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History of science: The crucible of change

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Philip Ball gets to grips with a revolutionary history of the scientific revolution.

The Invention of Science: A New History of the Scientific Revolution
David Wootton *Allen Lane*: 2015.
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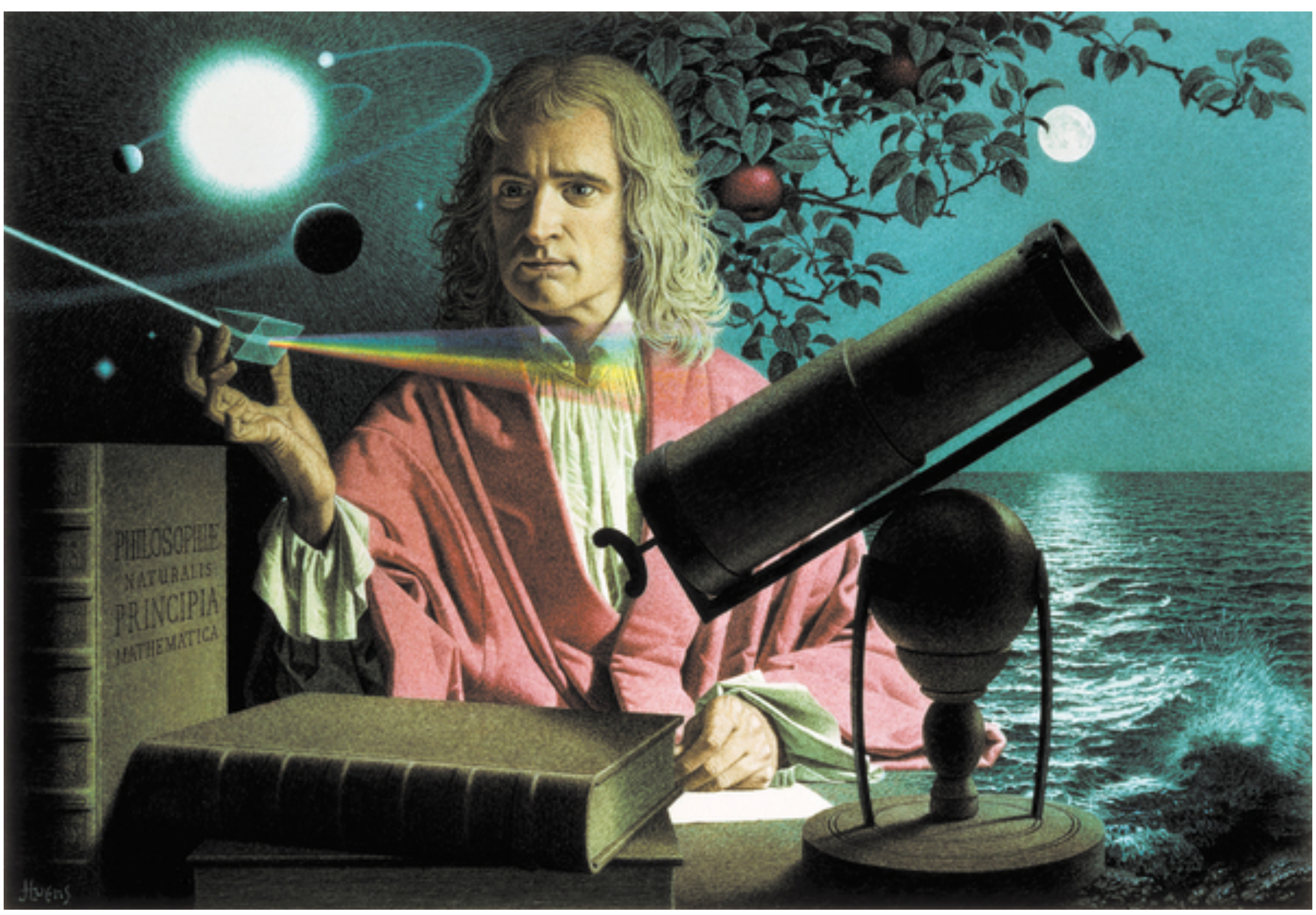
David Wootton's *The Invention of Science* will cause arguments, and is all the better for it. The idea of a 'scientific revolution' — the supposed birth of modern science, beginning around the start of the seventeenth century and emerging from the work of Galileo Galilei, Johannes Kepler, Isaac Newton, Robert Boyle and their contemporaries — has been rejected by many historians of science. But Wootton argues that the period marked a true turning point, in which the whole process of doing science was transformed into a social enterprise with established norms and procedures.

Nay-sayers deny that any 'essence' of modern science crystallized in this period. As science historian Steven Shapin wrote at the beginning of his 1996 *The Scientific Revolution* (University of Chicago Press), “There was no such thing” as this revolution. But Wootton uses the term unapologetically, and assesses the contributions of the luminaries of the period from a stance that he admits is Whiggish — essentially, judging their ideas in the light of present understanding.



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Isaac Newton, drawn in 1974 by Jean-Léon Huens, was at the heart of the scientific revolution.

All too often, such a “presentist” view is taken to extremes by scientists writing history, either because they don't know any better or because, like physicist Steven Weinberg in *To Explain the World* (Allen Lane, 2015), they believe that the history of science belongs to its practitioners (see R. P. Crease *Nature* **518**, 300; 2015). This manifests as a tendency to dish out medals for getting things 'right' — leading Weinberg to dismiss Plato as silly, philosopher Francis Bacon as irrelevant and Galileo's errors as the result of off-days. In this view, pursuits such as alchemy and astrology were useless mumbo jumbo, and Newton and Boyle let the side down by practising them. Finding out about nature was just a matter of doing the right experiments and interpreting them with the proper scientific method.

Wootton's book is very different, however. It is perceptive, thought-provoking, deeply erudite and beautifully written. Wootton argues that the scientific revolution took place between 1572 and 1704, and contends that it led to genuine intellectual progress and to a new, more effective way of understanding the world. Does he make a persuasive case? I'll come back to that.

Those two dates hint at what Wootton deems crucial. Danish astronomer Tycho Brahe's observation of a nova (which he interpreted as a new star) in 1572 fatally undermined the Aristotelian concept of the unchanging heavens. The publication of Newton's *Opticks* in 1704 completed the Newtonian revolution, rendering the world mechanical and mathematical. The crucible of change was thus the seventeenth century: the time when Bacon argued for a systematic approach to what we now call science, Galileo asserted that mathematics is the language of nature, and institutions including the Royal Society in London formalized how science was studied. At the outset, the very meanings of concepts such as experimentation were unclear, and classical authorities such as Aristotle still held sway. By the end, a recognizably modern science existed.

That much is broadly accepted, and many of the milestones Wootton covers are familiar. These include the exploration of the geography, flora and fauna of the New World and its relevance to debates about the structure of the (spherical) Earth; the invention of the telescope and Galileo's observations of the Moon and the satellites of Jupiter; and Newton's 1687 book *Principia Mathematica*.

What elevates Wootton's account is how he uses a close and perceptive reading of such developments to explore changes in the way nature was investigated and conceptualized. He argues that the transformation was in how knowledge was obtained, recorded and assessed, even more than in what was known about the world.

“Wootton comes not to bury relativism, but to curb its excesses.”

The core of the book is conceptual, not chronological: Wootton looks at changing meanings of words such as fact, experiment, theory and evidence. 'Fact', for instance, was originally a legal term meaning a deed or act. It was not until the 1660s that it was used in England to signify a reproducible piece of knowledge about the world. Wootton argues that this usage became inevitable with the emergence of a print culture that, by an almost Darwinian process, let knowledge replicate fast enough to drive out error with an accumulation of evidence.

It is precisely because of this attention to context that *The Invention of Science* is not as heretical as it thinks it is. Wootton's tilting is against the 'relativist' position that provoked the 'science wars' of the 1990s, in which scientists including Weinberg were dismayed by historians who argued that social factors such as authority and status shaped how science evolved. At their worst, relativists maintained that scientific knowledge was entirely a social construct, no more 'true' than Galenic medicine or witchcraft. It is because this absurd argument still persists among some historians that Wootton's nuanced approach is needed.

But few historians of science are that extreme, and Wootton sometimes exaggerates the position of the milder 'relativists' who he says dominate the discipline today. For example, he takes particular issue with Shapin's highly influential 1985 collaboration with science historian Simon Schaffer, *Leviathan and the Air-Pump* (Princeton University Press), which argued that the reception of Boyle's experiments on gases and vacuums had as much to do with politics as with objective 'evidence'. But Shapin and Schaffer do not imply that Boyle's gas law is, as a result, mere convention. Rather, they challenge the naivety of the idea that science, proceeding openly and aloof from its sociopolitical environment, reaches incontrovertible truths by unassailable reason. Wootton's equally valid point is that the undoubted contingency of science's methods and context does not make its results any less reliable, or not always. The two views do not seem incompatible.

“What marks out modern science”, Wootton writes, “is not the conduct of experiments ... but the formation of a critical community capable of assessing discoveries and replicating results”. Science needed to be reported openly and debated by peers, as it was (after a fashion) in the Royal Society's *Philosophical Transactions*, the first true scientific journal, launched in 1665. It is a very plausible case, and one that most historians of science should not find too hard to swallow.

In any event, Wootton admits that he is seeking a middle ground: he comes not to bury relativism, but to curb its excesses. Far from renewing hostilities, this timely and thoughtful book should encourage historians of science to discover how much they agree on, and to refine the points of dispute. “The task,” Wootton says, “is to understand how reliable knowledge and scientific progress can and do result from a flawed, profoundly contingent, culturally relative, all-too-human process.” That is beautifully put and, in my view, right on the mark.

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