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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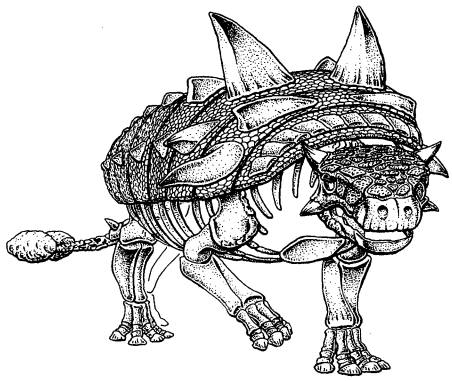
Paleovertebrates

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

Vignettes: Research vs. Administration

Any experiment is spent 95% in the preparation and 5% in the doing. If you analyse your day, the majority of it is taken up with essentially non-productive activities. Consider then, if you also had to run the entire institute as well. Politics, seminars, hosting visitors, grant administration, personnel issues, etc. would ensure that you had very little time for experiments. Thus, in attempting to do experiments as well, at best all you could concoct would be a DIY approach to institute management (not being trained in the necessary areas) that would probably lead to an unsatisfactory administration and a lot of disgruntled colleagues.

—*Neil F. Sullivan*, in *Technology Transfer: Making the Most of Your Intellectual Property* (Cambridge University Press)

I was very romantic about physics when I first started. I came in through astronomy and the big bang theory, but actually, I was more drawn to the steady state theory. Studying physics was my method of contemplation. All through college and grad school, I put myself to sleep every night by imagining that the universe was inside my head, so vast and silent. I could lie there with my eyes closed and contemplate the universal darkness or, if I was in a different mood, I could contemplate the random scatterings of light. Darkness or light. Darkness THEN light. It worked. Every night I eased off into perfect rest, and slept eight productive hours. That was the point. I wasn't like some of the others, who really got excited devising experiments or arguing about strong force and weak force. Apart from getting to sleep, my only real interest was how Oppenheimer got all those warring personalities to live together in the desert. I didn't know a single other physicist who wasn't bored by just the idea of personality. I think that I've loved being an administrator after all.

—*A university provost*, in *Moo*, a novel by Jane Smiley (Knopf; Fawcett Columbine paperback)

is no record of dinosaurs there (p. 154). But there is also no sediment in which such a record could have been preserved, and dinosaur skeletons do occur in sediments preserved in the continental interior of Asia (p. 153). Nonetheless, the extermination of the dinosaurs is linked to the reduction and fragmentation of coastal floodplains alone. In another case, a 10-million-year decline in dinosaurian diversity in the western interior of North America (p. 29) is implied to be global, although no other region of the world is cited wherein a similar decline occurs. Absence of evidence seems to have been interpreted ambiguously. The number of known dinosaurian species increases in the last part of the dinosaurian record in Mongolia, but in both Montana and Mongolia such trends may simply be the result of local environmental changes.

The book emphasizes noncatastrophic models, which are broadly popular within the paleontological community, and contains many interesting details and insights. The chapter entitled "Who's who of the late Cretaceous" is a concise and charming review of the vertebrate assemblages, accompanied by sketches of typical fossils—an approach worthy of emulation. The volume makes the telling point that the survival of stenothermic vertebrates does not support a catastrophic temperature decline, and underscores the need to link environmental stresses to the environmental requirements of different organisms through the extinction interval.

What caused the extinction of the dinosaurs? *Evolution and Extinction* (p. 427) concludes that "there has not yet been formulated a theory alternative to the [meteor] impact hypothesis that explains all—or even most—of the data as fully as [it] does." And in *Dinosaur Extinction* it is said of the impact (pp. 205–206) that "a literally earth-shattering event magnified the differences between species doing well and species doing not so well." Perhaps an often spirited controversy is gradually giving way to what Luis Alvarez, whose work helped spark the controversy, termed "a violent agreement."

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Also Noteworthy

The Great Dinosaur Extinction Controversy. CHARLES OFFICER and JAKE PAGE. Helix (Addison-Wesley), New York, 1996. xiv, 209 pp., illus. $25 or C$34.

In this book Dartmouth geologist Charles Officer, who has been a vigorous opponent of the meteoroid-impact theory of dinosaur extinction, joins with a journalist to give his view of the controversy and its history. The account is written at the level of a lay audience, and along the way the authors are highly critical of *Science* in particular for its handling of the issue. Their conclusion is that "the Alvarez hypothesis has collapsed under the weight of accumulated geologic and other evidence . . . , as well as from an increasingly obvious absence of scientific evidence proffered in its support," and they regard the whole episode as a case of "pathological science."

Katherine Livingston

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Books Received

Algal Ecology. Freshwater Benthic Ecosystems. R. Jan Stevenson, Max L. Bothwell, and Rex L. Lowe, Eds. Academic Press, San Diego, 1996. xxvi, 753 pp., illus. $84.95. Aquatic Ecology.

Biological Membranes. A Molecular Perspective from Computation and Experiment. Kenneth M. Merz, Jr. and Benoît Roux, Eds. Birkhäuser, Boston, 1996. xiv, 594 pp., illus. $99.50.

Chemical Modification of Enzymes. B. I. Kurganov, N. K. Nagradova, and O. I. Lavrik, Eds. Nova, Commack, NY, 1996. iv, 658 pp., illus. $98.

Dealing with Risk. Why the Public and the Experts Disagree on Environmental Issues. Howard Margolis. University of Chicago Press, Chicago, 1996. x, 227 pp., illus. $27.95 or £21.95.

Earth Processes. Reading the Isotopic Code. Asish Basu and Stan Hart, Eds. American Geophysical Union, Washington, DC, 1996. xviii, 437 pp., illus. $65; to AGU members, $45.50. Geophysical Monograph, vol. 95.

Geochemical Reaction Modeling. Concepts and Applications. Craig M. Bethke. Oxford University Press, New York, 1996. xviii, 397 pp., illus. $50.

Holographic Interferometry. Principles and Methods. Thomas Kreis. Akademie Verlag, Berlin, 1996 (U.S. distributor, VCH, New York). 351 pp., illus. $95. Akademie Verlag Series in Optical Metrology, vol. 1.

Introduction to Quantum Theory and Atomic Structure. P. A. Cox. Oxford University Press, New York, 1996. vi, 90 pp., illus. Paper, $9.95. Oxford Chemistry Primers, 37.

Lost Crops of Africa. Vol. 1, Grains. Board on Science and Technology for International Development, National Research Council. National Academy Press, Washington, DC, 1996. xxii, 383 pp., illus. Paper, $24.95.

Marginal Worth. Teaching and the Academic Labor Market. Lionel S. Lewis. Transaction, New Brunswick, NJ, 1996. viii, 162 pp. $29.95.

Polymeric Systems. I. Prigogine and Stuart A. Rice, Eds. Wiley, New York, 1996. x, 742 pp., illus. $130. Advances in Chemical Physics, vol. 94.

Virtual Auditory Space. Generation and Applications. Simon Carlile. Chapman and Hall, New York, and Landes, Austin, TX, 1996. xiv, 248 pp., illus. $69.95. Neuroscience Intelligence Unit.