The Early Earth

Origin of the Earth. HORTON E. NEWSOM, JOHN H. JONES, *et al.*, Eds. Oxford University Press, New York, and Lunar and Planetary Institute, Houston, TX, 1990. vi, 378 pp., illus. $50. From a conference, Berkeley, CA, Dec. 1988.

Lord Kelvin calculated that Earth began to solidify 40 million years ago, thus starting a long-time confrontation between geologists and "natural philosophers." Following the discovery of radioactivity, Earth was viewed as having a cold, tranquil beginning. The Schmidt-Safranov accretional theory gave long accretion times, 10^8 years, for Earth. Gravitational energy radiated away, and planets formed in an unmelted condition. In standard geological models, the planet heated up gradually as a result of the decay of radioactive elements. Much later the "core formation event" heated and differentiated Earth. However, it has long been clear to some earth scientists that early Earth was hot and that an origin involving extensive melting was unavoidable. The Hanks-Anderson rapid-accretion hypothesis implied a hot origin, with differentiation and core formation simultaneous with accretion. This book continues the debate.

The arguments for a hot origin include the absent early geological record, an ancient magnetic field, remarkable concentration of certain elements into shallow regions, occurrences of old ultrahigh-temperature rocks, depletion of volatiles, isotopic fractionations, calculated cooling rates, and the fact that the upper mantle is close to the melting point everywhere. Rapid accretion is one way to explain the evidence for an early hot Earth. Modern accretion theories invoke large impacts, which are essentially very rapid accretion events. These heat and melt the early Earth even while spreading out the accretional history. There is now little doubt that the physics of accretion, combined with the evidence for large impacts, angular momentum, and the presence of the moon, demands a molten early Earth, perhaps with repeated melting episodes. An Earth covered by a magma ocean must exist throughout accretion if the planet is collecting energy faster than it can radiate it away. As this magma ocean crystallizes, it becomes a slush and is eventually responsible for chemical stratification and outward segregation of large-ion and crustal elements by a "radial zone-refining" process. The zone-purified refractory crystals, at depth, eventually transform to high-pressure phases as Earth grows, without ever having been in high-pressure equilibrium with the near-surface ocean. There are still earth scientists, however, who argue for a homogeneous, well-stirred mantle and for "primordial" rocks and an "undegassed" mantle and that most of Earth never experienced wholesale melting and differentiation. These authors and their views are well represented here.

The 20 independent chapters by 31 authors address aspects of the solar nebula, accretion, giant impacts, the moon, the magma ocean, core formation, the continental crust, the hydrosphere, and the origin of life. The main themes are accretion, the magma ocean, siderophiles, and core formation, but no consistent treatment is attempted. Although there are important contributions dealing with the physics of accretion and the details of core formation, this book falls far short of being a book on the "Origin of the Earth." The gaps in it are enormous, and balance is missing. There can be no understanding of the origin of our planet without input from petrology, geophysics, and geochemistry. There is also a great deal of circular reasoning. Rocks from the shallow mantle are chosen as representative if they appear "primitive" and "unfractionated." They are then used as evidence that Earth has not been fractionated. These rocks are assumed to be typical of the whole mantle, and therefore it is assumed that the mantle is homogeneous and different from other bodies. The paradoxes and problems pointed out by the editors in their summary sections have more to do with outmoded paradigms than with Earth. The "primordial mantle" and "genesis rock" concepts have been abandoned by their originators, but their ghosts are hard to exorcise. Mantle rocks have complex origins that involve melting, depletion, and re-enrichment. Even if all mantle rocks can be proved never to have equilibrated with the core and the present lower mantle, this would rule out only the more naive schemes of differentiation and magma ocean evolution on a fully formed planet.

A large fraction of the book is devoted to siderophiles and topics such as core formation and inhomogeneous accretion. The majority of the index entries refer to siderophiles, core, metals, sun, solar nebula, meteorites, asteroids, and other planets. There are no entries for peridotite, olivine, eclogite, basalts, isotopes, komatüte, geophysics, recycling, heat flow, magnetic field, or phase changes. Thus this is a book about a hypothetical planet, not one that necessarily evolves to Earth or that satisfies many terrestrial data.

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Some Other Books of Interest

Optics, Physiology and Vision. A Festschrift Honoring Professor Gerald Westheimer on His 65th Birthday. SUZANNE P. MCKEE and KEN NAKAYAMA, Eds. Pergamon, New York, 1990. vi pp. + pp. 1529–1921, illus. $45. Also published as *Vision Research*, vol. 10, no. 11 (1990).

In August 1989 a symposium was held to honor Gerald Westheimer on his 65th birthday, and this volume is composed of revised versions of papers presented on that occasion. The volume opens with an introduction by Suzanne McKee, who traces the course by which Westheimer traveled from Nazi Germany to the position he has occupied at the University of California since 1960, stops along the way having included Australia, where as an adolescent he was apprenticed to an optometrist, and Cambridge, England, where he worked with Horace Barlow and others who constituted what was "surely one of the most illustrious groups ever assembled in vision research." McKee also gives a brief account of Westheimer's research, beginning with his dissertation work on saccadic and smooth-pursuit eye movements using a "novel approach . . . we would now identify as linear systems analysis" and noting his influential work on aspects of human spatial vision. There follow 26 technical papers, arranged alphabetically by first author. One of the more general papers is Barlow's "Conditions for versatile learning, Helmholtz's unconscious inference, and the task of perception," in which he presents an argument that "to understand perception one must view it as prologue to learning." Another is Steinman *et al.*'s "New directions for oculomotor research," which reviews Westheimer's contributions to the subject and discusses the implications of the capability, due to new instrumentation, of observing oculomotor performance under more naturalistic conditions. The remaining papers, mostly reports on their authors' own research, include among their topics aspects of spatial discrimination, hyperacuity, and stereopsis. The volume also includes a list of Westheimer's publications, 1945–1990.—**K.L.**

Evolutionary Innovations. MATTHEW H. NITECKI, Ed. University of Chicago Press, Chicago, IL, 1991. x, 304 pp., illus. $44.95; paper, $17.95. From a symposium, Chicago, IL, May 1988.

The 1988 Field Museum spring systematics symposium was devoted to the theme of innovation in evolution, and the book that has resulted is presented as a "cross section of present-day ideas" on the subject. In an

opening paper Joel Cracraft defines evolutionary innovations broadly as "the appearance of new characters or structural/functional complexes" and considers the concept of "key innovations" from ontological, methodological, and empirical points of view, rendering (in apparent opposition to some subsequent contributions to the volume) an unfavorable judgment on its utility. Under the heading Genetics and Development Brian Charlesworth traces and comments on ideas about the evolutionary genetics of adaptations, Rudolf Raff *et al.* discuss heterochrony with reference to current studies of sea urchins, and Gerd Müller presents a "side-effect hypothesis" according to which qualitatively new structural features arise as "by-products of epigenesis that appear when quantitative modifications of developmental processes reach a threshold of the affected system." A section headed Morphology and Physiology contains four papers, in the first of which James Cheverud discusses genetic constraints on the appearance of new trait combinations and presents some results of a study of papionin primates that bear on the matter. Karel Liem then takes up the issue of key innovations with reference to genealogical and ecological hierarchy, proposing the integrative approach "symecomorphosis." Jeffrey Jensen also discusses key innovations, expounding the procedure of "historical testing" as an alternative to reliance on "subjective adaptive arguments." Warren Burggren and William Bemis conclude the section with a discussion of the potential of comparative physiology in evolutionary studies. In the final pair of papers in the volume Adolf Seilacher discusses "the sand-dollar syndrome: a polyphyletic constructional breakthrough" and David Jablonski and David Bottjer discuss the ecology of evolutionary innovation from a paleobiological point of view. The volume opens with an introduction in which the editor recounts some earlier history of the subject and gives an overview of the contributions. It concludes with an index.—**K.L.**

Insect Defenses. Adaptive Mechanisms and Strategies of Prey and Predators. DAVID L. EVANS and JUSTIN O. SCHMIDT, Eds. State University of New York Press, Albany, 1990. xvi, 482 pp., illus. $73.50; paper, $24.95. SUNY Series in Animal Behavior.

This treatment of insect survival strategies is arranged in four sections, on the evolution of "major defensive ensembles," on strategies and tactics of predation, and on prevention of predation by avoidance or escape and by counterattack. The first section contains chapters by Malcolm Edmunds on crypsis ("the color resemblance of an animal to its background so that predators . . . have difficulty in distinguishing it") and Tim Guilford on aposematism ("the coincidence between conspicuous coloration in potential prey animals") and a consideration by Scott Sakaluk of the balancing of reproductive and survival needs. In the second section, predatory behavior and defense strategies are discussed by George Uetz with respect to web-building spiders and by Werner Schuler with respect to birds, and Michael Robinson expounds the hypothesis that the origins of intelligence are to be found in complex information-processing tasks such as are involved in food-finding. Looking at survival strategies from the point of view of potential prey, Robert Lederhouse discusses primary defenses of lepidopteran caterpillars, David Evans discusses the timing of life-history and daily events as a means of avoiding predation, and James Fullard discusses sensory interactions between moths and bats as "one of the most parsimonious predator-prey relationships ever discovered." Then Theodore Sargent and Kevina Vulinec respectively discuss startle and aggregation as anti-predator mechanisms, Douglas Whitman *et al.* and M. Deane Bowers discuss uses of repellent and toxic chemical compounds (allomones and "recycled" plant natural products), and, with respect to hymenopterans, Justin Schmidt and Christopher Starr discuss venoms and colony defenses. The editors have provided a brief introduction to each section of the book but no introduction or conclusion to the work as a whole. Author and subject indexes are included.

—**K.L.**

Books Received

Applied Mineralogical Thermodynamics. Selected Topics. N. D. Chatterjee. Springer-Verlag, New York, 1991. xvi, 321 pp., illus. Paper, $59.

Aquatic Weeds. The Ecology and Management of Nuisance Aquatic Vegetation. Arnold H. Pieterse and Kevin J. Murphy, Eds. Oxford University Press, New York, 1990. xviii, 593 pp., illus. $135.

Atlas of the Developing Rat Brain. George Paxinos *et al.* Illustrations by Alicia L. R. Fritchle. Academic Press, San Diego, CA, 1991. Variously paged. Spiral bound, $99.50.

Biosphere 2. The Human Experiment. John Allen. Anthony Blake, Ed. Penguin, New York, 1991. iv, 156 pp., illus. $29.95, paper, $16.95.

Biotechnology, Microbes and the Environment. Steven C. Witt. Center for Science Information, San Francisco, CA, 1990. vi, 219 pp., illus. Paper, $17.50. Brief Book.

The Byzantine Shops at Sardis. J. Stephens Crawford. Harvard University Press, Cambridge, MA, 1990. xxii, 156 pp., + plates. $50. Archeological Exploration of Sardis, monograph 9.

Case Studies in Family Violence. Robert T. Ammerman and Michel Hersen, Eds. Plenum, New York, 1991. xvi, 406 pp., illus. $59.50.

Chromatography and Isolation of Insect Hormones and Pheromones. A. R. McCaffery and I. D. Wilson, Eds. Plenum, New York, 1990. xiv, 376 pp., illus. $89.50. Chromatographic Society Symposium Series. From a symposium, Reading, U.K., March 1989.

The Cult of the Cat. Nicholas J. Saunders. Thames and Hudson, New York, 1991 (distributor, Norton, New York). 96 pp., illus. Paper, $14.95.

The Development and Treatment of Childhood Aggression. Debra J. Pepler and Kenneth H. Rubin, Eds. Erlbaum, Hillsdale, NJ, 1991. xviii, 470 pp., illus. $69.95. From a symposium, Toronto, Canada, June 1988.

Distribution and Taxonomy of Birds of the World. Charles G. Sibley and Burt L. Monroe, Jr. Yale University Press, New Haven, CT, 1991. xxiv, 1111 pp. $125.

Ecological and Evolutionary Genetics of *Drosophila*. J. S. F. Barker, William T. Starmer, and Ross J. MacIntyre, Eds. Plenum, New York, 1990. xviii, 524 pp., illus. $95. Monographs in Evolutionary Biology. From a workshop, Armidale, Australia, Jan. 1989.

Ecological Responses to Environmental Stresses. J. Rozema and J. A. C. Verkleij, Eds. Kluwer, Boston, MA, 1990. xiv, 311 pp., illus. $190. Tasks for Vegetation Science, 22.

Electromagnetism. I. S. Grant and W. R. Phillips. 2nd ed. Wiley, New York, 1991. xvi, 525 pp., illus. Paper, $34.95. Manchester Physics Series.

Electron Deficient Boron and Carbon Clusters. George A. Olah, Kenneth Wade, and Robert E. Williams, Eds. Wiley, New York, 1991. xvi, 379 pp., illus. $59.95. A Wiley-Interscience Publication. From a symposium, Los Angeles, CA, Jan. 1989.

Electronic Processes on Semiconductor Surfaces during Chemisorption. T. Wolkenstein. Roy Morrison, Transl. Ed. Consultants Bureau (Plenum), New York, 1991. xvi, 444 pp., illus. $115. Translated from the Russian edition (Moscow, 1987) by E. M. Yankovskii.

Electronic Properties of Multilayers and Low-Dimensional Semiconductor Structures. J. M. Chamberlain, L. Eaves, and J.-C. Portal, Eds. Plenum, New York, 1990. xiv, 477 pp., illus. $105. NATO Advanced Science Institute Series, vol. 231. Series B, Physics. From an advanced study institute, Castera-Verduzan, France, Sept. 1989.

Essential Medical Genetics. J. M. Connor and M. A. Ferguson-Smith. 3rd ed. Blackwell, Boston, MA, 1991 (U.S. distributor, Mosby-Year, Chicago, IL). viii, 259 pp., illus. Paper, $29.95.

Evaluation of Environmental Data for Regulatory and Impact Assessment. S. Ramamoorthy and E. Baddaloo. Elsevier, New York, 1991. x, 466 pp., illus. $171.50. Studies in Environmental Science, 41.

Excursions in Geometry. C. Stanley Ogilvy. Dover, New York, 1990. viii, 178 pp., illus. Paper, $4.95. Reprint, 1969 ed.

The Expendable Future. U.S. Politics and the Protection of Biological Diversity. Richard J. Tobin. Duke University Press, Durham, NC, 1990. x, 325 pp., illus. $45; paper, $18.75.

Experimental Embryology in Aquatics Plants and Animals. Hans-Jürg Marthy, Ed. Plenum, New York, 1990. x, 407 pp., illus. $95. NATO Advanced Science Institute Series, vol. 195. Series A, Life Sciences. From an advanced study institute, Banyuls-sur-Mer, France, Sept. 1989.

Fluorine in Bioorganic Chemistry. John T. Welch and Seetha Eswarakrishnan. Wiley, New York, 1991. xx, 261 pp., illus. $59.95. A Wiley-Interscience Publication.

Fluxes Between Trophic Levels and Through the Water-Sediment Interface. Daniel J. Bonin and Han L. Golterman, Eds. Kluwer, Boston, MA, 1990. xviii, 342 pp., illus. $172. Developments in Hydrobiology, 62. From a congress, Marseille, France, June 1989. Reprinted from *Hydrobiologca*, vol. 207 (1990).

Free to Be Foolish. Politics and Health Promotion in the United States and Great Britain. Howard M. Leichter. Princeton University Press, Princeton, NJ, 1991. xviii, 281 pp., illus. $35.

From Industry to Arms. The Political Economy of High Technology. Anthony DiFilippo. Greenwood, New York, 1990. xvi, 205 pp., illus. $42.95. Contributions in Economics and Economic History, no. 114.

A Guide to SPSS for Analysis of Variance. Gustav Levine. Erlbaum, Hillsdale, NJ, 1991. xviii, 151 pp., illus. $39.95; paper, $22.50.

Handbook of Clinical Sociology. Howard M. Rebach and John G. Bruhn, Eds. Plenum, New York, 1991. xxiv, 410 pp., illus. $55.

Handbook of Thin-Layer Chromatography. Joseph Sherma and Bernard Fried, Ed. Dekker, New York, 1991. viii, 1047 pp., illus. $165. Chromatographic Science, vol. 55.

Insect Neuropeptides. Chemistry, Biology, and Action. Julius J. Menn, Thomas J. Kelly, and Edward P.