BOOK REVIEWS

A Call for Redirection

Frontiers of Illusion. Science, Technology, and the Politics of Progress. DANIEL SAREWITZ. Temple University Press, Philadelphia, PA, 1996. xiv, 235 pp. $54.95; paper, $19.95.

Since Newton, great scientists have humbly averred that they have seen farther only because they have stood "on the shoulders of giants." Daniel Sarewitz contends in this cogent book that scientists have rather been standing on the shoulders of society and would do better to acknowledge the responsibilities of this position forthrightly.

A principle yoking science and democracy is that without the ability to observe actions—to witness—accountability cannot exist. As a Congressional Science Fellow and then consultant to the House Committee on Science, Space, and Technology (1989–1993), Sarewitz witnessed a great deal of U.S. science and technology policy in the making. In this book, he compares "the promises made on behalf of the R&D system" with its actual performance and explores ways to modify both "to create greater consistency, a more realistic level of expectation, and an increased capacity to achieve societal goals" (p. 14), thus drawing science back into accountability.

Sarewitz identifies five myths of science policy that inform these promises (pp. 10–11):

1. The myth of infinite benefit: More science and more technology will lead to more public good.
2. The myth of unfettered research: Any scientifically reasonable line of research into fundamental natural processes is as likely to yield societal benefit as any other.
3. The myth of accountability: Peer review, reproducibility of results, and other controls on the quality of scientific research embody the principal ethical responsibilities of the research system.
4. The myth of authoritativeness: Scientific information provides an objective basis for resolving political disputes.
5. The myth of the endless frontier: New knowledge generated at the frontiers of science is autonomous from its moral and practical consequences in society.

He devotes a chapter to debunking each, demonstrating how self-serving the scientific voice often sounds to the policy ear. For the research advocate who harkens to these mythic voices, Sarewitz's rendition will be about as comfortable as listening to oneself on a tape recorder for the first time.

Demythologizing science policy is only part of Sarewitz's concern. He becomes more provocative, if somewhat less coherent, in addressing how society educes benefits from science. Sarewitz believes that the marketplace is an essential link between science and social benefits, but he finds the "principal filters" of the marketplace—consumer demand and profitability—inadequate to ensure that precise goals like "curing a certain disease [or] generating power more efficiently" are achieved. Because market pressures outweigh such goals, science may make significant economic contributions "without necessarily making a net positive noneconomic contribution to the quality of human life or the welfare of society" (pp. 122–123).

Nevertheless, politicians find research attractive—often more so than other types of social action. Nowhere is science's role as "surrogate" for such action more apparent than in the mismatch between biomedical research spending trends and aggregate public health statistics. For example, the research emphasis on diseases of the elderly makes it "no anomaly that the United States has among the highest childhood mortality rates in the industrialized world while also boasting the longest life expectancy for people over the age of eighty-five" (p. 150). Politicians are willing to substitute research for social action exactly because the mythic construction of science denies foreknowledge of its consequences and yet still promises benefits. This combination frees politicians and scientists alike from accountability while tantalizing the public with ill-distributed fruits of research.

But here Sarewitz's analysis is incomplete. Surely, redefining social issues as technical ones can abet the misallocation of resources, as in health care, and the exclusion of laypersons from decision-making, as in risk assessments. Yet it has aided progress against many previously moralized problems like child abuse and alcoholism. Furthermore, there is no guarantee that resources shifted from research would actually be committed to social action. Even with the miserably partisan 104th Congress discounted, it is not difficult to see that the bipartisanship inspired by science even as a surrogate for social action is desirable for American democracy as well.

With the role of science in American society currently under debate—given proposed contractions in real federal R&D spending and controversy over allegedly increasing anti-science attitudes—*Frontiers of Illusion* is a timely intervention. Sarewitz wisely sidesteps the question of how much and concentrates on the more enduring why and wherefore of science policy. Such scrutiny is crucial when politicians are paring the budget because it forces us to consider whether maintaining or increasing the number of research grants at the expense of some social programs or research management is really the best way of pursuing social goals.

Sarewitz also attempts to sidestep the "science wars," knowing that his call for greater accountability potentially places him among the anti-science minions. He therefore claims realist credentials by "baldly and unapologetically" asserting his recognition of the scientific method as valid for achieving "an objective understanding of the physical and natural world." But deftly splitting what the "pro-science" forces have mistakenly lumped, Sarewitz insists that "the question is not 'do we need science?' but 'what science do we need?' " (p. x). His experience in Washington—a city better populated by research advocates than academic leftists, New Age mystics, or eco-fascists—turned him from the mythology of science and led him to consider how an alternatively constructed science might serve society better.

Sarewitz offers five admirable ways to begin reconstructing the R&D system. First, he suggests expanding its gender and racial diversity—not because nonwhite, non-males will do science differently, but because they may choose to do different and more beneficial science. Second, he recommends more cooperative research among natural and social scientists to help keep progress in the laboratory and progress in society in step. Third, he calls for honest brokers, neither politicians nor scientists but issue-specific technology assessors, to examine links between the social and the technical and help integrate policy and research. Fourth, he joins an increasing chorus calling for more democracy in the research system and technical decision-making. Fifth, he urges the fostering of a global R&D community with global priorities.

Even these systemic changes are not enough for Sarewitz. He argues that, like those of astronomers before Kepler, our efforts to "retrain loggers, put animals in pre-

serves, promote ecotourism, [and] do more research" amount to adding more and more circles to an increasingly unwieldy system. Rather than adding these epicyles, we need to scrap circles entirely and think in different terms. The new paradigm Sarewitz proposes is sustainability. Appropriately skeptical of sustainability as a technical concept, Sarewitz nevertheless hopes to take advantage of its very "conceptual malleability" as "an alternative to the mentality of infinite growth" (p. 193), of the endless frontier. Among the benefits of thinking in terms of sustainability is that it emphasizes a new set of metrics for the R&D system: the direction and distribution of progress, rather than its distance; and the assessment and choice of impacts, rather than their mere accumulation.

For a decade now analysts and researchers have agonized over a drifting U.S. science policy. Sarewitz's model—a sustainable science focused on accountability and well-distributed social benefits—describes a stable orbit for a newly conceived research system.

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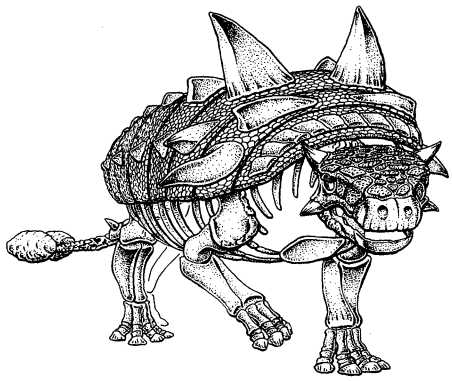
Paleovertebrates

The Evolution and Extinction of the Dinosaurs. DAVID E. FASTOVSKY and DAVID B. WEISHAMPEL. Illustrations by Brian Regal. Cambridge University Press, New York, 1996. xviii, 461 pp., illus., + plates. $44.95 or £29.95.

Dinosaur Extinction and the End of an Era. What the Fossils Say. J. DAVID ARCHIBALD. Columbia University Press, New York, 1996. xviii, 237 pp., illus. $49.50 or £40. Critical Moments in Paleobiology and Earth History.

These two books seek to explain to a growing group of interested nonspecialists how dinosaurs are currently understood by vertebrate paleontologists. Both books are well researched and well written, both advocate a cladistic definition of interorganismal relationships, and both emphasize that avian dinosaurs (hereafter "birds") were descended from nonavian dinosaurs (hereafter "dinosaurs"). *Evolution and Extinction* is a textbook, explanatory in tone and presenting alternative hypotheses in a disinterested manner ("The fossil record may be written in stone, but its interpretation is not," p. 4). *Dinosaur Extinction* is an exposition of a thesis, argued for the purpose of persuading readers that a popular causal hypothesis is not supported by all the evidence ("We must examine what the fossils say and, more often, what they do not say," p. xviii).

The framework of *Evolution and Extinction* is straightforward. A quarter of the text is devoted to introductory material on fossilization, geochronology, plate tectonics,



"*Ankylosaurus*, the armored, club-tailed ankylosaur." [From *The Evolution and Extinction of the Dinosaurs*]

cladistic procedures in classification, and the affinities and origin of dinosaurs. The central part presents descriptions of the anatomy of various groups of dinosaurs and primitive birds. The final quarter contains discussions of dinosaurian metabolism, distribution, and extinction. For the authors, global stresses (blackout, wildfires, acid rain) caused by a meteoritic impact briefly impaired the growth of green plants. Lethal famines spread among organisms (including dinosaurs) that depended on such plants, whereas occupants of food chains linked to organic detritus survived.

Because this book will assuredly appear in new editions, improvements may usefully be suggested. Greater care in the artistic reconstruction of habitats is a priority. Enlightening as anatomically defined nodes on cladograms are, students would appreciate seeing more of them in skeletal context. Linnaean families do generate meaningful patterns through geologic time (as implied on p. 390), which remain unduplicated by clades. The authors promise (p. 4) that "as we learn who dinosaurs really are, we can understand who *we* really are," but the student is left to imagine appropriate analogies. And a chapter title "Discovering order in the natural world" is but a play on words, for the chapter is limited to a discussion of cladistics.

Praiseworthy attributes nonetheless abound. The book is written with clarity and humor (see, for example, p. 126: "Whatever the pretensions of dinosaurs to deep thought, stegosaurs cannot be ranked among the crowning luminaries"). The contributions of outstanding figures in the study of dinosaurs are presented in a manner that does not distract one from the dinosaurs (it was a pleasure to find figure box 11.1 showing the young Werner Janensch at Tendaguru in former German East Africa). Explanations of cladistics are lucid, and the discussion of the parallel evolution of mechanical and digital wristwatches (box 3.1) is as insightful as it is delightful. The etymological information about dinosaurian names is fascinating. This book presents a solid foundation for any university-level class on dinosaurs.

Dinosaur Extinction draws heavily from the fossil record preserved in sediments deposited in eastern Montana immediately before and after the dinosaurs' disappearance. These strata are unique in that they have yielded large samples of land-dwelling vertebrate remains across the extinction interval. Half of the book is devoted to the limitations of the record, the phylogenetic position of dinosaurs, their global and temporal distribution, and the vertebrate contemporaries of the dinosaurs—all with special reference to eastern Montana. The remainder of the volume discusses the pattern of disappearance and survival in various groups and how this relates to stresses that are thought to have caused the extinctions. The author concludes that ecosystems were stressed by a global withdrawal of epicontinental seas and atmospheric pollution from enormous lava floods in India. A meteoritic impact then caused a global blackout and precipitated the final extinction of already-stressed organisms.

Does the fossil record in eastern Montana, as described, adequately reflect the role of dinosaurs in terrestrial ecosystems during the closing phases of the dinosaurian era? Tabulations of dinosaur species (table 5.1) are based on about 100 incomplete skeletons collected prior to 1990 in terminal Cretaceous strata (as listed in *The Dinosauria*, D. B. Weishampel *et al.*, Eds.; University of California Press, 1990). The relative abundances of different dinosaurian groups were estimated from fewer than 600 isolated bones (P. M. Sheehan *et al.*, *Science* **254**, 835 [1991]). The estimate of small-vertebrate (including amphibian, lizard, and mammalian) diversity rests on a database of 150,000 isolated teeth and bones (p. 115). On the assumption that half of this database pertains to pre-extinction forms, the count of dinosaurian species, making up 18% of all vertebrate species, is based on but 1% of available specimens. Dinosaurian diversity may be relatively undersampled.

According to *Dinosaur Extinction*, piedmonts behind the coasts are assumed to have contained no dinosaurs because there