

age and quality and more is claimed than is delivered, but this volume deserves the attention of anyone interested in broad-scale evolutionary questions for the clarity with which it presents the issues and the laudable attempts to test competing theories.

C. R. C. Paul leads off the volume with a defense of the adequacy of the fossil record for testing theories about the evolutionary process. The fossil record is, of course, an incomplete and biased record of the history of life, but, as Paul points out, incompleteness in coverage does not necessarily imply inadequacy for testing theories if predictions are sharp and questions are carefully drawn. The following paper by R. A. Fortey is a careful analysis of the punctuated equilibrium vs. gradualism dichotomy (addressed by about half of the papers in this volume). Fortey's paper alone is worth the price of this volume, for not only does he analyze the predictions of these competing theories of the "normal" mode of species-level evolution, he goes on to explore the nature of acceptable evidence for each theory. Punctuated equilibrium, the hypothesis that most morphological change is concentrated in rapid "punctuated" events separated by long periods of stasis, deals primarily with qualitative characters, whereas its antithesis, gradualism or the postulation of slow, continuous acquisition of morphological changes, concentrates primarily on quantitative characters; proponents of each theory can find what they expect in the fossil record simply by discounting certain kinds of data. This point is beautifully (if inadvertently) illustrated by the contribution by R. C. Whatley on the evolution of two genera of benthic marine ostracods, where stasis is seen in the ornamentation of the valves (qualitative characters) and a prolonged trend toward increased body size (a quantitative character) is simultaneously seen. Whatley's conclusion that punctuated equilibrium is the normal mode of evolution in these genera is based solely on his willingness to discount the importance of body size while emphasizing the taxonomic importance (but unknown functional significance) of valve ornamentation. Unfortunately the other major contribution made by Fortey's paper—the observation that if punctuated equilibrium and gradualism can be observed in different faunas in the same formation unequivocal evidence for the existence of both mechanisms exists *and* an estimate of their relative importance can be made—is not echoed elsewhere in this volume.

Although all of the contributions in this volume are of interest, if only for the fossil data themselves and the ways they can be used, the impact of many is muted by questionable assumptions or erroneous asser-

tions. For example, Smith and Paul assume without evidence that the morphological shifts they see in a species of fossil urchins represent ecophenotypic variation and conclude that the changing morphology really represents stasis; Johnson assumes a population bottleneck in a lineage of Jurassic scallops and invokes genetic drift to explain a morphological shift when the populations involved are far too large for drift to be a significant factor; and Skelton's paper on rudists is rife with untested and unsupported assumptions on the functional morphology of these bizarre bivalves. On the other hand, Kemp's discussion of the modes of macroevolution is excellent, and examples of each model can be found elsewhere in this volume. Skelton's paper on rudists, despite the shortcomings mentioned above, is notable for his presentation of a null hypothesis (stochasticity) and four alternative hypotheses. Banner and Lowry's contribution on globigerine foraminiferans shows just how good the fossil record can be; Banner and Lowry not only address changes in developmental timing as an evolutionary mechanism but offer excellent evidence demonstrating that it has in fact occurred.

Purists will argue that this volume is limited in scope, and it does indeed ignore many of the evolutionary controversies extant today. The volume would have been much improved by better communication among the authors and free criticism of each other's contributions. However, what it lacks is less important than what it offers—the chance to see how evolutionary models fare against the only record available of how evolution proceeds, the fossils themselves.

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Seismology in Japan

Earthquake Prediction. KIYOO MOGI. Academic Press, Orlando, FL, 1985. xii, 355 pp., illus. \$58.

Earthquake prediction, which was a small, barely credible branch of seismology two decades ago, has become a major discipline in its own right, drawing results from fields as diverse as applied physics, geodesy, and field geology. During this period, progress has been considerable. Large earthquakes along many of the earth's major tectonic plate boundaries (including those in California and Alaska) can now be predicted with considerable precision over timescales of decades or longer. Shorter-term prediction

has proven to be more difficult, but it is a subject of active research, with intensive monitoring experiments being undertaken in regions of the United States, Japan, China, and the Soviet Union where large earthquakes are anticipated within the next 30 years or where the societal impact of large or moderate shocks may be great. Research to date has uncovered several persuasive examples of precursory seismic activity or crustal movements operating over intermediate or short time intervals (years to hours) prior to large earthquakes. However, no single, universal precursory signal has yet been found; it may well be that precursory activity varies considerably from event to event and is absent in some cases. This evident variability suggests the importance to earthquake prediction of well-documented case histories of many earthquake sequences. In this respect the contributions from Japanese seismology are particularly valuable. Japan's seismic history is very long, extending back to the 7th century A.D., its instrumental seismic record dates back almost a century, and its current earthquake prediction program, begun in 1965, is the most extensive and best supported in the world.

Kiyoo Mogi is one of Japan's leading scientists, and his work has had an important impact throughout the field of seismology. The book under review is a very personal account of Japan's earthquake prediction program, drawing on Mogi's many research papers and emphasizing his important early work on spatial and temporal patterns of seismicity as well as his laboratory simulations of earthquake faulting. The book has two major themes, structural heterogeneity in the earth's crust and its influence on earthquake activity and seismic quiescence as a precursory signal. Mogi concentrates on intermediate and short-term prediction and emphasizes, in my view correctly, the primary importance of seismicity data and geodetic and borehole measurements of crustal deformation as constraints on pre-failure processes.

The chief strengths of the book are its observational orientation and the extensive discussion of several well-studied earthquake sequences. The rather complete documentation of observations made during the 1974–1985 seismic episode on the Izu Peninsula in central Honshu is especially informative. Mogi's discussion of the daunting problem of attempting to predict all potentially destructive earthquakes in the intensely urbanized Tokyo metropolitan area is also interesting.

However, the book's scope is rather restricted and directly reflects its author's own research interests, presenting only his interpretations and concentrating almost exclu-

sively on Japanese observations. Though Mogi includes chapters on the physical basis, methods, and strategy of earthquake prediction, coverage of these topics is neither systematic nor complete. Although few seismologists reading this book can fail to be offended by at least one cutting omission or idiosyncratic interpretation, the work has a clear value in a developing field where no consensus has yet emerged. It should be of interest to all specialists wishing to learn about Japanese seismology and that country's progress in the field of earthquake prediction.

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Heavy-Ion Collisions

Frontiers in Nuclear Dynamics. R. A. BROGLIA and C. H. DASSO, Eds. Plenum, New York, 1985. xii, 402 pp., illus. \$69.50. Ettore Majorana International Science Series, Physical Sciences, vol. 25. From a symposium, Erice, Sicily, July 1984.

A major theme of modern nuclear research is the study of nuclear matter under extremes of temperature, density, and spin. These studies bear on the nature of the fundamental strong interaction, on the physics of quantal many-body systems, and on the properties of neutron stars and supernovae. Much recent progress can be attributed to experiments that make use of accelerated beams of large nuclei. In contrast to the gentler interactions associated with "light ions," collisions with a "heavy ion" projectile can severely stress a target nucleus. Analysis of the debris, in combination with models of the collision process, offers an otherwise unattainable glimpse of the nuclear material. *Frontiers in Nuclear Dynamics* surveys the diverse and evolving field of heavy-ion physics through a set of lecture notes prepared for an international school.

The large nuclear fragments emerging from a heavy-ion collision can be spinning rapidly, often enough to cause dramatic changes in their internal structure. The study of such "high spin" states through the energies and angular distributions of the many photons emitted during their de-excitation has been very fruitful, and numerous connections to nuclear structure under more prosaic circumstances have been made as a result of such studies. Lectures by D. Schwalm *et al.* and by F. Stephens summarize what can be learned with large arrays of photon detectors that surround the collision, with much welcome detail on design and data analysis. The story is one in which

steady improvements in instrumentation are constantly refining the physics, and the next generation of experiments should significantly advance our understanding of how nuclei respond to rotation.

The nature of the collision process itself can be more elusive. Lectures by A. Winther and W. von Oertzen review grazing collisions, from which the nuclei emerge relatively intact. These interactions are understood in terms of the quantal properties of the target and projectile and a semiclassical analysis of their relative motion. However, more central collisions require consideration of the dynamical properties of the nuclear material, as is discussed in lectures by C. Ngô and G. Bertsch. Bertsch presents the formalism and results of the time-dependent mean-field method appropriate to low-energy collisions, as well as a very promising approach to intermediate energies, simulation of the Uehling-Uhlenbeck equation.

Measurement of the nuclear equation of state and the detection of new phases of nuclear matter, two of the field's holy grails, are discussed in D. Scott's lectures. Prerequisites are the attainment of approximate equilibrium in the small systems (less than about 100 nucleons) occurring in the collision and a demonstrated sensitivity of experimental observables to the equation of state. Though there is some circumstantial evidence that the former takes place, the jury is certainly not in yet, and the complexity of the latter makes firm statements about it difficult. However, there has been progress in these matters since Scott's lectures, and there is now considerable optimism about ultimately deducing an equation of state from the data.

Heavy-ion collisions at ultrarelativistic energies are perhaps foremost among the "frontiers" that will be explored in the coming years. This regime offers the possibility of "melting" the nucleons and creating a novel plasma of quarks and gluons. The present book is deficient only in not containing an exposition of this subject of a quality commensurate with its other coverage.

The 11 lecturers, all experts in their fields, have generally taken their pedagogy seriously. The resultant material exemplifies the diversity of heavy-ion phenomena and the arsenal of experimental and theoretical tools used to understand them. The lectures will serve well either to introduce a graduate student to the field or to provide more experienced scientists with useful reviews.

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Books Received

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Alzheimer's Dementia. Dilemmas in Clinical Research. Vijaya L. Melnick and Nancy N. Dubler, Eds. Humana, Clifton, NJ, 1985. xxii, 312 pp. \$34.50. Contemporary Issues in Biomedicine, Ethics, and Society.

Americium and Curium Chemistry and Technology. Norman M. Edelstein, James D. Navratil, and Wallace W. Schulz, Eds. Reidel, Dordrecht, 1985 (U.S. distributor, Kluwer, Hingham, MA). viii, 339 pp., illus. \$44.50. Topics in f-Element Chemistry. From a symposium, Honolulu, Dec. 1984.

Analog-Digital Conversion Handbook. Daniel H. Sheingold, Ed. Prentice-Hall, Englewood Cliffs, NJ, 1986. xliii, 671 pp., illus. \$32.95. Analog Devices Technical Handbooks.

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The Darwinian Heritage. David Kohn, Ed. Princeton University Press (in association with Nova Pacifica), Princeton, NJ, 1986. xii, 1139 pp., illus. \$95; until 30 April 1986, \$79.50. Based on a symposium, Florence, June 1982.

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