peptides, and miscellaneous other compounds and pigments. Each chapter has a brief summary, and the whole is summarized in a final chapter.

As a result of having been written by a single author—no longer a common practice in our scientific community—the book is not only well balanced but also enjoyable reading. It will be a guide to many investigators in this field and also an interesting reference book for general scientists. It deserves a warm recommendation.

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A Principle of Physics

The Discovery of the Conservation of Energy. YEHUDA ELKANA. Harvard University Press, Cambridge, Mass., 1974. x, 214 pp. $8.50.

The principle of the conservation of energy was a surprisingly late addition to the principles of classical mechanics. Elkana argues that neither the conservation principle nor the concept of energy itself was firmly fixed until 1847, when Helmholtz gave them precise meaning in his paper "Über die Erhaltung der Kraft." Until then the concept of energy was in a "state of flux," and one cannot talk unambiguously about "discoverers" of the conservation law. Furthermore this state of flux is characteristic of the creative stage of conceptualization in science. Once a concept is fixed by careful definition and mathematical formulation, it becomes a part of working science, and no longer serves the same creative function as before. A concept in a "state of flux" is valuable precisely because of its indefiniteness. The principle of the conservation of energy resulted from a general metaphysical presupposition that *something* in the physical world must be conserved through all physical changes. The long history of the principle was an attempt to determine precisely what that "something" might be.

The problem as Elkana poses it is an interesting one, but his own presentation is often confusing. In his introduction he outlines a sequence of historical events which he believes must also be the *logical* sequence of discovery. He follows the historical sequence with another list of factors that "constituted a solid basis for the enunciation of the conservation principle." Since this list is quite different from the "historical" or "logical" list, the reader is left to wonder how he should weld the two together.

The list of factors that constitute the basis of the conservation principle appears somewhat suspicious. It consists of the following four items: (i) an a priori belief in general conservation principles in nature, (ii) a realization that the Newtonian and Lagrangian formulations of mechanics must be correlated not only mathematically but also conceptually, (iii) a belief that the organic "forces" of animal heat and vital forces are reducible to the laws of inanimate nature, and (iv) the certainty that whatever is conserved in nature must be expressible in mathematical terms. If these are taken to be the necessary conditions for the discovery of the principle of the conservation of energy, then the author has preselected Helmholtz as the discoverer, for Helmholtz was the man with precisely these interests, attitudes, and skills. As might be expected, the author attempts to demonstrate the relative unimportance of two other factors that Thomas Kuhn emphasized in his paper "Energy conservation as simultaneous discovery" (*Critical Problems in the History of Science*, M. Clagett, Ed., University of Wisconsin Press, 1969, pp. 321–356), that is, the "availability of new conversion processes in the 19th century" and a "concern with engines."

After the statement of the problem, the book continues with chapters on mechanics, thermodynamics, and physiology, a chapter analyzing Helmholtz's paper, and chapters on the institutional setting and the philosophical background. Each of these chapters points toward Helmholtz as the man who finally succeeded in demonstrating the principle of the conservation of energy in its greatest generality. One curious problem appears in the chapter analyzing Helmholtz's paper. The author shows quite conclusively that Helmholtz did not distinguish between "force" and "energy" as we now understand those concepts. Sometimes *Kraft* meant one thing, sometimes another, and Helmholtz did not realize that there was any ambiguity in his use of the word. We are asked to believe that this was necessary as long as he was still struggling to analyze the concept. But if, as the author asserts, the concept of energy as we know it today emerges from that paper, one would expect Helmholtz to have resolved the ambiguity. We can still ask the question: "When were the concept of energy and the conservation principle firmly fixed?"

In addition to the ambiguity and confusion in the presentation of the argument, the book suffers from a large number of errors that seem to be the result of carelessness. In the chapter on mechanics, Lagrange's equations of motion are stated incorrectly. There follows a derivation of the equations taken from Dugas's *History of Mechanics*. The derivation contains at least eight errors. These errors may be from Dugas (I have only the French edition, which gives the derivation correctly), but they remain a puzzle for the reader to unscramble. The chapter also contains a long quotation from Cavendish in which a crucial diagram is missing, so that it is impossible to follow Cavendish's argument. In the chapter on heat and energy, the basic laws of thermodynamics are taken from a modern text, but they are not quoted correctly, and the reader will struggle to give some significance to the expression $dW = -dW$, where dW is the work done by an adiabatic system. The notes present further difficulties. Some quotations have no citation at all, and when a citation is provided, as often as not there is no page reference.

There is some useful information in this book about the history of the concept of energy and the principle of its conservation, but one must be prepared to work through a great deal of confusion in order to find it.

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Fluorocarbons

Fluorine in Organic Chemistry. R. D. CHAMBERS. Wiley-Interscience, New York, 1973. xviii, 392 pp., illus. $19.50. Interscience Monographs on Organic Chemistry.

Fluorine is a unique element, and highly fluorinated organic compounds are usually considered to belong to a separate field that has little relation to normal organic chemistry. Most earlier texts and reviews in this field have concentrated on collecting data illustrating the novel properties and chemistry of fluorocarbons. A major achievement of