BOOK REVIEWS

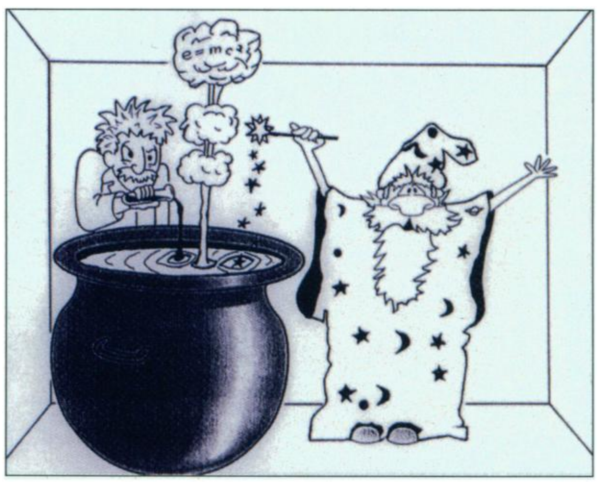
Public Understandings

Conjuring Science. Scientific Symbols and Cultural Meanings in American Life. CHRISTOPHER P. TOUMEY. Rutgers University Press, New Brunswick, NJ, 1996. x, 199 pp. $47, ISBN 0-8135-2284-6; paper, $16.95, ISBN 0-8135-2285-4.

Science, according to Christopher P. Toumey, is regarded by most laypeople in the United States in an "Old Testament style," much as the Israelites beheld Jehovah: with respect, fear, and utter incomprehension. This is not a happy state of affairs, says Toumey, even if some scientists think they like the idea of being an object of worship from afar. Because the average person "knows science only in terms of certain symbols that stand for science" (p. 7), the public is vulnerable to manipulation by anyone capable of deploying those symbols effectively. Present some superficially plausible credentials, don the white lab coat, or speak in mathematical formulas, and *Voilá!*—you have "conjured" scientific authority out of thin air, and surprising numbers of people will pursue your path toward the Promised Land as surely as once they followed a cloud by day and a pillar of fire by night.

Furthermore, suggests Toumey, in the absence of any broad-based understanding of scientific reasoning, scientific controversies become blank screens onto which the multifarious hopes and fears of a culture can be projected. Debates ostensibly about the risks and benefits of fluoridating public water supplies, or about the validity of reports of successful cold fusion, are transmuted into emotional dramas of government conspiracies or technological quick fixes. In 1986, Toumey reminds us, three months before election day, nearly half the respondents in a survey of California voters supported a ballot measure sponsored by right-wing conspiracy-monger Lyndon LaRouche calling for the quarantine of those infected with HIV. Though the measure was defeated, the episode illustrates the true dangers of scientific illiteracy, in Toumey's view—not just, as is often claimed, that tomorrow's adults will be unprepared for the demands of the workplace, but that sectors of the public, led by "conjurers" such as LaRouche, will impose their opinions in scientific controversies, and will do so not from an appreciation of the scientific issues but in satisfaction of their existential needs.

In this engaging and clearly written book, Toumey, a cultural anthropologist, demonstrates how the symbols that stand for science "become severed from the substance of science and then reattached to other meanings" (p. 59). Through a series of brief case studies of controversies surrounding such issues as fluoridation, AIDS, cold fusion, and evolution, Toumey reminds us of the obstacles impeding the public's understanding of science: the tendency, for example, on the part of the media to portray scientific controversies as having "two sides" with roughly equivalent credibility;



Conjuring science. [From the cover of the book with that title; Kathryn Luchok]

or the public's tendency to demand certainty from science and then to regard admissions of uncertainty as evidence of the bankruptcy of scientific institutions. Toumey also argues that these conditions have arisen relatively recently in the United States. During the Colonial era and through the early 19th century, the public applauded the study of nature as virtuous and viewed the practice of scientific investigation as unmysterious. By the late 19th century, as science became professionalized and insulated, scientists' ways of looking at the world became known to outsiders principally through the work of popularizers—science journalists and science teachers, who, in Toumey's view, have done a distressingly poor job of teaching the culture and values of science while doing a distressingly successful job of perpetuating myths.

Solutions to the problems documented in this book are not going to be simple, but it is unfortunate that the author speculates so little about specific implications of his analysis. Rather than suggest, for example, how science journalism and science education might be improved, Toumey tends to be dismissive toward these professions and to paint them with a broad brush. Other shortcomings of the analysis are noted by Toumey himself. The book makes arguments about American exceptionalism but offers no cross-cultural data: Is science conjured differently in other societies? Is public understanding of science really better in other countries? Toumey claims that some European countries have developed meaningful forms of public participation in science, such as the Danish "consensus conferences," which assemble panels of laypeople to scrutinize scientific issues and offer informed opinions. But if the United States is so backward in this regard, how do we explain the pioneering strategies of self-education developed by U.S. AIDS activists, who have taught themselves the relevant virology and immunology and now contribute to scientific discussions of research priorities and clinical trial methodologies?

It is also unfortunate that Toumey sustains, at an analytical level, the same divide between the world of science and the broader society that he decries at the practical level. While Toumey is fascinated by the cultural meanings that laypeople superimpose onto scientific claims, he fails to devote attention to the meanings that scientists themselves promote as they seek to make sense of their endeavors. Toumey argues that his lack of analytical symmetry is justified because scientists communicate in a spare, stripped-down vocabulary that lacks the metaphorical flourish of the extrascientific conjurers. But though this may be true of formal scientific writing, it doesn't describe how scientists talk, either among themselves or to outsiders. A compelling argument could be made that an anthropological inquiry into the place of science in modern society should examine the beliefs of scientists and laypeople alike.

Toumey again rules the world of science out of bounds for analysis when he suggests that the adjudication of controversies by scientists themselves is straightforward and requires no investigation. The cold fusion controversy, for example, would have been resolved rapidly through attempts to replicate the findings of Stanley Pons and Martin Fleischmann, claims Toumey, had not the media complicated the evaluation process by transforming the story into a moral battle with heroes and villains. In fact, replication in science is often far from simple, as Harry Collins and Trevor Pinch argue in *The Golem* (Cambridge Univ. Press, 1993), one of the most important books on the public understanding of science (but one that Toumey does not cite). As Collins and Pinch note in their own discussion of cold fusion, it was no easy task for experts to decide whether particular scientists had adequately repeated Pons and Fleischmann's experimental procedures. Therefore (p. 69) "negative results could be explained away by the believers as being due to differences in the replicating instrument." The bottom line is that scientists, just like laypeople, are constantly in the business of assessing who or what is credible. To address the manipulations of science that Toumey eloquently describes, and to work toward more productive relations between scientists and laypeople, we must gain a clearer understanding of the processes by which scientific credibility is asserted, evaluated, and contested, both within the inner circles of science and in the broader society.

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Vignettes: Yesteryear in Oxbridge

At Oxford [William Henry] Perkin . . . replaced . . . William Odling, who had retired from the Waynefleet chair in 1912 at age 83, after occupying it for forty years. A cultivated Nestor of chemistry, Odling was a connoisseur of engravings but not interested in the patient pursuit of detail via experiments done at the laboratory bench. Preferring the philosophical and speculative aspects of chemistry, Odling was not the slave of his laboratory, which he thought it a breach of etiquette for the professor to enter. . . .

Oxford was a collegiate university devoted to arts subjects, teaching, and connoisseurship; science was seen as peripheral, specialist publication suspected as narrow, and from the colleges' enclave, research seen as an ungentlemanly, boorish, and even foolish German idea.

—*Jack Morrell*, in *Research Schools: Historical Reappraisals* (Gerald L. Geison and Frederic L. Holmes, Eds.; *Osiris*, vol. 8)

We were a polite society and I expected to lead a quiet life teaching mechanics and listening to my senior colleagues gently but obliquely poking fun at one another. This dream of somnolent peace vanished very quickly when Rutherford came to Cambridge. Rutherford was the only person I have met who immediately impressed me as a great man. He was a big man and he made a big noise and he seemed to enjoy every minute of his life. I remember that when transatlantic broadcasting first came in, Rutherford told us at a dinner in Hall how he had spoken into a microphone to America and had been heard all over the continent. One of the bolder of our Fellows said "Surely you did not need to use apparatus for that."

—*Geoffrey Taylor*, 1952, as quoted by George Batchelor in *The Life and Legacy of G. I. Taylor* (Cambridge University Press)

Neutrino Questions

Stars as Laboratories for Fundamental Physics. The Astrophysics of Neutrinos, Axions, and Other Weakly Interacting Particles. GEORG G. RAFFELT. University of Chicago Press, Chicago, 1996. xxii, 664 pp., illus. $77 or £61.50. Theoretical Astrophysics. ISBN 0-226-70271-5.

The foundation of astrophysics is the belief that the same laws of physics that hold on Earth govern what goes on in the stars. Thus we can use nuclear cross-sections, atomic energy levels, and fundamental laws discovered in our terrestrial laboratories to calculate stellar processes. However, there may be relevant fundamental physics that has not yet been discovered on Earth. This leads to the possibility that new laws of physics may be discovered by studying the stars. It is this possibility that is the subject of Raffelt's book.

The physics of interest to Raffelt concerns the properties of elementary particles, primarily neutrinos and hypothetical particles called axions. In fact, more than half the book is devoted to neutrinos. The importance of neutrinos for astrophysics derives from the fact that they are the only known particles that interact only weakly. This means that if they are produced at high temperatures inside stars they can escape more easily than other particles and so can be a major agent of energy loss. In the case of a collapsing star leading to a type II supernova, nearly all of the energy of collapse (of order 10^{53} ergs) is emitted in the form of neutrinos over a period of about 10 seconds. The fact that neutrinos can escape easily from deep inside a star means that neutrino astronomy could make possible the study of stellar regions that cannot be directly explored in any other way. In particular, the detection of neutrinos from the sun has confirmed our general picture of the nuclear reactions occurring there.

The one indication of new physics from astrophysical observations is the quantitative disagreement between the measured neutrino fluxes from the sun and the results of detailed calculations. This could be explained by oscillations of electron-neutrinos from the sun into another type of neutrino if neutrinos have mass. Indeed, this is the strongest evidence available in favor of a non-zero neutrino mass. The subject of neutrino oscillations and solar neutrinos is covered very clearly in the book. Though the treatment is not as detailed as that in *Neutrino Astrophysics* by John Bahcall (Cambridge Univ. Press, 1989), it is very adequate and up to date.

The detection of neutrinos from a supernova in the Large Magellanic Cloud in 1987 (SN1987A), even though they were only 19 or 20 in number, was one of the most important astrophysical events of recent times. These were the first neutrinos observed from a source outside the solar system, and they actually came from outside our own galaxy. Raffelt develops in detail theoretical analysis, much of it his own original work, on the propagation of neutrinos in dense media such as supernova cores. A variety of conclusions have been drawn from the observation of SN1987A neutrinos, ruling out exotic sources of energy loss, limiting the Dirac mass and magnetic moments of neutrinos,