

Managing the bomb's supply side

Unmaking the Bomb A Fissile Material Approach to Nuclear Disarmament and Nonproliferation

Harold A. Feiveson, Alexander Glaser,
Zia Mian, and Frank N. von Hippel
MIT Press, 2014. \$30.00 (296 pp.).
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Reviewed by Matthew Bunn

Plutonium and highly enriched uranium (HEU) are the essential ingredients of nuclear weapons. They do not exist in appreciable quantities in nature and are quite difficult to produce. But with such materials in hand, most states—and potentially even some particularly sophisticated terrorist groups—would be able to make at least a crude nuclear explosive. Hence controlling those materials and the means to make them is a critical element of regulating the path to the bomb.

Unmaking the Bomb: A Fissile Material Approach to Nuclear Disarmament and Nonproliferation is a brilliant survey of how weapons-usable materials are controlled and produced. In clear, concise prose, Harold Feiveson, Alexander Glaser, Zia Mian, and Frank von Hippel take us from the dawn of the nuclear age to the present. (Truth in advertising: von Hippel is a friend and former boss of mine, and the other authors are colleagues.) They describe the technologies that can be used to produce plutonium and HEU; the history of production around the world; the global stockpiles of those materials and how to reduce them; the ways in which civil nuclear energy systems could increase states' ability to produce materials for weapons; and options for ending further production and civilian use of those materials, including for purposes such as scientific research and medical isotope production.

Unmaking the Bomb paints a deeply disturbing picture. Our species has produced enough separated plutonium and HEU for well more than 100 000 nuclear

weapons. Those materials, which exist in hundreds of buildings and bunkers in more than 20 countries—with widely varying security measures in place—create grave security dangers and potentially impose obstacles to disarmament. Fortunately, as the book makes clear, few technical barriers exist to reducing stocks of HEU. Indeed, until 2013 nearly 1 in 10 light bulbs in the US was being powered by material from dismantled Russian nuclear bombs. For 20 years the US had been buying low-enriched uranium produced from 500 tons of HEU—enough to fuel more than 20 000 nuclear weapons.

Plutonium presents a trickier problem. The fuel-production costs, including those to handle and secure the toxic, weapons-usable material, exceed the fuel's value. (Indeed, the cost of the US program to turn excess weapons plutonium into fuel has ballooned to more than \$30 billion.) The authors of *Unmaking the Bomb* explore several alternatives for plutonium disposal, particularly options for preparing it for storage in geologic repositories or deep boreholes.

Today nearly all nuclear power reactors use low-enriched uranium fuel that cannot support an explosive chain reaction. And although those reactors produce plutonium in their spent fuel, the amount is 1% by weight, and it would require a complex chemical process known as reprocessing to get the plutonium into a form that could be used in a bomb or recycled as fuel. The authors make a persuasive case that economics, safety, security, and nonproliferation arguments all tilt against such reprocessing for civilian power.

Unmaking the Bomb covers three topics surprisingly briefly. First, for a book whose subtitle includes the word “disarmament,” it only briefly addresses key aspects of that goal, from how nuclear weapons would be dismantled to how the whole process would be verified. It does, however, briefly discuss “nuclear archaeology” techniques that might be useful in determining whether countries' declarations of how much plutonium and HEU they have match up with the physical evidence from their production facilities. Second, the book devotes only a few pages to the global nuclear inspection regime imple-

mented by the International Atomic Energy Agency and how it might be strengthened.

Third, and most surprising, *Unmaking the Bomb* includes only a few sentences on keeping plutonium and HEU secure and out of the hands of terrorist groups—despite a global series of nuclear security summits that started in 2010. The final chapter recommends policy initiatives in four areas, but effective security of stockpiles is not one of them.

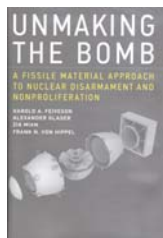
Fundamentally, managing the dangers posed by plutonium and HEU is one of the greatest challenges our species will face for decades—perhaps centuries—to come. *Unmaking the Bomb* is essential reading for understanding that challenge and the steps that would be needed for the world community to rise to it.

An Observer's Guide to Clouds and Weather A Northeastern Primer on Prediction

Toby Carlson, Paul Knight, and
Celia Wyckoff
American Meteorological Society,
2014. \$30.00 paper (224 pp.).
ISBN 978-1-935704-58-4

With meteorological practice currently focusing on mathematical modeling and quantitative analysis, it is refreshing to read a solid academic return to the more artful, look-out-the-window aspects of the field. *An Observer's Guide to Clouds and Weather: A Northeastern Primer on Prediction* is a handy book that will serve the atmospheric science community well as both an introduction for undergraduate students and a refresher of the fundamentals for long-time practitioners.

As stated in the preface, the authors “wish to make the reader's experience much more intimate with the atmosphere than simply viewing computer-generated output.” The authors are Toby Carlson, an emeritus professor in the Pennsylvania State University's department of meteorology; Paul Knight, a senior lecturer in the department and the climatologist for the Commonwealth of Pennsylvania; and Celia



Matthew Bunn is a professor of practice at Harvard University's John F. Kennedy School of Government in Cambridge, Massachusetts, and leads Harvard's Project on Managing the Atom.

Wyckoff, former editor for Penn State's *World Campus*, who also contributed cloud photographs.

I was a Penn State meteorology undergraduate student in the 1970s, when Knight was a graduate student there; my first class in the discipline was synoptic meteorology, taught by Carlson. He was a terrific teacher, clear in his instruction and supportive of his students' development. His and Knight's engaging teaching and writing styles are apparent in the *Observer's Guide*. For example, in chapter 1, "The Basic Processes That Create the Weather," lucid analogies help explain key concepts such as the Coriolis force and the balance of forces. Moreover, the authors aptly supply context: "The atmosphere is in a tenuous balance between two large forces, the Coriolis force and pressure gradient force. Imbalances are nevertheless necessary for cyclones and anticyclones to move, develop, and decay, and for the transfer of heat from lower to higher latitudes."

In chapter 2, "Cloud and Weather Patterns," the authors continue to lay the foundation necessary to understand the material presented in later chapters about reading the sky and forecasting the weather. They elucidate the classic open wave cyclone. Clear, sequential figures accompanied by synoptic-map depictions aid the reader's understanding of atmospheric stability, the upper atmosphere, and cyclonic development and its connection to advection. I found the up-to-date discussion of the occlusion process in the evolution of fronts to be particularly enlightening. Other fine presentations, with appropriate photos and diagrams, show up in subsequent chapters and cover such topics as smaller-scale storms and the basics of weather forecasting, explanations for familiar storm systems like the Alberta clipper and the nor'easter, diurnal events such as sea breezes, and somewhat atypical events like backdoor cold fronts. The superiority of ensemble forecasting is also addressed.

The sixth and final chapter, "The Observer's Guide to Weather Forecasting," synthesizes the content of the previous chapters. As the title indicates, it guides the reader through practical exercises by using weather observations coupled with map analysis. The authors note that "good observations—paying close attention to the evolving sky panorama—can help both the professional forecaster and the amateur to better understand the meteorological events taking place and thereby to improve their forecasts, especially those

short-range, local forecasts referred to as nowcasting." Creative techniques and time-tested wisdom, including appropriate caveats, are proffered. Helpful hints and rules of thumb for effective forecasting abound.

One particular concern I have with the book is the small size of the cloud photographs and related satellite maps. Those images are important to understanding descriptions given in the text, so larger exhibits and, in some cases, exhibits with better contrast would certainly help improve the reader's comprehension.



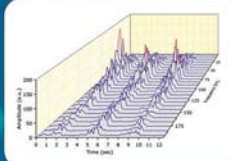
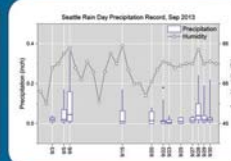
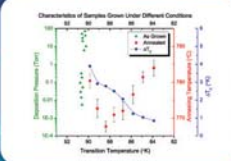
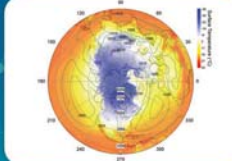
Serious students will profit greatly by carefully reading *An Observer's Guide to Clouds and Weather* before their first introductory course in meteorology, especially since many essential terms and dynamics, such as "baroclinic," "frontogenesis," "static stability," and "vorticity," are identified and succinctly explained. Interested laypeople, amateur weathercasters, and professional meteorologists will all find this concise volume to be a beneficial guide to the airy world around us. After all, as the authors conclude, "meteorologists, including many

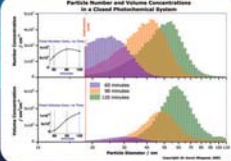
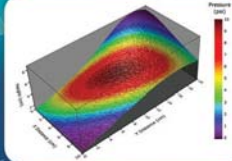
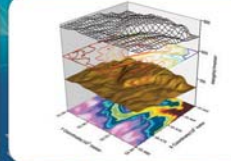
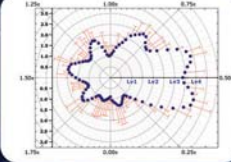
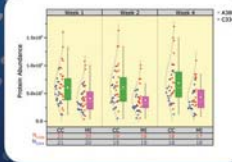
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meteorology students, sometimes lose themselves in a welter of computer simulations. Sometimes what is missing is to simply read the sky!"

Anthony J. Sadar

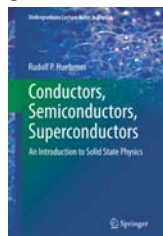
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Conductors, Semiconductors, Superconductors An Introduction to Solid State Physics

Rudolf P. Huebener
Springer, 2015. \$59.99 paper
(215 pp.). ISBN 978-3-319-09140-2

With its commonplace title, *Conductors, Semiconductors, Superconductors: An Introduction to Solid State Physics* might appear to be just another introductory text covering this well-established area of contemporary physics. Actually, it is anything but typical.

Written by University of Tübingen professor Rudolf Huebener and originally published in German in 2013, *Conductors, Semiconductors, Superconductors* aims to generate interest in students and young scientists and to serve, as stated in the preface, "as a motivating pre-stage and companion of the established and very detailed textbooks." It guides the reader through the major themes of solid-state physics from a historical and human perspective and provides insight into the way the topics were originally understood by early leaders in the field.



Mainstream science textbooks do not usually focus on the human aspects; Huebener's, by contrast, includes lesser-known details about seminal figures. The result is a technical text interlaced with many historical digressions, including portraits, reproductions of lab notebooks, images of various instruments, and historical illustrations of the described phenomena. Consequently, the book provides a refreshing reminder of why, even in our digital age, good old-fashioned record keeping remains important. The text also notes that many important scientific discoveries were made by young scientists, a fact that should motivate the target audience.

The book's unique approach makes it a pleasure to read and will inspire readers to want to learn more about its topics—both their science and their his-

tory. The impressive list of selected physics and chemistry Nobel Prizes is a nice finishing touch that highlights the importance of the subjects selected for treatment in this relatively concise text.

The author chose to focus on electronic phenomena that, not being amenable to classical-physics descriptions, demonstrate the reality of quantum mechanics. He describes experimentally accessible macroscopic quantum systems, notably superconductors and systems with long-range magnetic order, from the unified point of view of the electronic structure of solids. And he underscores the important roles of the atomic arrangement in the crystal lattice, the nature of the chemical bond, chemical composition, and behavior at the nanometer scale. The discussion is illustrated by examples of milestone advances and inventions, such as the discovery of superconductivity and the invention of x-ray spectroscopy, transistors, solid-state lasers, electron microscopy, and quantum interference devices.

Huebener is known worldwide for his scientific contributions to many of the phenomena he discusses. His book *Magnetic Flux Structures in Superconductors* (extended reprint, Springer, 2001) is one of the most cited academic works on that topic. I have no doubt that *Conductors, Semiconductors, Superconductors*, the most recent of his books targeting younger scientists, will be of broad interest to students and researchers in the natural sciences and engineering. It will also nicely complement more advanced but somewhat dry academic texts. I, for one, would be delighted to recommend this book to the students taking my class.

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Are We All Scientific Experts Now?

Harry Collins
Polity, 2014. \$12.95 paper (140 pp.).
ISBN 978-0-7456-8204-4

In his remarkable manifesto, sociologist Harry Collins, a major voice in the field of science studies, answers the provocative question presented in the book's title: *Are We All Scientific Experts Now?* Collins starts out by outlining science's fall from grace in the public's eye and by presenting a tongue-in-cheek caricature of scientific expertise based on the zeitgeist he holds responsible for the distortions. He goes on to present a compelling "taxonomy of expertise"

that leads him to deny, in no uncertain terms, the specialist status to anyone who is not a member of the scientific community and is not able to make "judgements from the platform of the norms and aspirations that drive the community."

Collins contrasts two waves of studies that led to very different views of science. In the first, iconic and heroic scientists with unique knowledge were elevated to almost mythological status; the rest of society was left to marvel at and celebrate the benefits of their work. The second wave, in which Collins played a major role, set out to question and deconstruct the scientific mythos. Its call to arms was Thomas Kuhn's *The Structure of Scientific Revolutions* (University of Chicago Press, 1962).

Indeed, the second wave showed that science was much more messy and complex than previously thought. That is illustrated by what chemist and philosopher Michael Polanyi called "tacit knowledge," the idea that scientists and other creators are guided by more than what can explicitly be exchanged using the written and spoken word. Tacit knowledge is beautifully illustrated by Collins in his study of the development of the transversely excited atmospheric laser. The realization that science has a tacit, cultural component led some in the public arena to call for an egalitarian-derived dismissal and devaluation of scientific expertise, a diminishing of scientists' authority in society, and an advocacy for broader participation of nonexperts when making technical decisions.

Unfortunately, Collins only briefly sketches the unintended and detrimental impacts that the diminishment of science's role has had on science itself and on Western society. That vaguely criticized zeitgeist warrants a much deeper analysis. At the same time, I'm impressed by the author's self-critical assessment of wave two—in particular, his acknowledgment of the need to restore the privileged role of experts in technical decision making. His call for a third wave of science studies to correct overinterpretations and reverse policies and societal trends caused by the diminished recognition of scientific expertise is in itself remarkable.

Collins's new book contains some gems. In particular, his taxonomy of expertise will help scientists understand why the foundations of expertise often shift and experts are often contested in the public arena. There's ubiquitous expertise, which is acquired simply by growing up in society and learning to