

symmetries is often even more interesting. For example, the observation of elliptical, not circular, planetary orbits led to Kepler's laws and was a powerful stimulus in the development of Newtonian mechanics. A more modern example is the observation of the violation of parity (spatial reflection symmetry), one of the first ingredients in weak interaction physics and unified gauge theories.

At present two forms of symmetry breaking intrigue elementary particle physicists. One of these involves the underlying structure of the broken symmetry of the electroweak gauge theory of Weinberg and Salam. Here the underlying symmetry of the theory is removed by interactions of a hypothesized "Higgs boson." There are aesthetic arguments against this Higgs mechanism, although no compelling alternative exists. A prime goal of the proposed superconducting supercollider will be to test this scheme and find the Higgs boson, if it exists. The other form of symmetry breaking now attracting attention involves CP violation. Here C refers to the operations of charge conjugation, that is, the interchange of a particle and its antiparticle. P stands for the parity transformation, the inversion of all spatial coordinates through the origin ($x \rightarrow -x$). Even though both C and P are maximally broken in the weak interactions, their combined operation is very nearly a symmetry. Twenty-five years ago the first evidence for CP violation was found as a 10^{-3} effect in the decays of K mesons. No other CP violation has been found outside of K decays.

Both of these topics are interesting because they may take us beyond the present standard model. (Indeed they may be related, because all known mechanisms of CP violation involve the Higgs sector of the theory either directly or indirectly.) The standard model is a self-consistent structure sufficient to explain current data, but we are looking for a glimpse beyond it. CP violation may be a key to this because, as a rare effect, it has the magnitude appropriate for interactions mediated by particles heavier than those produced at present accelerators.

This volume contains 18 reviews on many of the important topics in the study of CP symmetry. The intent appears to be to provide a snapshot of present work in the field. Similar material is most often available in journals, but the book accomplishes a valuable service in drawing it together.

The book opens with a lucid description of the basic theoretical background of CP violation by Jarlskog. Complementary experimental reviews by K. Kleinknecht and S. Stone thoroughly describe the studies of weak decays of kaons and B mesons. These

reviews would be useful for students starting work in the field or even browsers who want to find out what is being studied.

Next come nine papers on possible future signals and alternate models of CP violation. Of these, the one that will probably have the greatest utility and longest lifespan is the survey of B meson physics by I. Bigi, V. Khoze, N. Uraltsev, and A. Sanda. The decays of B mesons display a rich variety of possible signals, and considerable effort is being expended in Europe and the United States to create facilities that can see this form of CP violation. This field will be active for at least 10 to 15 years, and Bigi *et al.* here provide the most thorough and readable account of the issues that I know of. I have seen no review comparable to the excellent summary of electric dipole moments by S. Barr and W. Marciano. On the negative side, I found L.-L. Chau's discussion of signals in B and K decays misleading, since Chau has not updated her previous analysis to include either tightened experimental constraints or further theoretical analysis.

One of the enjoyable aspects of working in the field of CP violation is the variety of related theoretical issues. The last six chapters of the book tour some of these. I greatly enjoyed the chapter "Strong CP problem" by R. Peccei. This title refers to the strong interaction, quantum chromodynamics, which could easily violate CP but apparently doesn't. This seems unnatural in the standard model, and many interpret it as indicating some new physics, such as new particles called axions. Peccei carefully discusses the issues. E. de Rafael's chapter on chiral perturbation theory is a readable, but brief, introduction to this subtle and useful tool.

My greatest concern about the book is that most likely it will become out of date reasonably quickly. With the exception of those by Bigi *et al.* and Peccei, most chapters involve theoretical or experimental methods that are evolving fairly rapidly. Some of the data in the book are already out of date, and even some of the theoretical analyses have progressed noticeably. The book is also incomplete in some regards. For example, two promising new directions that are receiving considerably scrutiny, $K_L \rightarrow \pi^0 e^+ e^-$ and hyperon decay asymmetries, are not discussed. It is, however, a reasonable summary of the present status of the field.

Overall, the volume offers a generally readable entry into this field for a reader who has a basic background in particle physics.

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Celestial Spectra

Multiwavelength Astrophysics. FRANCE A. CORDOVA, Ed. Cambridge University Press, New York, 1988. xii, 400 pp., illus. \$59.50.

Two or three years ago, I thought it would be instructive to show students spectra of compact celestial sources ranging all the way from 100 MHz in the radio domain to the highest energy gamma rays around 10^{15} eV or 10^{30} Hz. I know of no single compendium of such information, and I had to gather much of it from odd sources.

My first act in reading *Multiwavelength Astrophysics*, therefore, was to leaf through it to see how many such spectra were shown. There are three, perhaps not covering quite the full range of available wavelengths, but at least spanning more than 10 orders of magnitude. They represent Cyg X-3, for which 20 orders of magnitude are covered, 3C273, and NGC 4151. In addition, ζ Puppis, 3C345, and Mrk421 are shown with spectra that cover close to 10 orders of magnitude in frequency. Of course such spectra tend to be coarse, primarily showing the power distribution across the spectrum. Finer features detailing chemical makeup, state of ionization, and pressure or temperature, only show up at higher resolution. Still, it was refreshing to find so many of these broad spectra.

The book is divided into two major parts. The first is by far the most extensive and is arranged according to type of celestial source—the sun, active late-type stars, hot stars, cataclysmic variables, x-ray binaries, classical novae, x- and γ -ray bursts, supernovae and their remnants, interstellar matter in elliptical galaxies, and active galactic nuclei. By any standards, the individual chapters are excellent reviews of their respective fields. Most of them emphasize the fact that the astrophysical conclusions are based on observations at a variety of wavelengths, but others leave that inference to the reader.

Jeffrey Linsky's paper on the active late-type stars is particularly explicit in demonstrating that polarization measurements, or shifts in spectral line frequencies with time, or any of several other types of correlative observations lie at the heart of star-spot analyses: multiwavelength astrophysics is not just a one-dimensional game involving wavelength.

Part 2 of the book deals with the methodology of multiwavelength observations. In three chapters, it identifies available databases and the centers where analyses can be carried out; lists capabilities of current instrumentation, giving a description of its uses in several wide-ranging campaigns on such sources as Halley's comet and Cyg X-3;

and enumerates future observatories that will facilitate multiwavelength work. I found the first two chapters particularly interesting in that they constitute a primer for conducting multiwavelength research. An infrared or submillimeter astronomer must find the third chapter disappointing because the author discusses only one infrared mission, SIRTf, and omits the European Space Agency's Infrared Space Observatory (ISO), scheduled for launch in 1993, and the planned NASA mission LDR and ESA mission FIRST.

Many of the papers in this volume provide outstanding examples of how an astrophysical picture emerges from a wealth of individually inconclusive indicators, intelligently gathered wherever technology provides opportunities and physical insight permits discrimination between competing ideas. Perhaps the most useful aspect of the book is that it tells the newcomer how to think in terms of multiwavelength observations. We don't find many tables compiling facts. Rather, we repeatedly become engrossed in discussions of how to derive astrophysically interesting conclusions. In the long run that may be the most valuable contribution this volume can make.

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A Biotic Transition

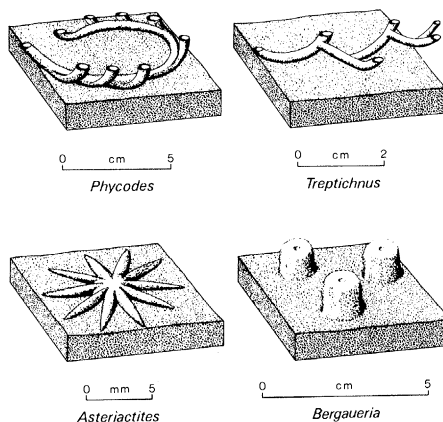
The Precambrian-Cambrian Boundary. J. W. COWIE and M. D. BRASIER, Eds. Clarendon (Oxford University Press), New York, 1989. x, 213 pp., illus. \$85. Oxford Monographs on Geology and Geophysics, vol. 12.

The most important events in the history of life arguably occurred during the few tens of millions of years that encompass the transition from Precambrian to Cambrian time. It was then that the body plans of most of the major groups of animals were developed during a period of unparalleled evolutionary invention; those metazoan diversifications cast the parts for the great play of life.

Despite the clear intrinsic interest of those seminal events, it has only been within the last couple of decades that a broad scientific effort has been mounted to explore the geologic and paleontologic record of that time; reasonably complete sections across the transition are rare, trace fossil studies had been in their infancy, and body fossils are relatively rare and are so primitive or allied so remotely to living groups that their interpretation is difficult. Furthermore, the temporal relations of fossil occurrences are

uncertain. Fortunately, progress in studies of transition events has been accelerating steadily. One of the principal driving forces has been, of all things, the attempt to establish international agreement on a reference horizon and locale (a "Global Stratotype Section and Point"—GSSP) for the Precambrian-Cambrian boundary. This effort has led to the careful examination of a number of sections that embrace the boundary, with an eye to discovering the most complete, most fossiliferous, and generally most useful GSSP. From these (and to be sure many other) studies has come a flood of new information bearing on the early metazoan radiation.

The Precambrian-Cambrian Boundary is a collection of essay-reviews, rich in data, written by several British members of a Working Group established under the International Geological Correlation Programme to recommend a GSSP. At present there are three major candidate sections: one is in Yunnan Province, one in Siberia, and one in Newfoundland. These and other important sections are described in some detail in a series of chapters. The biostratigraphy of the earliest fossils with mineralized skeletons, which appear near the boundary (more cannot be said until the boundary is selected), is reviewed on a global scale, as is the sequence of trace fossils from their earliest appearance through the Lower Cambrian. These two groups of fossils are promising as stratigraphic tools, although they lead to slightly different results when used to correlate geologic formations. The most serious deficiency is in the coverage of the biostratigraphic record of the phytoplanktonic acritarchs, which may prove to be especially useful in Precambrian-Cambrian correlations. There is reason to hope that these three fossil groups will provide the correlations needed to certify the sequence of events during the transition.



"Some of the trace fossils which first appear before the earliest trilobites in Tommotian and Atdabanian strata." [From T. P. Crimes, "Trace fossils," in *The Precambrian-Cambrian Boundary*]

Two papers consider the absolute ages of the rocks near the boundary. These discussions are sobering. By convention the boundary age is usually taken as 570 million years. The possible age, however, for the base of the Tommotian Stage, the horizon most likely to be chosen as the boundary, ranges at least from 600 to 530 million years. Recent evidence tends to favor an age nearer the younger end of this large range, but clearly the issue is not decided.

This volume brings together a wealth of biostratigraphic and chronostratigraphic information. For readers with a good working knowledge of the principles of biostratigraphy and a reason to inquire into the nature of the stratigraphic record during the early metazoan radiations, access to this volume is indispensable.

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Reprints of Books Previously Reviewed

Pyroclastic Rocks. R. V. Fisher and H.-U. Schminke. Springer-Verlag, New York, 1989. Paper, \$65. Reviewed 227, 48 (1985).

The Strategy of Life. Teleology and Mechanics in Nineteenth-Century German Biology. Timothy Lenoir. University of Chicago Press, Chicago, 1989. Paper, \$14.95. Reviewed 221, 146 (1983).

The Visible College. A Collective Biography of British Scientists and Socialists of the 1930s. Gary Werskey. Free Association Books, London, 1988 (U.S. distributor, Columbia University Press, New York). \$60. Reviewed 206, 674 (1979).

Books Received

Advanced Information Technology in the New Industrial Society. The Kingston Seminars. Arthur Cotterell, Ed. Oxford University Press, New York, 1988. xiv, 113 pp., illus. \$29.95; paper, \$18.95.

Advanced Power Sources for Space Missions. National Research Council. National Academy Press, Washington, DC, 1989. xii, 140 pp. Paper, \$23.50.

The Biology of the Brain. From Neurons to Networks. Rodolfo R. Llinás, Ed. Freeman, New York, 1989. xii, 170 pp., illus. Paper, \$10.95. Readings from *Scientific American*.

The Challenge of Global Warming. Dean Edwin Abrahamson, Ed. Island Press, Washington, DC, 1989. xviii, 356 pp. \$34.95; paper, \$19.95.

The Facts on File Dictionary of Artificial Intelligence. Raoul Smith. Facts on File, New York, 1989. viii, 211 pp., illus. \$24.95.

The Geology of Iztaccihuatl Volcano and Adjacent Areas of the Sierra Nevada and Valley of Mexico. Graham T. Nixon. Geological Society of America, Boulder, CO, 1989. viii, 58 pp., illus., + map in pocket. Paper, \$20. GSA Special Paper 219.

Low Temperature Detectors for Neutrinos and Dark Matter II. L. Gonzales-Mestres and D. Perret-Gallix, Eds. Editions Frontières, Gif sur Yvette, France, 1988. x, 518 pp., illus. \$63. From a workshop, Annecy-Le-Vieux, France, May 1988.

Macroevolutionary Dynamics. Species, Niches, and Adaptive Peaks. Niles Eldredge. McGraw-Hill, New York, 1989. xii, 226 pp., illus. \$28.95; paper, \$14.95.

The Oblique Derivative Problem of Potential Theory. A. I. Yanushauskas. Consultants Bureau (Plenum), New York, 1989. viii, 251 pp. \$79.50. Contemporary Soviet Mathematics. Translated from the Russian by Norman Stein.