Does Science Education Need the History of Science?

By Graeme Gooday, John M. Lynch,** Kenneth G. Wilson,*** and Constance K. Barsky*****

ABSTRACT

This essay argues that science education can gain from close engagement with the history of science both in the training of prospective vocational scientists and in educating the broader public about the nature of science. First it shows how historicizing science in the classroom can improve the pedagogical experience of science students and might even help them turn into more effective professional practitioners of science. Then it examines how historians of science can support the scientific education of the general public at a time when debates over "intelligent design" are raising major questions over the kind of science that ought to be available to children in their school curricula. It concludes by considering further work that might be undertaken to show how history of science could be of more general educational interest and utility, well beyond the closed academic domains in which historians of science typically operate.

IF EVERYBODY LEARNED THE HISTORY OF SCIENCE, would it help us save our planet? Maybe so.[1] Would it benefit any civilization beyond the Earth to know the history of terrestrial science? Probably not. Have any Nobel Prize winners declared that history of science was the secret of their creative success? Well—not yet, anyway. History of science is thus probably not quite the universal panacea that some of us—in our more hyperbolic moments, at least—have been tempted to claim. Granted these caveats, historians of sciences are surely not indulging in their discipline only for their personal gratification. There are arguably great benefits to studying the history of science that others can share, most especially benefits for science students learning the history of their particular discipline. This kind of claim is neither mere truism nor partisanly self-serving

* Division of History and Philosophy of Science, Department of Philosophy, University of Leeds, Leeds LS2 9JT, United Kingdom.

** Barrett Honors College and Center for Biology and Society, Arizona State University, Tempe, Arizona 85286-1612.

*** Department of Physics, Ohio State University, Columbus, Ohio 43210.

**** Learning by Redesign, Granville, Ohio 43023.

[1] Naomi Oreskes's contribution to this Focus section (coauthored with Zuoyue Wang) illustrates that this is not beyond the realm of possibility.

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rhetoric. But to prove it historians of science need good dispassionate and well-evidenced reasons to defend the educational benefits of their subject. In what follows, we offer some such reasons.

First among them is that at least one Nobel laureate (in physics) has already found benefits in introducing history of science in the precollege science curriculum. Kenneth G. Wilson, in collaboration with Constance Barsky, has conducted over a decade of research on the impact of such integrated historical teaching in that particular educational sector. They argue that exposure to the history of science helps students considering science as a career to think, ask questions, and explore the concepts and ramifications of broad topics, enabling them to grasp what science is about and how it is conducted. In particular, they suggest focusing on such topics as the history of engineering and the recognition that the existence of a large number of concurrent redesign processes in science and technology can build understanding of how and why socioeconomic changes arise as new versions of artifacts are introduced. More generally, they suggest that knowledge and understanding of the history of science can enable future practitioners of science better to anticipate and respond to the challenges of rapid globalization and be better prepared to mold our future.[2]

Following in this vein, the remainder of this essay answers our opening question in the affirmative. It does so by documenting two of the specific benefits for science of education in history of science: in the training of prospective vocational scientists and in educating the broader public. We will be avowedly instrumentalist and science-friendly in considering how—and how far—history of science can enhance the learning of science and perhaps even help make its students into better scientists. After examining the role of *history* of science in the education of future scientists, we will also consider the role *historians* of science can play in the education of the general public, particularly at a time when—in the United States, at least—science education is being challenged in debates over so-called intelligent design. Finally, we invite discussion of ways in which further research on the learning and teaching of history of science can bring benefits to educators who too often find themselves obliged to defend what they do every day; taking this approach further still, we argue for the value of history of science being taken up beyond the walls of the academy.

BRUSHING UP THE PEDAGOGICAL CASE FOR HISTORY OF SCIENCE IN THE UNDERGRADUATE CLASSROOM

There are two possible objections to our instrumentalist, science-friendly approach. The busy historian of science, overwhelmed with large classes of science majors, might observe that it's just plain common sense to say that these students generally not only like studying history of science but also evidently benefit from it. But this is a primitively obvious fact only to those with close daily experience of teaching. The skeptic who knows

[2] Given the limits of current K–12 education in practice, Wilson and Barsky propose that a pilot curriculum and teacher preparation project be established to test such ideas, with follow-ups perhaps ten and then twenty years later. Teacher preparation is likely to be a critical issue: at present, they believe, few education reform projects—especially those in mathematics and science—supply enough preparation and technical assistance, and with sufficient quality, for teachers' historical work with precollege students to have much hope of success. Kenneth G. Wilson and Constance K. Barsky, "Applied Research and Development: Support for Continuing Improvement in Education," *Daedalus*, 1998, *127*:233–258; and Barsky, Wilson, and B. Daviss, "A Model Development Concept (MDC) for Education: A Framework for Change," *Proceedings of the Redesign in Science Education Conference (RISE)*, Columbus, Ohio, 20–21 Oct. 2000.

nothing of our classroom labors might ask the telling question about opportunity cost: Isn't there something else that students might more profitably spend their time learning? Why devote time to learning history of science when there are so many other valuable mind-broadening disciplines that might fulfill the liberal studies requirements of the science major's crowded curriculum? We concede that the useful analytical skills cultivated by history of science could be picked up by studying other forms of history. Nevertheless, we believe that the history of science cultivates particularly important forms of knowledge and understanding concerning science that cannot be obtained so effectively by any other means.

The other objection is rather more challenging: that history of science dangerously corrupts the science student and thus should not be studied at all. This superficially bizarre claim was first addressed over three decades ago by Stephen Brush in his oft-cited piece "Should the History of Science Be Rated X?" That essay examined a claim attributed to some unnamed historians—namely, that past scientists' behavior might provide a poor model for science students to follow in developing a virtuous career; worse than that, candid historical revelations might dispose them to doubt the integrity of science altogether. Somewhat revealingly, Brush never actually pinpointed any specific claim from either a historian or a scientist that science students should not study the history of science lest some dreadful disadvantage befall them.[3]

The two strongest claims identified by Brush fall well short of such dire predictions. First, he cites a 1967 survey of science teachers that revealed a consensus that history of science was not a "legitimate subject" to be addressed in a science curriculum; yet there was no suggestion that extracurricular pursuit of history of science was therefore necessarily *illegitimate*. Brush also cites Thomas Kuhn's comment that historical studies might divert the science student from the most productive research career; but this is no more than a pessimistic view of one possible outcome, since Kuhn does not deny that other such students might derive at least some kind of benefit from the history of science.[4]

Overall, Brush's conclusion in 1974 was that for anyone wanting to promote ideal models of behavior in science, history of science simply was not an appropriate resource: if you want role models for scientists, he suggested, you might as well turn to fiction instead.[5] Nowadays, amid growing concerns about fraud, inhumanity, and accountability in science, such a project would probably have recourse to the myriad publications in applied ethics. But nowadays also, it could be said, the force of Brush's concern is no longer hypothetical. Two recent phenomena in American culture have highlighted two sources of hostility to history of science—or at least *particular* forms of the history of science as manifested both in education and in public culture more generally.

[3] Stephen Brush, "Should the History of Science Be Rated X? The Way That Scientists Behave (According to Historians) Might Not Be a 'Good Model' for Such Students," *Science*, 1974, *183*:1164–1172. These remarks on Brush's lack of specificity derive from Graeme Gooday, "U-Rated Not X-Rated: Reassessing How Science Students Could Benefit from Learning History of Science," 2005, http://prs.heacademy.ac.uk/view.html/prsdocuments/68.

[4] Brush, "Should the History of Science Be Rated X?" p. 1165. However, see Brush's comments on how Kuhn was interpreted as offering an antiscience message in his discussions of L. Eisenbud's speech "Science for Antiscientists," presented at the American Physical Society meeting, Washington, D.C., 26 Apr. 1972: *ibid.*, p. 1172 n 58. For further discussion of Brush see Eugene Garfield, "Current Comments: Identifying Paradigms in Science," *Current Contents*, 1974, *17*:5–6. For a more recent response see Jane Maienschein, "Why Study History for Science?" *Biology and Philosophy*, 2000, *15*:339–348; and Richard Duschl, "Using and Abusing: Relating History of Science to Learning and Teaching Science," 2000, http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/0000019b/80/1a/c1/90.pdf.

[5] Brush, "Should the History of Science Be Rated X?" pp. 1170–1171.

A decade ago, several scientists in the "Science Wars" revealed their concern that certain kinds of science studies scholarship was cultivating a pernicious form of relativism that undermined science and corrupted those who studied it. More recently, the intervention of the social epistemologist Steve Fuller in the *Kitzmiller v. Dover* trial, where he sought to historicize the case for intelligent design in science, prompted scientists once again to denounce the inappropriate use of history of science (albeit Fuller's own version) to undermine the authority of science.[6] Yet few conscientious teachers of history of science today need worry much about falling foul of such criticism: does any of us actively promote either relativism or the sabotage of scientific authority as an overt (or even covert) goal in our curricula? Such outcomes might occasionally be the unintended side effects of how science students interpret their class materials. But this is surely no more dangerous to science than the well-established phenomenon that at least some such students have loved their history of science classes so much that they abandoned science and took up the professional study of its history instead.[7] And who knows whether that has been to the detriment of science?

But if we can take care neither to teach irresponsible forms of history of science to our students nor to teach them too much of it—nor too well, lest we transform all science majors into historians of science—what then can be said of the positive benefits to the science student? Most obviously, they can learn key *skills* that might not be so readily attained in the science curriculum.[8] These might include the ability to read and interpret primary sources (e.g., Darwin's *Origin of Species*), acquired through detailed class study. Students can develop confidence in critical thinking of the sort required to evaluate secondary scholarship. Moreover, they can learn that one route to intellectual independence from fallible secondary sources is to learn to rely judiciously on other, more trustworthy authorities—notably primary sources. Finally, they can learn to formulate, marshal, and defend a cogent argument, such as that required in a senior thesis. It could, of course, be claimed that these skills could also be learned by studying other forms of history—say, environmental history or political history; and maybe these would be of greater interest for at least some science students. But for those who want to keep in sight of their main discipline, what better way of developing these skills than helping them to build on the science that they already know, into areas of history that are actually germane to their professional development?

There is perhaps a stronger case for including history of science within the science students' curriculum. By learning about their disciplines' past, such students can acquire professional orientation to and initiation in both the subculture of their chosen field and its broader cultural setting. As an extension of that, students can learn who the major players

[6] For the concerns that prompted the "Science Wars" see Paul R. Gross and Norman Levitt, *Higher Superstition: The Academic Left and Its Quarrels with Science* (Baltimore/London: Johns Hopkins Univ. Press, 1994). Reacting to Fuller's intervention see Steve Mirsky, "Teach the Science," *Scientific American*, Feb. 2006, pp. 36–38. Fuller has received considerable criticism from fellow scholars in science and technology studies; see below for further discussion of this point.

[7] This was the case with one author of this piece (Graeme Gooday). It would be interesting to know from *Isis* readers what proportion of them moved into history of science for just this reason.

[8] What follows summarizes Gooday, "U-Rated Not X-Rated" (cit. n. 3). That piece draws on the U.K. Quality Assurance Agency Benchmark statements for Higher Education curricula that aim to spell out the key skills, knowledge, and understanding for all major Higher Education disciplines. For Honors degrees see http://www.qaa.ac.uk/academicinfrastructure/benchmark/honours/. For an attempt to develop a comparable benchmark statement for history of science, technology, and medicine see http://prs.heacademy.ac.uk/view.html/prsdocuments/114.

in their fields were: beyond noting passing references to canonical figures or eponymous laws or constants, they can learn about Charles Darwin, Michael Faraday, or Marie Curie-Sklodowska and about the life and work that led to the creation of the canon. Similarly, they can learn about the provenance of standard techniques by way of historical study of their origins, the vivid familiarity thereby attained thus at the very least making it easier to remember what might otherwise be dull facts. And last, but not least, students can become acquainted with the key institutions, formative episodes, and accomplishments of their fields, a process that can contribute to the formation of professional identity in ways that are probably more effective than simply learning and replicating the contents of science textbooks and laboratory routines.

Arguably most important is the understanding of the broader processes of science that studying its history can uniquely offer. The key role of history here is characterizing the complexities of how science *changes*. So many science textbooks unhelpfully—and above all inaccurately—cultivate a rather static image of scientific disciplines, as if they were completed with comprehensive certainty. It is perhaps not difficult to understand how this gross oversimplification might arise as the result of a pedagogical need to "tidy up" the presentation of science to meet the needs and capacities of students. But faced with the textbook spectacle of such an apparently unalterable monolith, is it any wonder that students can have difficulty conceiving how they might ever contribute to science?

By contrast, studying the history of science as a *process* of perpetual flux and innovation can cultivate their expectations of how they might contribute to future forms of its change, especially by interactions with medicine and technology. Moreover, if student expectations are better attuned to open-endedness in the character of science, they can more readily appreciate the incompleteness and fallibility of models and theories they regularly (and thus perplexingly) have to discard as they encounter each new stage of their curriculum. Much more of science thus becomes comprehensible through study of its history—and in ways that cannot easily be addressed by scientists working within a time-pressured science curriculum.

Nevertheless, the skeptical reader will voice a number of doubts about these claims for the unique value of history of science in science pedagogy. Are these not merely aspirational rather than empirical claims? They perhaps seem to refer only to an idealized world in which the educational aims and values of teachers are completely fulfilled in practice—and how often is that accomplished? We have also rather obviously not yet allowed for such contingencies as the skills of teachers in accomplishing their goals and the variable receptivity of science students to unfamiliar messages in unfamiliar disciplines.

To test the plausibility and even the actualization of these claims, we thus need future research to bring us the testimony of science students about their experience of studying the history of science.[9] We also need to cultivate some comparative capacity to track the careers of those scientists who studied the history of science to see what benefits—if any—it brought them in the longer term. Most important, we need someone other than a historian of science to participate in carrying out and interpreting such tests. After all, why should skeptical students trust the self-interested testimony of historians of science who tell them that they need to learn the history of science? Historians of science thus need to

[9] Unfortunately, we must accept that it is probably unethical to engage in controlled tests on science students, allowing only some to take history of science courses!

collaborate with scientists to ensure that claims made about the need for history of science in the natural science curriculum are not mistaken for wishful thinking.

Having outlined a view of the value of teaching history of science to science students that broadly agrees with the benefits suggested by Wilson and Barsky, let us look at one specific area where interaction between historians and scientists has already shown clear benefits for science education.

HISTORY OF SCIENCE IN THE SERVICE OF EDUCATIONAL ACTIVISM

The specific area in which we feel that historians can further aid science education is in countering the assault on it currently being mounted by various groups of antievolutionists, whether believers in a young earth or in intelligent design. This is currently a problem that is probably unique to the United States, but it has the potential to become a global concern for educators and scientists. Focusing thus on the particularities of the U.S. case, as historians, we care about both history *and* science, and we need to ask ourselves what we can do to support the cause of science education in the troubled climate of American public education. In short, we should ask ourselves, What is the value of history of science in the two-pronged strategy to preempt the unwarranted incursions of creationism and to promote the goal of attaining excellence in science teaching?

Antievolutionism has been a resilient factor in American society since the publication of Darwin's *Origin of Species* in 1859. There have been numerous opportunities for historians and philosophers to enter the public square to clarify or conceptualize the issues at stake and elevate the cultural discourse. While the philosophers appear relatively involved (for example, in addressing claims that evolution is "just a theory"), the engagement of historians seems to be a little underdeveloped. Yet one should not imagine that historians have remained completely uninterested in the issue; it is only that they have been *relatively* uninvolved.[10] So what can historians of science add to this public discourse about science education? Obviously they can provide historical analyses that place current public and scientific controversies into perspective. Equally important, they can correct misguided attempts at revisionist history that misinform the public about science.

Beginning in 1968, a series of judicial decisions, culminating in *Edwards v. Aguillard*, deftly excluded scientific creationism from the American public school science classroom. As the historian Barbara Forrest demonstrated in her testimony at the *Kitzmiller v. Dover* trial, creationists almost immediately responded by rebranding their writings.[11] They dropped all references to a "creator" and appealed instead to an "intelligent designer," and mentions of "creationism" and its cognates became references to "intelligent design." Over 150 years ago, writing of the claims of critics he condemned as "anti-geologists," Hugh Miller commented that "the follies of the present day" are copies, "unwittingly produced, and with of course a few variations, of follies which existed centuries ago."[12] Forrest's testimony demonstrated that intelligent design creationism was just such a copy—*wittingly* produced, as it were, and aimed at inserting scientific creationism into the

[10] The magnum opus on American antievolutionism remains Ronald Numbers's *The Creationists*, which has recently been reissued in an expanded version (Harvard Univ. Press, 2006). It is worth noting that Numbers has become politically active in counteracting creationism; see http://www.bpnews.net/bpnews.asp?ID=22610.

[11] The decisions in question are *Epperson v. Arkansas* (1968), *McLean v. Arkansas* (1981), and *Edwards v. Aguillard* (1987). Complete trial archives for *Kitzmiller v. Dover* are available online at http://www2.ncseweb.org/wp/?page_id=5.

[12] Hugh Miller, "The Physical Science Chair," *Witness*, 17 Sept. 1845, p. 396.

curriculum under a new name. Her historical testimony on this point was central to Judge John E. Jones III's decision to censure the Dover Area School District for attempting to introduce intelligent design into its curriculum. Of course, such forms of public engagement are not without their perils. Steve Fuller received significant criticism from his own academic community for his involvement in the *Kitzmiller v. Dover* trial. It was clear to many that Fuller's treatment was a result of his entering a domain beyond the scope of his established research expertise; his experience serves as a warning for any historian of science considering entering the legal arena on the intelligent design debate—or, indeed, on any other publicly contested issue.[13]

Antievolutionists have traditionally played fast and loose with history in ways that historians of science are particularly well placed to identify and correct. There is a long—but poorly evidenced—tradition of claiming, for example, that Karl Marx and Friedrich Nietzsche were followers of Darwin or that scriptural geologists (Miller's "anti-geologists") were as qualified as mainstream practitioners of geology in the mid-nineteenth century.[14] More recently, some creationists have become obsessed with Ernst Haeckel, bizarrely claiming that Darwin's ideas, published in 1859, were somehow dependent on the allegedly forged images in Haeckel's *Anthropogenie* (1874). On their account, this reliance on putatively fraudulent scholarship should force us to question not only Darwin's writings but evolutionary theory more generally and, more to the point, subsequent developments within the field. Attempts to bring these historically inaccurate claims and ill-conceived questions into the classroom have already occurred under the banner of "Teach the Controversy," and they feature in the creationist supplemental textbook *Explore Evolution: The Arguments for and against Neo-Darwinism*.[15]

What can historians of science do to counter this clear misuse of history? Somewhat perversely, much of our community has remained silent over the past decade while antievolutionists have publicly twisted historical fact regarding Haeckel. It took three biologists to set the record straight in 2005. They explicitly made the point that Darwin did not in fact rely on Haeckel but, rather, on information taken from the antievolutionary Karl von Baer. They further noted that the creationists "are deeply confused or intentionally confusing regarding the history and significance of this well-known field."[16]

This preoccupation with Haeckel is taken a stage further by Richard Weikart, a senior fellow of the Discovery Institute, the leading organization promoting and funding the dissemination of intelligent design. In his provocatively titled *From Darwin to Hitler: Evolutionary Ethics, Eugenics, and Racism in Germany*, Weikart implicitly indicts Darwin and Haeckel for acts that occurred long after their deaths. In line with older creationist claims, we are asked to reject modern scientific theories because of how older versions of

[13] For more on the reaction of his fellow sociologists to Fuller's attempt to argue for an "equal opportunities program" for intelligent design see the various essays in *Social Studies of Science*, 2006, *36*(6):819–868.

[14] For more on creationist misuse of history see John M. Lynch, "Pithecophobes of the World, Unite! Revisionist History and Creationist Rhetoric," 1998, http://darwin.bc.asu.edu/pub/pithecophobes.pdf. For discussion of the claim regarding the qualifications of scriptural geologists see Terry Mortenson, *The Great Turning Point* (Green Forest, Ark.: Master Books, 2004). For a more nuanced view see the introduction in Lynch, ed., *Creationism and Scriptural Geology*, 7 vols., Vol. 1 (Bristol: Thoemmes, 2002).

[15] Stephen C. Meyer, Scott Minnich, Jonathan Moneymaker, Paul A. Nelson, and Ralph Seelke, *Explore Evolution: The Arguments for and against Neo-Darwinism* (London/Melbourne: Hill House, 2007).

[16] K. M. Pickett, J. W. Wenzel, and S. W. Rissing, "Iconoclasts of Evolution," *American Biology Teacher*, 2005, *67*:275–282, on p. 282. For a subsequent examination of Haeckel's drawings and their history see Nick Hopwood, "Pictures of Evolution and Charges of Fraud: Ernst Haeckel's Embryological Illustrations," *Isis*, 2006, *97*:260–301.

these theories were misused. Unlike the claims regarding Haeckel's embryology, Weikart's claims regarding a lineage from Darwin to Hitler via Haeckel have been examined by historians of science and indeed have generally been found lacking. Numerous reviews have accused Weikart of selectively viewing his rich primary material, ignoring political, social, psychological, and economic factors that may have played key roles in the post-Darwinian development of Nazi eugenics and racism. Since there is no clear and unique line from Darwinian naturalism to Nazi atrocities, useful causal relationships are difficult to infer; thus, as Robert J. Richards observes, "it can only be a tendentious and dogmatically driven assessment that would condemn Darwin for the crimes of the Nazis."[17]

In his examination of Haeckel's embryological images, the historian of science Nick Hopwood notes perceptively that "historical research can hardly expect to bridge the ideological chasm across which the recent controversy over Haeckel's illustrations has been fought out." Historians can indeed little expect to see their research alter the claims of antievolutionists. While Hopwood correctly points out that "there are plenty of more productive questions to debate," we would like to claim that as academic historians of science we have a certain civic duty to help correct historical misinformation in science textbooks.[18] In so doing, we are not suggesting that students should not hear allegations about Haeckel's fraud—far from it—but that his work should be placed within a properly conceived historical framework.

Looking forward, in thinking about how historians of science might help scientists in defending their educational prerogatives it is particularly appropriate to consider the broader plans of the Discovery Institute. In a funding document from the mid-1990s, the institute expressed the goal of seeing "design theory permeate our religious, cultural, moral and political life" within twenty years.[19] Faced with such a prospect, should the main body of historians adopt a neutral—even stoical—stance on this matter and let the antievolutionists continue to misinterpret history for their own cultural ends? Given the rebranding of creationism as "design theory" and its rejection of naturalism in all fields, one need only consider what a "design theory"–inspired vision of history would look like to realize that this issue runs deeper than mere consideration of science, its history, and science education. There are obviously consequences for the very practice of history as an open critical discourse and for science education as a rational-critical enterprise. Can any historian who cares about the integrity of both science and its history refuse to offer support in such circumstances?

[17] Richard Weikart, *From Darwin to Hitler: Evolutionary Ethics, Eugenics, and Racism in Germany* (London/New York: Palgrave Macmillan, 2005). For an alternative view see Robert J. Richards, "The Moral Grammar of Narratives in History of Biology—The Case of Haeckel and Nazi Biology," in *Cambridge Companion to the Philosophy of Biology*, ed. Michael Ruse and David Hull (Cambridge: Cambridge Univ. Press, 2007), pp. 249–451, on p. 451. It should be pointed out that Richards also takes on the historical analyses of Daniel Gasman and Stephen Jay Gould regarding Haeckel. For reviews of Weikart's book see Sander Gliboff, in *H-Net Reviews*, 2004, http://www.h-net.org/reviews/showrev.cgi?path=37981105462766; Paul Lawrence Farber, in *Journal of the History of Biology*, 2005, *38*:390–391; and Nils Roll-Hansen, in *Isis*, 2005, *96*:669–671.

[18] Hopwood, "Pictures of Evolution and Charges of Fraud" (cit. n. 16), p. 301.

[19] For details of these twenty-year goals see Barbara Forrest and Paul R. Gross, *Creationism's Trojan Horse* (Oxford: Oxford Univ. Press, 2004). The document is available online at http://darwin.bc.asu.edu/pub/wedge.pdf.

CONCLUDING THOUGHTS

In answer to the question posed in the title of this paper, the answer is certainly Yes, there are at least two ways in which science education needs the history of science. Including history of science as part of the science curriculum, and using it strategically to defend the autonomy of the science curriculum from inappropriate extrinsic forces, can help—and, indeed, has helped—to produce a stronger training for those whose scientific careers will be forged in our schools, colleges, and universities in decades to come. But there is, as we have indicated, much more that historians of science can do—and indeed must do. We need to produce harder and more extensive evidence of the educational efficacy of historical thinking about science. We also need to work more closely with scientists to fend off irresponsible uses of history that might infiltrate the science curriculum. Of themselves, these twin projects could keep historians of science busy for decades, but we welcome debate not only on further initiatives along these lines, but also on other ways in which our discipline can critically benefit science education in the twenty-first century.