BOOK REVIEWS

Holistic Cosmology

The Life of the Cosmos. LEE SMOLIN. Oxford University Press, New York, 1997. viii, 358 pp., illus. $30. ISBN 0-19-510837-x. Published in the UK by Weidenfeld and Nicolson; £20, ISBN 0-297-81727-2.

The universe is a self-organizing entity. There we have the essence of Lee Smolin's admittedly speculative explanation of everything, from the laws of physics to the origin of intelligent life and even an alternative to God Herself. *The Life of the Cosmos* is an eloquent exposition of a theory that combines cosmology, physics, and philosophy in an attempt to "sketch out a vision" of what our picture of nature will be when the sought-after unification of quantum theory and relativity theory has been achieved. The aims are profound, the vistas outlined are vast, and the discussion is highly creative. What could be more challenging than to construct a Theory of Everything?

Smolin posits that black holes provide the underlying solution to how our universe came to be as it is. The argument proceeds as follows. Every time a black hole forms, a new universe is spun off deep within. Fine so far; this we believe as disciples of Stephen Hawking. Within these universes, the constants of nature suffer small but random changes every time a black hole forms and a new universe develops. The most probable universe emerges from this evolutionary sequence with the maximal number of evolutionary pathways, and hence black holes. We are at the peak of a grand cosmic summit of natural selection of the laws of physics. And—here is the beauty of the argument—such a course of events is inevitable: we are the outcome. Not a bad postulate if it is testable, which Smolin argues to be the case. For example, one need only search for the black holes.

Sadly, however, the challenge Smolin poses fails at almost every encounter with astronomical reality. Our universe is far—by about four orders of magnitude, or a factor of 10,000—from being optimally loaded with black holes. Most cosmologists are convinced that enhancing the amplitude of primordial density fluctuations would enhance the black hole fraction. We are very far from saturation. Smolin's response to this criticism is an appeal to self-regulation of the inflaton, the field responsible for inflation, a concept that is beyond any present physics of which I am aware. He argues that small changes in fundamental parameters won't do much. That is simply untrue. Tilt the spectral index of primordial fluctuations blueward by 10 percent and one would fill the early universe with collapsed objects, possibly destined to make black holes. Even worse, imagine adding the tiniest admixture of black holes early on. Perhaps during an early phase transition some rare horizon volume received a fatal compression that pushed it over the precipice of black hole formation. The primordial black holes conserve their mass as the dominant relativistic energy density of the universe redshifts away. The result: one in a billion, even one in a trillion, is all it might take in terms of large primordial horizon-scale overdensities to result in a universe that today is vastly overloaded with black holes compared to what we see around us.

And dare I mention star formation? Smolin exposes the hazards for a quantum cosmologist of dabbling in murky waters that are governed more by astronomical common sense than by fundamental physics. He asserts that carbon is needed to form stars. Think of the obvious counterexample, us—or, more specifically, our antecedents, namely the first stars, or for that matter the metal-poor halo stars, which are as close to being carbon-free as makes a shred of difference to gas cooling. Nor need this be a puzzle: hydrogen cools as efficiently as does carbon, albeit at a higher temperature. But there is no limit to how small or large a lump of hydrogen one could fabricate, short of making snowballs of solid hydrogen, and stellar masses are well within the range of possibility.

And then there is feedback, a continuing theme. Feedback is crucial to self-organization. But would it not be advisable to know the sign of the feedback? Negative and positive feedback could differentiate ants from whales, or a Big Crunch from a Big Bang. It may suffice to give an example of the alarmingly large astrophysical uncertainties: reduce the number of supernovae, and one diminishes feedback. In this case the gas collapses with higher efficiency, making more stars and more black holes. This is quite the opposite of what Smolin tells us: no supernovae, no carbon, no stars, no black holes. Which is the truth and which is the fallacy? Nobody knows.

Perhaps these awkwardnesses offer a cautionary tale for physicists with cosmological inclinations, indicating the pitfalls of dabbling in other disciplines before constructing a more solid edifice. Of course, metaphysical cosmology is a well-trodden path, and Smolin is by no means the first to pursue it. No doubt this explains why his tome has received some surprisingly resounding endorsements, and I must admit, finally, that the book is worth reading, if only to see how a brave pioneering spirit can conjure up impressive mirages of the ultimate theory.

Joseph Silk
Department of Astronomy, University of California, Berkeley, CA 94720, USA, and Institut d'Astrophysique, 75014 Paris, France

Raising the Dead

The Science of Jurassic Park and The Lost World. Or How to Build a Dinosaur. ROB DESALLE and DAVID LINDLEY. BasicBooks, New York, 1997. xxix, 194 pp., illus. $18 or C$25.50. ISBN 0-465-07379-4.

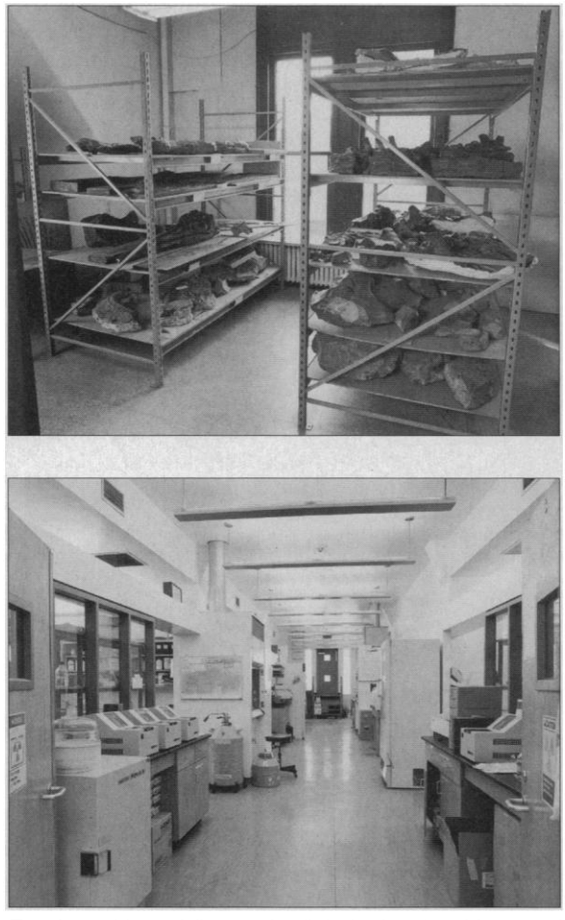
Dinosaurs aren't all bad. Anyone who educates children already understands their value. Young eyes may glaze at the announcement of a study module on "The Scientific Method," but let the subject be dinosaurs and kids can't get enough. Never mind that their devious docent is *really* teaching them spelling, geography, geology, physics, astronomy, arithmetic, biology, physiology, or ecology. Dinosaurs sugarcoat the pill of knowledge. The subject of dinosaurs is a natural invitation to learn deeply about the natural world and its riches.

I am not disturbed by the success of Michael Crichton's novels and their realization on screen by Steven Spielberg. We are sophisticated enough to understand that the novelist's purpose requires a certain suspension of disbelief. A page-turning novel or a smashing summer flick by its very nature cannot be a primary source of reliable scientific knowledge. Rather it can provide an invitation to learn. Authors DeSalle and Lindley take up the challenge of examining the scientific premises of *Jurassic Park* and *The Lost World*. The result is a thoroughly entertaining and informative book written in a breezy style. The book's strengths lie in molecular biology, and the authors provide a step-by-step reconstruc-

tion of the technical processes by which fossil DNA constituting the genome of a dinosaur could in principle be recovered and assembled.

Amber provides an excellent sterile environment for the preservation of biological tissues, and fragments of fossil DNA have been extracted from this source. We learn that amber from the Dominican Republic cannot contain DNA of Mesozoic dinosaurs because it is too young. An expedition to Hoboken, New Jersey, might be successful—85-million-year-old mosquitoes have been found there. Such extraordinary fossils have much greater potential as sources of mosquito DNA than of dinosaur DNA. *If* dino DNA were successfully extracted from amber, the genome would be extracted in several million fragments, each a few hundred base pairs long, that could then be amplified by the polymerase chain reaction, incorporated into plasmids, and cultured by *Escherichia coli*. The lab required to complete all these steps for a dinosaur genome would be the size of several football fields and would contain 100 million test tubes. The contents of these tubes could then be sequenced in 2 million "sequencer days." This would occupy 2000 sequencer machines for three years at a cost of some $250 million. Although a couple of supercomputers could in principle reconstruct complete sequences of DNA from millions of random fragments, the number of chromosomes is completely unknown—2*n* could conceivably range from 2 to 100 or more. So far the process described has produced only one strand of DNA, but sexual reproduction requires two nonidentical strands, so that lethal recessive mutations are masked. However, there is no *a priori* basis for knowing which point mutations will be complementary to the first strand and which deleterious. So the problems go. All in all, it seems that dinosaurs will remain on the Isla Nublar of our dreams for a long time to come.

The authors do a pretty convincing critique of nearly every conceivable aspect of the reproductive and husbandry programs of the dastardly scientists created by Crichton. They even puncture the self-important musing of the chaotician Ian Malcolm. Unfortunately, the weakest aspect of the book is the dinosaur paleontology itself. DeSalle and Lindley fail to address the burning issues that impact most earnestly on the prime consumers of dinosaurs in our culture, the children. They fail to note the conflation of *Velociraptor* with the real dinosaurian protagonist of Jurassic Park, *Deinonychus*, nor do they note the scaling problems of either this raptor or *Dilophosaurus*, shrunk from 20 feet (6 meters) in length to family-dog size. Did *Dilophosaurus* (or any dinosaur) spit venom or display a frill like the Australian frilled lizard? Could *Gallimimus* really run 70 miles per hour? No, no, and no! Was "*Velociraptor*" really as brainy as a chimpanzee? No, it was brainy like an opossum—a triumph for its day. The authors seem to struggle with the concept that not all dinosaurs are related to birds and that crocodilians constitute the closest living reptilian relatives of dinosaurs. They even commit the gaffe of locating grass, a flowering plant that became widespread deep in the ages of mammals, only 20 million years ago, in the Jurassic.



Top, Assemblage of dinosaur fossils in the American Museum of Natural History. *Bottom*, The museum's molecular laboratories with three of the eight PCR machines that "essentially drive the genetic research of the laboratory" to the left. [From *The Science of Jurassic Park*; Denis Finnin]

But all in all, despite its shortcomings, I recommend the book as a skillful presentation of science, especially molecular biology, to a general readership.

Peter Dodson
Department of Animal Biology and Geology, School of Veterinary Medicine, University of Pennsylvania, Philadelphia, PA 19104–6045, USA

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Browsings

"Almost a Man of Genius." Clémence Royer, Feminism, and Nineteenth-Century Science. Joy Harvey. Rutgers University Press, New Brunswick, NJ, 1997. xviii, 275 pp. + plates. $62. ISBN 0-8135-2397-4. Lives of Women in Science.

The life and work of a feminist philosopher and critic of science who translated Darwin into French and attempted to extend his ideas to social evolution.

A Devotion to Their Science. Pioneer Women of Radioactivity. Marelene F. Rayner-Canham and Geoffrey W. Rayner-Canham, Eds. Chemical Heritage Foundation, Philadelphia, and McGill-Queen's University Press, Montreal, 1997. xiv, 307 pp. + plates. $55, ISBN 0-7735-1608-5; paper, $19.95, ISBN 0-7735-1642-5.

Brief biographies of 23 researchers from the early years of the present century, grouped (according to place of principal work, not national origin) as French, British, and Austro-German.

Hairy Roots. Culture and Applications. Pauline M. Doran, Ed. Harwood Academic (Gordon and Breach), Amsterdam, 1997 (U.S. distributor, International Publishers Distributor, Langhorne, PA). xii, 239 pp., illus. $95, £62, or ECU 79. ISBN 90-5072-117-x.

Twenty-one papers on the culture, metabolism, and biotechnological potential of a type of genetically transformed plant structure.

Richard Feynman. A Life in Science. John and Mary Gribbin. Dutton (Penguin), New York, 1997. xviii, 301 pp., illus. $24.95.

The legendary physicist becomes the subject of a third biography, briefer than its predecessors (see *Science* **259**, 537 [1993] and **264**, 1617 [1994]) but intending to be the first to "capture the essence" of both his science and his "persona."

Slanted Truths. Essays on Gaia, Symbiosis, and Evolution. Lynn Margulis and Dorion Sagan. Copernicus (Springer-Verlag), New York, 1997. xxiv, 368 pp., illus. $27. ISBN 0-387-94927-5.

Twenty-four reprinted essays, some with co-authors, ranging from a memoir of J. Robert Oppenheimer through the subjects indicated by the title to some reflections on science education.