v In 1908 Duhem said that "scientific progress is like a mounting tide, where waves rise and withdraw, but under this to-and-fro motion there is a slow and constant progress." Ilkka Niiniluoto, "Scientific Progress," *The Stanford Encyclopedia of Philosophy* (Spring 2007 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/spr2007/entries/scientific-progress/>.
- ^{vi} Plinio Prioreshi, *A History of Medicine*, Omaha, Horatius Press, Volume I, Second Edition, MCMXCVI, Foreword.
- ^{vii} The word "truth" is in quotation marks for the reasons given below.
- ^{viii} Plinio Prioreshi, *A History of Medicine*, Omaha, Horatius Press, Volume III, MCMXCVIII, Foreword.
- ^{ix} As mentioned in the Forewords of Volume II and VI, the term is a reference to English and American political parties of the eighteenth and nineteenth centuries used with contemptuous meaning. For a discussion of whiggism, see: A. Rupert Hall, "On Whiggism," *Hist. Sci.*, XXI, 46-59, 1983.
- ^x For a discussion of "Whiggish historiography," see: Ernst Mayr, "When is Historiography Whiggish?" *Journal of the History of Ideas*, LI, 2, 301-309, 1990.
- ^{xi} It is of interest that the term "Whiggish" as applied to history goes back to 1931 to H. Butterfield, *The Whig Interpretation of History*, London, 1931. See E. Mayr, "When is Historiography Whiggish?" *Journal of the History of Ideas*, 51, 2, 301-309, 1990.
- ^{xii} Rose-Marie Sargent, *The Diffident Naturalist: Robert Boyle and the Philosophy of Experiment*, Chicago, The University of Chicago Press, 1995, pp. 11-12.
- ^{xiii} Rose-Marie Sargent, *The Diffident Naturalist: Robert Boyle and the Philosophy of Experiment*, Chicago, The University of Chicago Press, 1995, p. 216.
- ^{xiv} Examples: Lorraine Daston, "On Scientific Observation," *Isis*, XCIX, 1, 97-110, 2008; Steven Shapin, *The Scientific Revolution*, Chicago, The University of Chicago Press, 1996; Michel Friedman, "History and Philosophy of Science in a New Key," *Isis*, XCIX, 1, 125-134, 2008; Peter Galison, "Ten Problems in History and Philosophy of Science," *Isis*, XCIX, 1, 111-124, 2008; Alan Richardson, "Scientific Philosophy as a Topic for History of Science," *Isis*, XCIX, 1, 88-96, 2008.
- ^{xv} "Science, like Nature, does not proceed by jumps." See: Plinio Prioreshi, *A History of Medicine*, Omaha, Horatius Press, Volume VI, MMVII, General Conclusions.
- ^{xvi} See: Plinio Prioreshi, *A History of Medicine*, Omaha, Horatius Press, Vol. VI, MMVII, General Conclusions.
- ^{xvii} A large list of references on the Scientific Revolution up to about ten years ago can be found in: Steve Shapin, *The Scientific Revolution*, Chicago, The University of Chicago Press, 1996, pp. 167-211.
- ^{xviii} John Henry, *The Scientific Revolution and the Origins of Modern Science*, Second ed., New York, Palgrave, 2002, p. 110.
- ^{xiv} Steve Shapin, *The Scientific Revolution*, Chicago, The University of Chicago Press, 1996, pp. 3-4.
- ^{xx} John Henry, *The Scientific Revolution and the Origins of Modern Science*, Second ed., New York, Palgrave, 2002, p. 1. See also: Mitchell Young (Ed.), *The Scientific Revolution*, Detroit, Thomson Gale, 2006.
- ^{xxi} "Without anger or bias." Tacitus, *Annals*, I, 1.
- ^{xxii} John Henry, *The Scientific Revolution and the Origins of Modern Science*, Second ed., New York, Palgrave, 2002, pp. 5, 110-111.
- ^{xxiii} Plinio Prioreshi, *A History of Medicine*, Omaha, Horatius Press, Volume VI, MMVII, Chapter II, A.
- ^{xxiv} Michele Maylender, *Storia delle Accademie d'Italia*, Bologna, Cappelli, 5 Vols., 1926-1930.
- ^{xxv} The motto of the Accademia del Cimento (Academy of the Experiment) was *Provando e riprovando*, that is, "By testing and retesting."