are incorporated, and the results seem well supported. He proposes four orders of marsupials arranged in two cohorts: the Ameridelphia, which includes all Western Hemisphere forms with the exception of the small opossum *Dromiciops*, and the Australidelphia. This arrangement of *Dromiciops* is also supported by karyotypic evidence (Sharman) and has obvious zoogeographic significance.

Naturally, there are things to criticize in such a large and complex undertaking. There are too many typographical errors and too many of the figures were poorly designed for the required reductions in size. I find it unacceptable to include, as some authors have, the distinctive dasyurid *Antechinomys* within the genus *Sminthopsis*. Except for dental morphology, all other aspects of anatomy and the isozyme data support separate generic status for *Antechinomys*. Rather than list deficiencies and disagreements, however, I prefer to emphasize the major contributions made in these two volumes, their welcome synthesis of various viewpoints and approaches, and the genuine effort that was apparently made to keep the authors in communication with each other. This seems to have been a symposium true to the literal sense of the word, and the volumes are ones any biologist would be pleased to own. They are clearly essential for any mammalogical library and are to be recommended for any scientist or research group concerned with the comparative approach to ecology, physiology, behavior, paleontology, or evolution.

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Biochemistry

Structure and Function Relationships in Biochemical Systems. Proceedings of a symposium, Rome, Sept. 1981. FRANCESCO BOSSA, EMILIA CHIANCONE, ALESSANDRO FINAZZI-AGRÒ, and ROBERTO STROM, Eds. Plenum, New York, 1982, x., 386 pp., illus. $49.50. Advances in Experimental Medicine and Biology, vol. 148.

The work of Alessandro Rossi Fanelli provides the focus in this proceedings of a symposium organized to celebrate his 75th birthday. A concise and vivid profile of Rossi Fanelli from both a personal and a scientific perspective is provided by N. Siliprandi in the opening paper. This is followed by a unique statistical analysis by W. E. Blumberg of the honoree's publications and collaborations.

The rest of the volume consists of 26 scientific papers that are divided into five sections. The first is titled Hemoglobin, Myoglobin, and Other Respiratory Proteins and is composed of a theoretical paper by Wyman, discussions of mammalian, fish, and invertebrate hemoglobins by Perutz, Gibson and Carey, and Antonini *et al.*, and a paper on the effects of heavy metals on respiratory proteins of marine organisms by Bonaventura *et al.* Perutz's paper incorporates the extensive literature on this subject in a concise, up-to-date view of hemoglobin structure and function. The papers by Gibson and Carey and Antonini *et al.* serve to emphasize the utility of studies of hemoglobins from fish and invertebrates and their contribution to our understanding of mammalian hemoglobin structure and function.

The second section, Mechanism of Action of Metal-Containing Enzymes, deals extensively with present knowledge of the structure and function of cytochrome *c* oxidase. Papers by Malmström, Chance *et al.*, and Brunori *et al.* discuss current views regarding the participation of the Cu and heme centers in the reduction of O_2 to H_2O as well as structural alterations involved that may be relevant to the role of this redox protein in energy coupling. An excellent paper by Beinert discusses the influence of conformational alterations on function for a number of enzymes containing iron-sulfur centers in addition to cytochrome *c* oxidase. The role of Cu in enzyme-catalyzed reactions is also treated in papers on the well-studied Cu-Zn superoxide dismutase and the less understood amine oxidases.

The third section, Bioenergetics, Membrane Structure, and Multienzyme Complexes, serves to remind us of the role of supramolecular organization in the functional control of biological processes. Topics addressed range from protein-membrane interactions to enzyme-enzyme interactions, with excellent papers by Lehninger on mitochondrial energy transduction and by Reed and Oliver on the pyruvate and α-ketoglutarate dehydrogenase complexes.

Modulation of the chemical function of the bound coenzyme by the environment provided by the host apoenzyme is discussed in the fourth section, Cofactor-Dependent Enzymes. Excellent papers by Snell and by Massey deal respectively with the comparative aspects of pyridoxal phosphate and pyruvoyl-dependent amino acid decarboxylases and with the correlation of flavin environment with function in a number of flavoenzymes.

The final section, Sulfur Metabolism, consists of a review of the chemistry and biological occurrence of persulfide groups by Wood and one of the biological utilization of selenium- and sulfur-containing amino acids by De Marco and Di Girolamo and a paper on some interesting observations of chemical reactions of selected sulfur-containing amino acids subsequent to enzyme-catalyzed oxidative deamination by Cavallini *et al.*

The volume is readable and informative. The papers are, in general, well written and provide concise, current treatments of their respective topics.

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An Era in Classical Physics

Energy, Force, and Matter. The Conceptual Development of Nineteenth-Century Physics. P. M. HARMAN. Cambridge University Press, New York, 1982. x, 182 pp., illus. Cloth, $27.50; paper, $8.95. Cambridge History of Science.

To laypersons classical physics has long been epitomized by Newtonian mechanics, in contraposition to the relativistic mechanics and quantum mechanics of our century. Peter Harman seeks to reform that consciousness by displaying for a non-mathematical audience the great subtlety and variety in the mechanical worldview of 19th-century physicists. The reader will see that energy physics, thermodynamics, electromagnetic field theory, and statistical mechanics were a long way from Newton. They were also a long way from Einstein and Bohr, but not so far as we imagine when we think of mechanics only in terms of forces acting between atoms in conformity with the laws of motion. During the second half of the 19th century "classical" physics posed for itself puzzles that still haunt those who wish to understand nature. What is an electromagnetic field? What is the meaning of the second law of thermodynamics? How are we to conceive that randomness in nature which seems to require a probabilistic description at the most fundamental level? Such are the questions to which Maxwell, Wilhelm Weber, Helmholtz, Boltzmann, William Thomson, Hertz, and others equally renowned sought answers. Their subjects did not exist in 1840, but by 1900 these men had upset the foundations of mechanical philosophy in their attempts to elaborate it.

Ernst Mach subjected the entire program of mechanical explanation to searching historical and philosophical criticism; Wilhelm Ostwald and the energeticists sought to found physical science on energy relations alone; and a wide variety of theorists considered replacing the mechanical universe with an electromagnetic one.

Many elements of this story are well known, but no one previously has attempted to collect the entire range of issues in one small book. We have seen numerous popular treatments, for example, of the problem of objects moving in the luminiferous ether that emphasize its relevance to Einstein's special theory of relativity, but Harman's book demonstrates the fertility of the ether for theory and experiment in optics, electromagnetism, thermodynamics, and matter theory as well. Teachers and students surveying the history of physics, as well as readers interested more generally in the history of scientific ideas, will welcome the overview, and as an attempt to set the concepts straight the book deserves high praise.

So brief an overview has limitations, however. This is not so much a history of physics as a descriptive catalogue of ideas arranged chronologically, and there are some unfortunate lacunae. At the most general level, we never learn what the relation is between analytical dynamics, energy physics, and field theory. A simple answer exists, even for a non-mathematical reader, in the replacement of Newtonian forces acting between atoms by extremum principles governing entire systems. Thomson and Maxwell began that shift by applying extremum conditions on the energy of fields to describe the moving forces on bodies located in and contributing to the fields. Hamilton's principle and Maupertuis's principle of least action provided similar foundations for analytical mechanics quite generally, although Thomson and Tait in their influential *Treatise on Natural Philosophy* (1867) continued to regard these principles as derivative from conservation of energy. Such determinants on whole systems were essential to many of the shifts in explanatory goals that Harman does describe: from atomistic mechanics to continuum mechanics, from action at a distance to contiguous action, from force physics to energy physics, and even from deterministic mechanics to statistical mechanics.

There exist also more specific conceptual difficulties. Helmholtz's "tensional force" (potential energy) between two bodies is presented in modernized form (p. 43) as a product of force and distance (presumably a sum of forces times infinitesimal changes in distance), whereas Helmholtz himself described it as a sum of the forces themselves "consumed" at each point along a path. The difference is subtle but critical to understanding how Helmholtz's concept of energy emerged from that of force. Similar problems appear with respect to Boltzmann's understanding of the relation between statistical mechanics and the second law of thermodynamics (pp. 142–143) and to Thomson's usage of "imaginary magnetic matter" for describing magnetism (p. 82). Harman has this matter spread over all space as a continuous magnetic ether, whereas for Thomson it appeared only at inhomogeneities in magnetic substances.

Harman includes in the book an extensive guide to secondary sources on 19th-century physics, providing a bibliographic essay of a sort that is much needed. It would be even more valuable, however, if he had indicated from which sources he has drawn his major theses. This is a matter not only of giving credit but of providing the reader with a basis for evaluation. Several of the difficulties with Harman's treatment seem to have arisen simply from the secondary articles drawn on.

I would like to call attention, finally, to the exemplary use Harman has made of diagrams from primary sources. They are remarkably clear and amplify in intriguing ways the textual material.

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Grand Unification

Third Workshop on Grand Unification. Chapel Hill, N.C., April 1982. Paul H. Frampton, Sheldon L. Glashow, and Hendrik van Dam, Eds. Birkhäuser, Boston, 1982. x, 374 pp., illus. $22.50. Progress in Physics, no. 6.

Two of the great triumphs of physics in the past dozen years have been the unification of the electromagnetic and the weak interactions and the development of the understanding of the strong force. Beyond these, models of the unification of these three forces have been proposed. The general idea of such unification is known as grand unification. Grand unification, just one step away from the ultimate unification of all forces (including gravity) in nature, is clearly one of the most exciting ideas in physics in recent years. It predicts, among other things, that matter must eventually decay (that is, protons are unstable) and that superheavy magnetic monopoles (with mass around 10^{-8} gram) must exist.

This book is a collection of 27 papers presented at a symposium on the subject. About half of the papers deal with theoretical aspects of grand unification, the other half with experimental aspects. Many of the papers are reviews, so readers can get a good picture of the latest developments in grand unification, up to 1982.

One of the most exciting happenings in physics in the past year is the report by Blas Cabrera of Stanford University of an event suggestive of a magnetic monopole. This was reported in many newspapers and magazines and the result was published in *Physical Review Letters*. However, because the length of such a letter is limited, many important details were missing. In this book, Cabrera explains at length his experimental set-up, the result, and his future plans. His detailed report should be of great value to readers who want to know more about his results.

Traditionally, particle physics tests are mostly the domain of high-energy experimental physicists. However, the development of grand unification has rapidly changed that. Of the 14 experimental papers only one discusses experiments done at high-energy particle accelerators. Many papers discuss crucial experimental tests of the grand unification idea that were being carried out by low-temperature physicists (monopole search) and atomic and nuclear physicists (neutrino mass, neutron-antineutron oscillation). Any experimental physicist who has access to deep underground facilities and does not have claustrophobia can always start a new proton decay experiment or join an existing one. For non–high-energy experimental physicists who are interested in performing tests of the grand unification idea, this book should prove invaluable.

The theoretical papers cover many aspects of grand unification, with heavy emphasis on the application of supersymmetry. Supersymmetry relates bosons and fermions and is one of the most profound symmetries known in physics. Many theorists believe it must have something to do with nature and probably with grand unification. The question is how. Steven Weinberg puts it appropriately in his paper: "Supersymmetry is a wonderful toy, with which many theorists have enjoyed playing for the last six or seven years. It is a toy of whose purpose we are so far unsure, and the question what supersymmetry is good for is clouded over by the fact that,