Science: the revolution

David Wootton
The Invention of Science: A New History of the Scientific Revolution.
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reviewed by James Franklin

The Scientific Revolution in seventeenth-century Europe was Western civilization's adolescent growth spurt. Methods were found to expose the workings of Nature and set rolling four centuries of technological, medical, and intellectual progress. No other civilization did that of its own accord, though some have been eager enough to imitate the results. Understanding what exactly happened, and how and why it happened (and how and why it didn't happen anywhere else) is important. It is also, as contemporary jargon has it, "contested."

Some of those doing the contesting are the usual suspects, writers of postmodernist bent who object to the whole notion that science progresses and often works its way towards the truth. Wootton writes, "The anxiety which now troubles historians when they read the words 'scientific,' 'revolution,' 'modern' and (worst of all) 'progress' in studies of seventeenth-century natural science is not just a fear of anachronistic language; it is a symptom of a much larger intellectual crisis which has expressed itself in a general retreat from grand narratives of every sort." Quite so.

Wootton is no relativist and tells a firmly "Whig" history, in the sense of a story of progress from ignorance to success. It is not a survey of the Scientific Revolution's discoveries, or a popular history of seventeenth-century science. It is more a description of intellectual tools with examples—tools like geometry and the model of the universe as a clock, the concepts of hypothesis, evidence and facts, the idea of how to confront theory with experiments. The account is clear, readable, and adorned with excellent and detailed examples that point up how the "natural philosophers," as they called themselves, found the way to break through into nature's secrets and developed a method for apparently endless progress in science and in its applications to technology.

One notably interesting section is the full account of the first useful steam engines around 1700, both the workable but really toy ones invented by the scientists Papin and Savery, and the large, commercially successful ones designed and built by the provincial ironmonger and lay preacher Thomas Newcomen. The latter were large, slow-moving, fixed engines very useful for pumping out mines. Wootton explains carefully and with diagrams how these worked and what the engineering obstacles were to usable steam power. A peculiarity of Newcomen's design is that it will work properly only if it is large—ideally about two or three times the height of a person—so it is hard to invent because the concept cannot be properly tested in a scale model. Newcomen raises a problem for the story that technology is applied science, as promised by the promoters of the new science in the early Royal Society. It appears that he was a talented man of the people with mechanical skills similar to a medieval millwright, untroubled by the doings of scientific intellectuals. Wootton argues that he could have and must have read some of Papin's writings, but possibly, rather than his work on steam, his *New Digester of Bones*, an account of a kind of pressure cooker for rendering down surplus animal parts.

Despite his correctness on the main issue, Wootton has some failures of emphasis, something wrong with the big picture. Two essential ingredients of the Scientific Revolution in particular are explained inadequately, the medieval background and mathematics.

Wootton accepts the self-image of the propagandists of the early Royal Society. According to them (essentially, to Sprat's 1667 *History of the Royal Society*), the Scientific Revolution is entirely new, English, experimental, inductive, and Baconian (in the sense of building up theories from masses of carefully collected facts). Gentlemen write in to the Society with their observations, savants "torture nature" with their experimental apparatuses, then the results are summarized in ever more general laws. (The phrase "laws of nature" is largely a concoction of the early Royal Society, intended to suggest that natural regularities are the commands of God.) The medieval obfuscations of Aristotelian philosophers are confounded. Knowledge of those laws effects miraculous transformations in useful technology.

According to that story, the chief enemy of the new science was the old Aristotelianism. Hidebound scholastic reactionaries occupying the university posts opposed the new thinkers in science and philosophy, who turned to the things themselves and threw open the windows on the dusty cobwebs of medieval tradition. That is something like saying that Anglophone democracy was created suddenly in 1776 in reaction to the evils of British absolute monarchy. Just as the parliamentary democracy established in England from 1688 supplied the assumptions and tradition within which the American "revolutionaries" could make certain new moves, so the pro-scientific Aristotelian tradition at independent universities formed the matrix within which the new men of the seventeenth century could kick over one or two traces. If we take a moment to compare the scientific culture of the seventeenth century with alternatives, such as the Islamic, Chinese, or Indian cultures of those times (much less more distant Aztec, Hebrew, or Scythian ones), it is immediately clear that late medieval Aristotelianism and the Scientific Revolution are closely related. Their relationship is that of childhood to adolescence. The former caused the latter much more than it impeded it. Wootton is aware of books like Hannam's *God's Philosophers* which demonstrate how that happened, but works to minimize their significance and to argue that the middle ages came up with mere preconditions for science.

Wootton lacks a solid grasp of the middle ages. He has collected many facts about that era, but solely for the purpose of showing the differences between then and later times. There were indeed many differences, and some of the highlights of the book involve the strangeness of what it was like not to know some of the basic facts of modern science. Particularly fascinating is the detailed account of pre-modern theories about the sphere of the earth. We all know, and we take for granted as the only possibility, that the earth is a near-sphere of solid rock (on the outside at least), and the sea fills in the hollows. In 1500, they didn't know that. Of several theories, the leading one was that there were two spheres, a smaller earth one and a bigger water one, with different centers. The earth sphere floated in the water sphere, poking out at the top so as to form the known land mass of Eurasia-Africa. The implication was that most of the surface of the globe must have been sea, so heading west in search of India was probably not a productive enterprise. Anyone spruiking a harebrained project like that would need to talk very fast and to find patrons as gullible as they were rich. If he were to promise to lead the expedition himself, that would be evidence of his sincerity, but not necessarily of his sanity.

The trouble, though, with looking just for differences between medieval and later thought is that it obscures how like us the medievals were and how much of the tools and results of science they actually discovered. Wootton labors to show that the very notion of discovery was absent before 1492 and that the word "discovery" only came into use as a result of the voyages to the East and West Indies. The medievals were not stupid and knew a discovery when they saw one. A sermon by a Fra Giordano in the church of Santa Maria Novella in Florence in 1306 says that it is not twenty years since the art of making eyeglasses was "found," and it was still possible to speak to the man who did it. That was not a one-off novelty either. The era in question included the excitement over Marco Polo's account of the marvels of Cathay, Dante, Giotto's advances in representing space, and the competitive cathedral building spree that gave us the massive Duomo of Florence. A visitor to Santa Maria Novella today can see the oldest surviving perspective painting constructed according to proper geometrical principles, Masaccio's *Holy Trinity*. It dates from about 1425, a century and a half before Wootton dates the very beginning of science.

The same lesson arises from thinking about the self-refuting nature of the early Royal Society's writing learned books on their own "discovery" of experimentation. The existence of the printed book depends on Gutenberg's intense program of experimentation with papers, inks, presses, and the casting of metal type, a full two centuries earlier.

The other thing wrong with swallowing the early Royal Society's myth-making is that it takes too seriously their picture of science as a bottom-up process of inducing general results from particular observations and experiments.

Some science did proceed that way, especially in the less general sciences like chemistry and biology. Some of it even successfully so (and some not, such as the gruesome Royal Society experiments on transfusions of sheep's blood into humans). But the most spectacular successes of the Scientific Revolution were nothing like that. They were continental, top-down, and mathematical instead of inductive, and the product of the mind of individual geniuses penetrating the necessities behind the flux of appearances, much as Aristotle had claimed science should be. Galileo's mechanics, Pascal's laws of pressure and his foundational work on probability, Huygens's model of the propagation of light, Leibniz's calculus—those were insights into the nature of things by top-quality individual minds, not accumulations of observations and experiments. Galileo, though an excellent experimenter himself, impudently says, "Without experiment, I am sure that the effect will happen as I tell you, because it must happen that way." Even more embarrassingly for the Sprat story, Newton's *Mathematical Principles of Natural Philosophy* was the same. As Pope wrote, "God said, 'Let Newton be'/ And all was light." That is not follow-your-nose induction.

Wootton's chapter on "the mathematization of nature" misses that story entirely. It does deal well with earlier events such as perspective, astronomy, map-making, and anatomy. (Indeed, it shows usefully that a mathematical revolution of a kind was under way well before what we call the Scientific Revolution.) But seventeenth-century mathematical science, from Galileo to Newton, was something wholly different. It was much more than a mathematical description of nature, in the way perspective paintings or maps are. It was a continuation by other means of the Aristotelian project of pure intellectual insight into nature—by means of quantities and formulas. Kepler's inferring of elliptical planetary orbits from data was indeed inductive, but the point of Newton's derivation of them from the inverse square law of gravity was to explain why they *must* be elliptical. The mathematical reasoning demonstrates a necessary connection, in just the way that Aristotle explains eclipses geometrically.

Newton is an embarrassment in another way for the anti-Aristotelian story. The new order made fun of the scholastics for their supposedly merely verbal explanations, like attributing the powers of a sleeping drug to an inherent "dormitive virtue." Very funny, but then Newton's "gravity" was an occult quality in exactly the same sense. All there is to gravity is its being postulated to "explain" the observed attraction of distant bodies. It works according to a mathematical formula, but it is not the sort of cause that the new science and its "mechanical philosophy" was hoping for, like corpuscles or internal geared wheels.

Now that Western civilization has reached its vigorous middle age—or declined into its dotage, as the case may be—it is time to reflect on where it came from. Wootton's book is a lucid and reliable guide to important parts of what happened, just a little biased in what it (in postmodern language) "constructs as other."