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BOOK REVIEWS

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The Invention of Science: A New History of the Scientific Revolution. David Wootton. 778 pp. Harper Collins, New York, 2016. Price: $18.99 (hardcover). ISBN 978-0-06-175953-6. (Danielson Dennis, Reviewer.)

I hope you won't stop reading this review if I tell you that I'm actually just an English professor, not a physicist (although I've given papers at APS and AAPT meetings), or that *The Invention of Science* was written by a historian, not a scientist, and also that the book stretches to over 600 pages (I usually hate long books). David Wootton's topic is *so* important to both historians and scientists, its message so well argued, and its style so readable and informative that I can't imagine any teacher or practitioner of physics finding it less delightful and thought-provoking than I, a mere humanities scholar, found it.

For one thing, you may or may not know that there's a whole school of historians-of-science who doubt whether the Scientific Revolution actually happened. Wootton calls these people "the relativists" (not Einsteinian ones!). They are very broadly involved with "postmodern" approaches to knowledge, some of whose defenders (to oversimplify Wootton's critique) seem to characterize scientists' contributions to knowledge as "socially constructed" and just as ultimately uncertain as most claims made by those in the humanities. The problem is, if you claim that science offers a story of *progress*, then you lay yourself open to charges of merely reading the past through the lens of the present and of reading history (in other words) *teleologically*, "Whiggishly," as if "we" or "the present state of scientific knowledge" were the end-point toward which that grand story was driving. But of course it is not a simple either/or. In chapter 16 ("These Postmodern Days"; pp. 544–555) and in one of his "Longer Notes" ("On Relativism and Relativists"; pp. 580–592), Wootton makes mincemeat of much that today passes in the humanities as "Science Studies." And he does so in a way that I think might resonate with and encourage critical realists on both sides of the humanities/sciences divide.

But that's the theoretical and historiographical part of the book, and it comes mainly at the end. There's some of that in the Introduction too (pp. 1–54); however, here Wootton really gets going on the main historical claims he wants to argue: that the Scientific Revolution began not with Copernicus but with Tycho Brahe because the latter actually made decisive *observations* (most notably of the supernova of 1572, which he proved mathematically to be superlunary); that William Gilbert in 1600, in his book on magnetism, published "the first major work of experimental science for 600 years"; and that between "1600 and 1733…, the intellectual world of the educated elite changed more rapidly than at any time in previous history." In short, the Scientific Revolution happened.

Chapters 3 and 4 ("Inventing Discovery" and "Planet Earth") zoom in to offer a fine-grained examination of a notion at the very root of what we call science, starting with Columbus's *discovery* of America, which gave rise to what Wootton calls "the discovery of discovery" (p. 61). He examines this and cognate words such as "invention" across writings in English, Latin, French, Spanish, and Portuguese, showing how radical was the idea that knowledge could be *new* knowledge. (Keep in mind how defenders of Copernicus such as Thomas Digges *claimed* that his heliocentrism was fundamentally a revival of "the most ancient doctrine of the Pythagoreans".) Thus, "the discovery of America was crucial in legitimizing innovation because within 40 years, no one disputed that it really was an unprecedented event and one that could not be ignored" (p. 79). So, discovery, invention, novelty, and progress are the foundations of what we call science. And they *were* new things and furthermore got disseminated and made public by yet another new thing: the printing press.

Part Two of the book is headed "Seeing is Believing," and even the form of Wootton's own book supports this familiar claim. He shows how the "mathematization of the world," along with the development of perspective drawing (another new thing), fueled astronomical discovery, cartography, and printed representations of the globe of Earth (Dürer) and of human physiology (Vesalius)—demonstrations fascinatingly supported by Wootton's 63 monochrome illustrations and 19 color plates. His book is a feast for the curious eye and for the curious mind.

I suspect the most intriguing parts of Wootton's book, however, even for the unsuspecting physicist and not only for a word-nerd like me, are his central chapters on concepts whose shifting shapes and intellectual history might for most of us be indeed a new discovery: Facts, Experiments, Laws, Hypotheses/Theories, Evidence, and Judgment (chapters 7–11, respectively). Chapter 7 takes up 59 pages and is quite by itself worth more than the sticker-price of the volume. Wootton shows how the idea of *the fact* arose and developed—differently in different places (*Tatsache* appearing a century later in German than *fact* does in English). It started out as something somebody does (*factum*), that is, it required an agent, just as a *deed* requires a *doer*. And sometimes it's an evil deed, a usage that survives in our archaic phrase "accessory after the fact." But facts came to be things that are out there, and true, and can be assessed and established and sometimes "disestablished." "Of course, we do not say that facts are by definition true, so when they are discovered to be false, they simply cease to be, like Tinkerbell" (p. 268). Moreover, sometimes, facts can be "killer facts," like Galileo's telescopically attested assertion that Venus had moon-like phases, which among the *cognoscenti* killed off

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Ptolemaic cosmology (but not the Tychonic model). Wootton's whole section on words invigorates and refreshes one's mind by letting us taste the power and yet contingency of what we perhaps formerly thought were pedestrian or straightforward concepts.

Complaints? I have a few but not many. As an admiring student of Copernicus, I think Wootton underestimates his importance as a practitioner of what my friend Howard Margolis called "around-the-corner thinking" (*It Started with Copernicus*). In particular, in a book about real scientists practicing real science, I am disappointed that Thomas Digges—the first translator of Copernicus into any vernacular language (and it was into English!)—is given such short shrift. Digges was genuinely a mathematical scientist who in print declared for an infinite universe years before Giordano Bruno, whose execution for heresy in 1600 seems to have cemented his popularity among modern folks and whose books, Wootton writes, "mark a true revolution." On this topic, I am afraid I still concur with Ernan McMullin, who showed how poorly Bruno understood Copernicus, commenting that "to call Bruno a 'Copernican' requires one to empty the label of all content save the assertion that the earth and planets move around the sun."

But nothing can detract from Wootton's magnificent and learned achievement. I've never read a more compelling, knowledgeable, and (in an entirely non-trivial way) entertaining history of the Scientific Revolution, which, according to Wootton—and I think he's right—did take place and is still going on.

Dennis Danielson is Professor of English at the University of British Columbia. He is the editor of The Book of the Cosmos: Imagining the Universe from Heraclitus to Hawking (2000) and the author of The First Copernican: Georg Joachim Rheticus and the Rise of the Copernican Revolution (2006).

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Blockbuster Science: The Real Science in Science Fiction. David Siegel Bernstein. 336 pp. Prometheus Books, Amherst, NY, 2017. Price $24 (hardcover) ISBN 9781633883697.

Foundations of Quantum Mechanics: An Exploration of the Physical Meaning of Quantum Theory. Travis Norsen. 325 pp. Springer International Publishing, Switzerland, 2017. Price $44.99 (paper) ISBN 978-3-319-65866-7.

Game Changers: Stories of the Revolutionary Minds Behind Game Theory. Rudolf Taschner. 237 pp. Prometheus Books, Amherst, NY, 2017. Price $18 (paper) ISBN 9781633883741.

Gravitation. Charles W. Misner, Kip S. Thorne, and John Archibald Wheeler. 1329 pp. Princeton U. P., Princeton, NJ, 2017. Price $60 (hardcover) ISBN 978-0-691-1779-3. (Reimpression of 1973 edition with new foreword and preface.)

Introduction to Magnetohydrodynamics (2nd ed.). P. A. Davidson. 573 pp. Cambridge U. P., New York, 2017. Price $64.99 (paper) ISBN 978-1-316-61302-3.

Nonlinear Optics: A Student's Perspective—With Python Problems and Examples. Mark G. Kuzyk. 352 pp. Create Space Independent Publishing Platform, North Charleston, SC, 2017. Price $12.95 (paper) ISBN 978-1523334636.

Out of the Shadow of a Giant: Hooke, Halley & the Birth of Science. John Gribbin and Mary Gribbin. 318 pp. Yale U. P., New Haven, CT, 2017. Price $32.95 (hardcover) ISBN 978-0-300-22675-1.

Problem Book in Relativity and Gravitation. Alan P. Lightman, William H. Press, Richard H. Price, and Saul A. Teukolsky. 613 pp. Princeton U. P., Princeton, NJ, 2017. Price $49.95 (paper) ISBN 978-0-691-17778-6. (Reimpression of 1975 edition.)

Quantum Field Theory Approach to Condensed Matter Physics. Eduardo C. Marino. 535 pp. Cambridge U. P., New York, 2017. Price $84.99 (hardcover) ISBN 978-1-107-07411-8.

Spectral Analysis for Amateur Astronomers: A Guide to the Spectra of Astronomical Objects and Terrestrial Light Sources. Richard Walker. 290 pp. Cambridge U. P., New York, 2017. Price $89.99 (hardcover) ISBN 978-1-107-16590-8.

Spectroscopy for Amateur Astronomers: Recording, Processing, Analysis and Interpretation. Marc F. M. Trypsteen and Richard Walker. 163 pp. Cambridge U. P., New York, 2017. Price $49.99 (hardcover) ISBN 978-1-107-16618-9.

Thrust into Space: Official 50th Anniversary Reissue. Maxwell W. Hunter II. 236 pp. Create Space Independent Publishing Platform, North Charleston, SC, 2016. Price $24.95 (paper) ISBN 9781535173797.

The Beauty of Numbers in Nature: Mathematical Patterns and Principles from the Natural World. Ian Stewart. 223 pp. MIT Press, Cambridge, MA, 2017. Price $24.95 (paper) ISBN 978-0-262-53428-4.

The Formative Years of Relativity: The History and Meaning of Einstein's Princeton Lectures. Hanoch Gutfreund and Jurgen Renn. Princeton U. P., Princeton, NJ, 2017. Price $35 (hardcover) ISBN 978-0-691-17463-1.

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The Quantum Labyrinth: How Richard Feynman and John Wheeler Revolutionized Time and Reality. Paul Halpern. 311 pp. Basic Books, New York, 2017. Price $30 (hardcover) ISBN 978-0-465-09758-6.

Welcome to the Universe: The Problem Book. Neil DeGrasse Tyson, Michael A. Strauss, and J. Richard Gott, 260 pp. Princeton U. P., Princeton, NJ, 2017. Price $35 (paper) ISBN 9780691177809.

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