ter fresh debate on the formation of disciplines and the sometimes surprising ways in which scientists have chosen to carve up the empire of nature.

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Explorations of the Cosmos

Observational Cosmology. ADELAIDE HEWITT, GEOFFREY BURBIDGE, and LI ZHI FANG, Eds. Reidel, Dordrecht, 1987 (U.S. distributor, Kluwer, Norwell, MA). xxvi, 854 pp., illus. $149. International Astronomical Union Symposium no. 124 (Beijing, China, Aug. 1986).

Symposiums on topics related to observational aspects of cosmology were held in Crete in 1983, in Tallinn in 1977, and in Cracow in 1973. Another took place in Balatonfüred, Hungary, in 1987, subsequent to the 1986 symposium in Beijing on which this book is based. The setting of the 1986 meeting was significant, not only because of ancient China's many contributions to astronomy and cosmology, but more particularly as an example of modern China's current eagerness to develop its scientific capabilities through international contacts and exchanges. This opening up is part of a renewal of university life that can be felt as a strong undercurrent of optimism (and often of impatience) among Chinese students and academics. Cosmology has played a significant indirect role in this movement, since Li Zhi Fang, China's best known cosmologist and an editor of the book under review, is known throughout his country as an outspoken supporter of intellectual liberalization in universities.

A comparison of *Observational Cosmology* with the proceedings of the earlier symposiums shows a continuity of concerns and goals as well as some substantial progress. Looking to the future in his summary remarks at the 1973 symposium, Martin Rees hoped soon to see the detection of fluctuations in the microwave background radiation, measurements of its deviation from a blackbody spectrum at millimeter wavelengths, the discovery of quasars and x-ray-emitting galaxy clusters at high redshift, and (with a perhaps ironical "of course") continuing progress on the "classical" problem of determining the size and density of the universe. In addition, he expected substantial progress on fundamental problems related to the physics of the early universe. There has indeed been an explosion of new ideas in this last area since about 1980, but the organizers of the Beijing symposium decided to exclude such topics from their meeting in order to keep a better focus on *observational* cosmology. Most of Rees's other hopes still remain hopes today. The reflex of the motion of our Galaxy has been detected as a dipole anisotropy in the microwave background, but there is still no unambiguous detection of small-scale anisotropies from which we might decipher the origin of galaxies. A significant excess background at submillimeter wavelengths was discovered in 1987, after the Beijing symposium, apparently a result of energetic activity in the pregalactic universe, but we are only now beginning to find quasars and galaxy clusters at redshifts significantly higher than those known in 1973. The traditional tests for size and geometry of the universe remain inconclusive and controversial.

On the other hand, these tests have provided the stimulus for one of the most striking areas of recent progress. In the late 1970s it became clear that the geometry of the universe could not be derived without a detailed understanding of the evolution of the galaxies used to trace its structure. Recent observational advances have made it possible to study the stellar and gas content of galaxies at such large distances that we see them as they were when the universe was less than half its present age. As a result we can now study galactic evolution directly, and the observations are gradually revealing a complex and fascinating story: we may be beginning to see galaxies in the process of formation. Several papers in *Observational Cosmology* give good reviews of this topic, but the reader should note that there have been significant advances since the Beijing symposium.

A second area of substantial progress has been the elucidation of the structure of the universe on large scales. The ability to measure redshifts, and thus rough distances, for large samples of galaxies has made it possible to map the structure of their distribution in three dimensions. The observational advance in this area is easily appreciated by comparing the maps in *Observational Cosmology* with those of earlier volumes. As new data have accumulated the structure has been characterized successively as cell-like, filamentary, frothy, bubble-like, and spongy. It seems clear that our ability to characterize the galaxy distribution and draw physically meaningful conclusions from its structure has not advanced as fast as the observations. However, this is currently a very active area of theoretical research.

Other areas in which our observational understanding is advancing rapidly include the intergalactic medium, dark matter in the universe, and gravitational lenses. A strong point of *Observational Cosmology* is the almost uniformly high quality of the review papers covering these forefront topics. There are also a number of very good papers reviewing less rapidly developing areas of study where it is easier to be complete and the discussion is slower to be outdated. Although the standard of the contributed papers in the volume is more uneven, they give a fair cross section of current observational research and of theoretical efforts to interpret the data. The book opens with a particularly fine historical survey by Sandage and closes with a highly readable summary by Longair. All in all it provides a good introduction to the present state of the farthest frontier of observational astronomy.

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Biotic Changes

Global Bio-Events. A Critical Approach. OTTO H. WALLISER, Ed. Springer-Verlag, New York, 1986. x, 442 pp., illus. Paper, $38.50. Lecture Notes in Earth Sciences, 8. From a meeting, Göttingen, F.R.G., May 1986.

"Global bio-events" are profound, relatively rapid, worldwide changes in fossil biotas. Their recognition is not a new phenomenon—fossils have long been used to demarcate the stratigraphic record. What is new is an increased appreciation of the importance of sudden change in the history of the earth and life. Hypotheses of punctuated equilibrium, asteroid impact, and periodic extinctions have made current interpretations of earth history and the tempo of evolution more in the spirit of Cuvier and less in the spirit of Lyell. Instances of rapid change in the stratigraphic and fossil record, rather than seen as evidence of an imperfect record, are now likely to be taken seriously.

This volume, the proceedings of the Fifth Alfred Wegener Conference (the first international meeting of International Geological Correlation Program Project 216), consists of six general papers that provide the theoretical rationale and methodological framework for the study of global bio-events and 35 short descriptions of work on particular time intervals.

In his introductory chapter, Walliser notes that bio-events may be originations, rapid diversifications, dispersals, or extinctions; that they may have a complex of terrestrial and extraterrestrial causes; and

that they may provide a means for high time resolution of strata. Sorting out their types, causes, and applications is an ambitious agenda. The contributors to the volume do not always succeed, but their efforts and results are important. Though some of the analyses seem unduly concerned with local details, an understanding of the significance of a bio-event rests on the compilation of such details. Still unresolved in many cases is the geographic extent of a particular bio-event. While many of the bio-events discussed in this book are undoubtedly global in their expression, others may reflect only local or basin-wide phenomena. How to distinguish the global signal from the local noise?

Only Kauffman's extensive review of event stratigraphy in the Western Interior Cretaceous of North America explicitly addresses the issue of distinguishing local, regional, and global bio-events. Even when the principles are clearly articulated, the practice is less than straightforward. The extent to which variations in species abundance, episodes of mass mortality, immigrations, and even extinctions are synchronous over vast areas should be proven rather than assumed. Individual stratigraphic sections are often full of bio-events of all sorts.

Boucot's essay expresses his skepticism of the approach to bio-events that uses compilations of stratigraphic ranges. Not only are they prone to errors of all sorts, he argues that compilations and analyses of the Sepkoski-Raup variety obscure the real signal—that of extinction and evolution within communities. Boucot calls paleontologists back to the trenches: back to document precise range limits and back to decipher the environmental and ecological context of the fossils. Indeed, this is what most of the contributors to this volume are doing. But such work is not going on in a theoretical vacuum—it is done to test the hypotheses that emerge from the more analytical and theoretical approaches.

Sepkoski provides a lucid review of the periodicity issue and answers some of the major criticisms elicited by his and Raup's earlier contributions. Working now with genera instead of families, Sepkoski's analyses continue to reveal a 26-million-year periodicity in extinction events since the mid-Permian but fail to detect a periodic signal in the Paleozoic. The periodicity hypothesis continues to resist refutation.

Fossils do not provide the only means to detect perturbations in the biosphere. Holser, Margaritz, and Wright review the variations in sulfur, carbon, and strontium isotopes through the Phanerozoic. I suspec that the potential of such geochemical work for the understanding of bio-events has yet to be fully realized. On the global scale, issues of temporal resolution, diagenesis, and local fractionation need to be worked out. At the local level, geochemical anomalies in the vicinity of bio-events need to be evaluated in the context of fluctuations higher and lower in the section. It's not just the fossils that are subject to vagaries of preservation, collection, and age determination.

In a largely theoretical contribution, Wilde and Berry present a model in which changes in deep-ocean circulation can be produced by climatic changes. As a cause for marine bio-events, the model is plausible but as yet largely untested.

The 35 short reports are organized stratigraphically, starting with the Precambrian and ending with the Tertiary. Most report on particular sections or particular bio-events. Their cumulative effect is impressive. It seems that no corner of the globe and no time is free of bio-events of one sort or another. The extinction events of the Late Devonian and the Cretaceous-Tertiary receive the most attention. Though geographic coverage is extensive, it is not global, being based with few exceptions on studies in Eurasia. Extinctions of marine invertebrates and protists are the bio-events most commonly discussed in this section of the book. Sea level lowering, climatic change, and bolide impact are the three most popular explanations for the biotic changes recorded in the rocks.

Many of the short papers are well-documented, succinct case studies. For example, Farsan presents evidence from stratigraphic sections in Iran and Afghanistan that suggests that the Late Devonian extinctions were protracted rather than sudden events. McGhee and others fail to find evidence for any geochemical anomalies at the Late Devonian extinction event in Germany. Whatley presents an impressive compilation of patterns of ostracod species diversity, origination, and extinction through the Mesozoic. Wiedmann documents the gradual decline of macroinvertebrates at the Cretaceous-Tertiary section at Zumaya, Spain, and argues for multiple causes for the end-Cretaceous extinctions.

Some of the short papers are brief progress reports, providing neither data nor scientific perspective. They have some value in fostering scientific communication but are likely to be quickly superseded.

The volume was produced from camera-ready copy. The production and editorial quality are satisfactory, but an index would have been a welcome addition.

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Some Other Books of Interest

Schrödinger. Centenary Celebration of a Polymath. C. W. KILMISTER, Ed. Cambridge University Press, New York, 1987. x, 253 pp. $54.50. From a conference, London, March–April 1987.

Erwin Schrödinger was born in 1887, and to celebrate the centennial of the event representatives of the various scientific fields that Schrödinger, in the editor's words, had made his own were invited to survey his contributions to their fields and his influence on their own work. This collection of 19 papers ranging in length from four to 25 pages and of varying degrees of breadth and technicality is the result. The contributors include Jon Dorling, J. S. Bell, Chen Ning Yang, W. E. Thirring, Martin Karplus, Kenichi Fukui, A. D. Buckingham, J. T. Lewis, James McConnell, O. Hittmair, S. W. Hawking, A. Salam, T. W. B. Kibble, and M. J. Seaton. Among the more biographically oriented contributions are a brief introduction by the editor, a chapter by Ludwig Boltzmann's grandson Dieter Flamm on Boltzmann's influence on Schrödinger, and an account by William McCrea of the Dublin Institute of Advanced Studies and Schrödinger's tenure there. In two final papers, Linus Pauling and M. F. Perutz assess Schrödinger's contributions to molecular biology, both giving negative evaluations of his famous book *What Is Life?*—**K.L.**

Methods in Computational Chemistry. Vol. 1, Electron Correlation in Atoms and Molecules. STEPHEN WILSON, Ed. Plenum, New York, 1987. xviii, 363 pp., illus. $65.

"With the increasing use of computational techniques in chemistry, there is an obvious need to provide specialist reviews of methods and algorithms so as to enable the effective exploitation of the computing power available," writes Stephen Wilson in the preface to this initial volume of *Methods in Computational Chemistry*. The series is intended to fill that need. "Each volume," Wilson continues, "will cover a particular area of research . . . and will provide a broad-ranging yet detailed analysis of contemporary theories, algorithms, and computational techniques." It is hoped that the series will be useful to those engaged in developing computational methods, to chemists, atomic and molecular physicists, biochemists, and molecular biologists wishing to use such methods, and to graduate students needing an introduction to the field. This initial volume is devoted to the problem of describing electron correlation effects in atoms and molecules, "the accurate calculation [of which] from first principles