Book Reviews

Elementary Particle Physics

Probing Hadrons with Leptons. Proceedings of a seminar, Erice, Italy, Mar. 1979. GIULIANO PREPARATA and JEAN-JACQUES AUBERT, Eds. Plenum, New York, 1980. x, 508 pp., illus. $59.50. Ettore Majorana International Sciences Series, Physical Sciences, vol. 5.

In the decade 1970–1980 there occurred a number of significant advances in our understanding of elementary particle physics. Important steps were taken in the development of a unifying gauge theory of the weak and electromagnetic interactions of elementary particles through an exciting concurrence of experimental and theoretical accomplishments. Simultaneously, a new view of the nature of hadrons and their strong interactions evolved from its birth as an extraordinarily prescient conjecture to maturity as a quantitative theory (albeit with certain basic difficulties) supported by a substantial body of experimental data. New degrees of freedom of hadronic matter indicative of hadronic substructures, that is, of hadron constituents, were found experimentally and incorporated naturally, first, in the elegant and simple quark-parton model and, later, in a more ambitious relativistic quantum theory of hadrons (quantum chromodynamics). Consolidation of these advances continues, and, in addition, the success they represent has stimulated serious attempts to formulate a theory that would unify the strong as well as the weak and electromagnetic forces, which is one of the newer concerns of present elementary particle physics.

In this volume many of these developments are described in a series of papers by experts in their respective fields. The papers cover much of the experimental effort of the past few years: e^+e^- colliding-beam experiments and lepton-hadron scattering experiments. They look forward in time, for example, indicating from the early results on e^+e^- scattering at 13- and 17-GeV center of mass energies at Petra the prospects at higher energies and luminosities (Böhm) and discussing the plans for lepton physics with the future 1000-GeV accelerator (Tevatron) at Fermilab (Kirk). They look backward in time to relatively low q^2 electroproduction experiments (Osborne), to early muon-scattering results at high q^2 (Anderson and Chen), and to data on neutrino-induced weak neutral currents (Haidt). In addition, new results on second-generation, that is, current, muon-scattering experiments from Fermilab (Strovink) and CERN (Stier, Aubert, and Smadja) are presented, as well as descriptions of the experimental apparatus employed in those experiments.

There are seven theoretical papers, in five of which the central issues are the properties of quantum chromodynamics (West) and the applicability of quantum chromodynamics to the description of the final states of e^+e^- interactions (Gaillard) and of lepton-induced reactions (Landshoff, Binétruy and Girardi, and Reya). A less sanguine view of quantum chromodynamics that includes an alternative program is put forth in the concluding paper of the volume (Preparata).

Much of the material here will appear in professional journals in papers of more limited focus and with greater detail. The principal virtues of the volume are its timeliness, its concentration on a single (but broad) subject, and the less formal and general nature of most of the papers. These advantages will make it of value to the researcher and to the advanced student alike. The clarity of the layout and of the printing further enhances its value.

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Igneous Petrology

Physics of Magmatic Processes. Papers from a conference, 1977. R. B. HARGREAVES, Ed. Princeton University Press, Princeton, N.J., 1980. x, 586 pp., illus. Cloth, $40; paper, $15.

Physics of Magmatic Processes is the second recent volume of papers honoring the great contribution to igneous petrology made by Norman L. Bowen. The earlier volume, *The Evolution of the Igneous Rocks: Fiftieth Anniversary Perspectives*, edited by H. S. Yoder, summarized modern advances in all the subjects treated by Bowen in his 1928 book, *The Evolution of the Igneous Rocks*, chapter by chapter. The present volume differs in that it contains discussions of ideas about the behavior of magma that have been developed largely since Bowen's time. Many of these ideas, however, were anticipated by Bowen in his concluding chapter, "Petrogenesis and the physics of the earth."

Bowen realized that petrogenesis of igneous rocks could not be studied independently of the contributions of geophysics. Unfortunately the relationship is often neglected today, and recent literature reflects the fact that geophysicists and geochemists consult with one another all too infrequently about limitations on magma genesis. The contributors to this volume partially bridge the gap by recognizing that, whereas the production of partial melts may be controlled by pressure, temperature, and volatile contents, their realization as magma bodies to be erupted or stored in the earth depends on physical factors—namely the contrasting rheologies of the melt and the enclosing solid mantle and crust separating the source region from the surface of the earth.

The scope of this volume is large. Several papers are devoted to the rheology of magmas, including density and viscosity of magmas at high pressure (I. Kushiro) and the mechanics of magma accumulation and transport during and following partial melting (H. R. Shaw; F. J. Spera). Other papers consider properties of melts, including the kinetics of nucleation and subsequent crystallization (E. Dowty; G. Lofgren) and the related subjects of melt structure (P. C. Hess) and chemical diffusion (A. W. Hofmann). The volume contains one paper on the geophysics of heat flow and magma genesis (E. R. Oxburgh), one on the thermodynamics of the albite-anorthite-diopside system (D. F. Weill, R. Hon, and A. Navrotsky), and one on trace element and isotopic limitations on magma genesis (S. R. Hart and C. J. Allègre). (Unhappily, the volume does not contain a comparable treatment of major-oxide mass balances of magmas and mantle source materials.) Finally, there is an excellent paper on processes that accompany cooling and crystallization of large mafic magma chambers (T. N. Irvine).

Some notable omissions decrease the usefulness of the volume as a modern reference on the physics of magmatic processes. There is, for example, no account of H. S. Waff's experimental studies of the wetting properties of partial melts at high pressure or of studies of chemical diffusion and crystal fractionation in silicic magma systems, as represented by the work of W. Hildreth and

R. L. Smith, that present a significant comparison and contrast with Irvine's study of mafic systems; there is no discussion of high-temperature rheology of the earth's mantle (a planned summary of the subject was prevented by the death of C. Goetze) or of diapir and plume mechanics elucidated by studies by B. D. Marsh, M. Parmentier, and others; and there is no modern assessment of the chemical, mineralogical, and density structure of the source regions for magmas as inferred from both geophysical and geochemical data.

Nonetheless, the breadth and quality of the papers that are included make the book a valuable addition to the bookshelves of geologists, petrologists, geophysicists, and geochemists. The volume should inspire an increase in interdisciplinary emphases in both teaching and research on the origins of magmas and magmatic processes.

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Tetrapod Origins

The Terrestrial Environment and the Origin of Land Vertebrates. Proceedings of a symposium, Newcastle upon Tyne, England, April 1979. A. L. PANCHEN, Ed. Published for the Systematics Association by Academic Press, New York, 1980. xii, 634 pp., illus. $87.50. Systematics Association Special Volume No. 15.

The origin of tetrapods has been a subject of debate since the discovery of the first lungfish in 1837. Although the arguments have evolved in response to expanding knowledge of fossil and Recent forms, crossopterygians generally have been considered to be the most likely ancestors to tetrapods. This view has been promulgated thoroughly in textbooks, and there it might have remained as dogma had it not have been for the appearance of Willi Hennig's *Grundzüge einer Theorie der phylogenetischen Systematik* in 1950. The full impact of Hennig's novel approach to the evaluation of homologies (dubbed "Hennig's principle" by Brundin in 1966) did not reach the community of English-speaking systematic biologists until a translation of the book (*Phylogenetic Systematics*, University of Illinois Press) appeared in 1966. A new generation of systematists has since surfaced—the cladists, armed with a new philosophical tool to assess phylogenetic problems. The most significant outcome of this systematic upheaval is the renewed interest in old problems and the animated disagreements that have arisen. The coup is far from complete, as is evidenced by this volume with the vigorous defense of pre-Hennigian systematics by Westoll and Panchen in contrast to the approaches of Patterson, Gardiner, and others.

Patterson and Gardiner resurrect the pre-Darwinian theory that dipnoans are the closest relatives of tetrapods. In defense of this thesis, Patterson applies Hennigian principles to his evaluation of schemes of tetrapod relationships that have been proposed since 1840; this is a synoptic version of the more extensive discussion by Rosen, Forey, Gardiner, and Patterson (*Bull. Am. Mus. Nat. Hist.* **167**, 159–267 [1981]). Patterson recapitulates the weaknesses of the most widely used approach, the search for ancestors, and points to the advantages of cladistic diagrams—that is, "their clarity and the ease with which they may be criticized" (p. 169).

A reader who is inclined to criticize will find ample opportunity in Gardiner's paper, "Tetrapod ancestory: a reappraisal." Gardiner bases his scheme of relationships on only a few characters, and of these some are wrong and others inconclusive. For example, true Westoll lines occur only in lungfishes. They are unknown in osteolepidids, panderichthyids, and tetrapods; yet Gardiner claims the presence of Westoll lines in these groups to be an advanced character shared with lungfishes. Moreover, Gardiner homologizes the paired bone I of lungfishes with postparietals in tetrapods; at the same time he homologizes the median bone B of lungfishes with the unpaired postparietal of *Ichthyostega*, an Upper Devonian tetrapod. Thus of the three parietal bones possessed by lungfishes, one is shared with *Ichthyostega* and the other two with all other tetrapods, according to his reasoning. For a more satisfying and complete discussion of the lungfish-tetrapod relationship, the reader is referred to Rosen *et al.* (1981, cited above).

In a volume of this distinction and diversity, it is disappointing that the "prologue" is not a more expansive philosophical dialogue. In it Westoll condemns Hennigian methodology in favor of a "paleontological approach" to the ancestry of tetrapods (see Patterson, *Syst. Zool.* **29**, 216–219 [1980], for related commentary). The two approaches need not be totally exclusive of one another, however. The study of "detailed comparative anatomy" and the "consideration of variation within and between subgroups" of fossils (Westoll, pp. 2–3) are the first steps of a cladistic approach as well as of a "paleontological" one, because first one must identify the characters—that is, the homologies. The philosophical dichotomy emerges in the methods of evaluating these homologies. Correctly applied, the Hennigian approach seeks to assess the validity of every apparent homology by whatever data possible. In contrast, the "paleontological approach" described by Westoll precludes the application of data from comparative anatomical studies and functional analyses of Recent forms to the study of fossils because "much of the material is skeletally incomplete and where even the best material gives negligible information about any structures or functions not affecting the skeleton directly (as by foramina for nerves or vessels, or muscle insertions), is clearly less precise by orders of magnitude." Instead, Westoll advocates reliance on the time sequence of the appearance of fossils and continued search for new material to solve questions of relationship. In this regard, it is unfortunate that Patterson, in his paper "Origin of tetrapods: Historical introduction to the problem," dismisses the fossils, even though the Upper Devonian lungfish *Griphognathus* is critical to the lungfish-tetrapod relationship argument. On the other hand, Janvier ("Osteolepid remains from the Devonian of the Middle East, with particular reference to the endoskeletal shoulder girdle") uses cladistic methodology to generate a scheme of relationships that is favored by Westoll.

The significant suite of characters shared by osteolepidid crossopterygians and tetrapods is not addressed directly, although Janvier, Rackoff, and Holmes provide additional information on the pectoral girdle and limb that favors such a relationship. The tympanum, often considered to be a common feature among all tetrapods, is shown by Carroll to be derived independently in different groups. Carroll's conclusions are supported by the results of the extensive study by Lombard and Bolt (*Biol. J.* **11**, 19–76 [1976]).

Nearly a quarter of the contributed papers are reviews of various tetrapod groups based on cladistic analysis. The classifications that have been extracted from these cladograms provide a focus for the attention of non-Hennigian systematists. The new nomenclature that follows from such reassessments frequently is unfamiliar and therefore uncomfortable for many scientists. For example, the term "Batrachosauria" applied to a group of amphibians by Panchen becomes identical with the Reptilia of Heaton. At the same time, the Sey-