philosophical approach to science, it will not be necessary to commend this book. For those who do not, or think that they do not, it will certainly be profitable to give an articulate proponent of this point of view a sympathetic hearing. For all, it will be an illuminating self-revelation of one scholar's intellectual progress.

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Scientific Contributions of Selman A. Waksman. Selected Articles Published in Honor of His 80th Birthday, 22 July 1968. H. BOYD WOODRUFF, Ed. Rutgers University Press, New Brunswick, N.J., 1968. xxii + 392 pp., illus. $15.

The scientific career of Selman A. Waksman, Nobel Laureate in Physiology or Medicine in 1952, is a classic version of the American dream of the poor boy who makes good by fulfilling the Calvinistic ethic of hard work. His story is made even more American because he came to this country as a young lad to escape the hazards and difficulties for Jews of life in Czarist Russia. His 80th birthday festschrift, edited by one of the closest of his former students, is devoted principally to the reprinting of selected articles on the many subjects in microbiology on which Waksman and his students worked: soil microbiology, in which he became the principal American authority; microbial enzymology and physiology, which he helped launch as sciences; sulfur bacteria; marine microbiology; taxonomy; and last, antibiotics, where his studies on isolation and characterization culminated in the discovery of streptomycin and the Nobel award.

The book is well illustrated both with plates from the representative published works and with photographs of Waksman, his colleagues, and his students. Particularly enjoyable reading is the tribute by Boyd Woodruff, summarizing Waksman's career and describing with sensitivity the warm personal qualities which have made him such an inspiring mentor to his students.

This volume should be of value in department libraries for the benefit of the current generation of graduate students in microbiology.

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Neural Function and Evolution

Primitive Nervous Systems. THOMAS L. LENTZ. Yale University Press, New Haven, Conn., 1968. xii + 148 pp., illus. $7.50.

It is now 50 years since the publication of G. H. Parker's *The Elementary Nervous System*. In that influential book Parker developed a coherent account of the evolutionary origin of nervous systems, based on his own experimental observations with lower invertebrates and the neurohistology available at that time. In the years since Parker's book appeared a number of workers, especially those who have concerned themselves with lower invertebrates, have proposed modifications of his ideas. The most recent of these is Lentz.

Lentz's account is a short book, shorter than its pagination indicates since nearly half of its pages (68 out of 148) are occupied by figures and facing pages, indices, and an extensive bibliography. The introductory chapter reviews theories on the origin of nervous systems. This is followed by a description of the behavioral physiology and neuronal organization of sponges, hydra, and flatworms. The emphasis here is on results from electron microscopy and histochemistry, areas in which Lentz has made valuable contributions. The structure and ultrastructure of the animals considered are illustrated with drawings of exceptional clarity. The final chapter is a speculative treatment of the origin of nerve cells. Lentz suggests that the primitive nerve cell was a secretory cell which released biologically active material in response to stimuli. It is proposed that the product of such cells modulated the activity of otherwise independent effectors. Neurons as they are found today resulted from specialization of receptive, conductile, and secretory processes in these cells. Unfortunately the arguments presented for this view are not very compelling, principally because of limitations in the kinds of animals Lentz has chosen to consider. Sponges, hydra, and flatworms are rather poor material on which to base a theory on the functional evolution of nervous systems since so little is known about neural function in each. There is considerable doubt as to whether sponges have nerve cells at all. Nothing in their behavior suggests the kind of neural coordination characteristic of higher animals. Hydras clearly do have nerve cells, but because of the probable occurrence of both nervous and nonnervous conducting mechanisms the role of the nervous system in determining their behavior is uncertain. In fact, with hydras the evidence is better for the participation of the nervous system in growth and regeneration than it is for its involvement in any particular behavioral act. Among cnidarians the structure and function of the nervous system are better known in anemones and scyphomedusae than in hydras, but these organisms are barely mentioned by Lentz. Although flatworms are now widely used in learning research they are not very encouraging material for electrophysiological methods and have been scarcely touched by modern techniques. Finally, the total neglect of ctenophores, strategically placed in terms of complexity between the cnidarians and the flatworms, is a serious omission.

This book will serve as a source of information on neurochemistry and ultrastructure in some lower invertebrates, but because of these limitations it will probably have little impact on contemporary thought about the early evolution of nervous systems.

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The Concept of the Atom

Atoms and Elements. A Study of Theories of Matter in England in the Nineteenth Century. DAVID M. KNIGHT. Hutchinson, London, 1967, 30s; Hillary House, New York, 1969, $4.50. vi + 168 pp., illus. The History of Scientific Ideas.

A critical history of atomism is one of the most important tasks of the history of science, whatever one's philosophical point of view may be. Together with Lasswitz's great work, Kargon's study of 17th-century atomism, and Thackray's investigations of 18th-century theory of matter (in preparation), David Knight's book completes the chain up to 1870. It is thus a work of first importance.

Atoms and Elements reviews briefly the traditions ruling in 1800: corpusculearean Newtonianism, chemical Newtonianism (theory of affinities), and Boscovichean theory of matter. The author considers Boscovich an anti-Newtonian, and an early field physicist, whose influence on both Davy and Faraday is beyond doubt. The Eulerian theory of matter, and Euler's most important disciple in England, Thomas Young, whose work initiated the far-reaching metaphysical debate on the nature of light, are not mentioned at all. This omission is decisive for the tenor of the book, and is rooted in the author's ambiguous philosophy of science: it does not seem to be clear whether he is a positivist or an antipositivist. This indecision blunts the edge of most of his arguments.

The preface promises a nonwhiggish history of science, and the emphasis on debates and on the critical discussion of metaphysical theories points in this direction. However, the treatment of most of the early 19th-century scientists implies that in the author's opinion some of them were speculative and "muddled" (Dalton) whereas others carefully separated between the empirically testable part of a scientific theory and the speculative part, and these are the real heroes (Davy, Wollaston, Thomson, Brodie, and the like). A positivistic bias in a historian of science is legitimate, and there are many great 19th- and 20-century positivistic histories to prove how fruitful such contributions can be. What is misleading here is the undecidedness of the author. Wollaston is called a hard-core positivist, although the very passage by him quoted on page 24 casts doubt on this assessment. Dalton is severely criticized all through the book as a metaphysical atomist who, unlike the others, did not know how to separate solid science from the empty speculation. Yet later we read that Dalton was "unclear as to whether his theory was a theory of matter at all or simply a theory of chemical atoms" (p. 146). Davy, on the evidence of his last dialogue on atomism, and on the authority of Pearce Williams, is treated as a Boscovichean metaphysician who "rejected the atomic theory, because in a sense it was not hypothetical enough" (p. 26), while a few lines earlier he appears as an instrumentalist who used hypotheses freely, "taking them up and dropping them as he went along." We are told that Thomas Thomson and Wollaston supplied the experimental proof to the testable part of Dalton's theory, but it is not stated that their researches were motivated by a commitment to Dalton's anti-Newtonian atomism. There is no attempt to distinguish between the official, positivistic philosophy of science of the 19th century, to which every scientist (except Faraday) paid lip service, and the different metaphysics of the various actors.

The physicists' theories of matter and their contributions toward a dynamical chemistry are briefly treated in the chapter called "Some theories of matter." [This subject is excellently treated by Knight in a recent article, "Steps towards a dynamical chemistry," in *Ambix*, vol. 14, p. 179 (1967).] Although this chapter emphasizes Whewell's role in the anti-Daltonian tradition, the fascinating controversy between Whewell and Herschel on the theory of matter is omitted. Here we also find an introduction to the vortex atom.

The most instructive parts of the book are the chapters on "Chemical molecular theories" and on the "Atomic debates" in the Chemical Society of the 1850's. These two chapters could have easily supplied the material for a whole book. The first is a straightforward history of chemistry, discussing in detail the theories of Dalton, Gay-Lussac, Canizzaro, and others, emphasizing the differences and controversies between them. The other analyzes the clash between the positivist and antipositivist interpretations of the newly introduced chemical symbolism. The views of and debates between Williamson, Brodie, Maxwell, Tait, and others are little known and here sharply focused on.

The last chapter, called "The end of the affair," is less a summary than a program for a further volume. All in all, *Atoms and Elements* is an important contribution but not a definitive one, and it is now clear beyond doubt that the topic treated justifies at least three full-scale monographs covering the 19th century.

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Interactions

Elementary Particles and Their Currents. JEREMY BERNSTEIN. Freeman, San Francisco, 1968. xiv + 322 pp., illus. $12. A Series of Books in Physics.

Within the past three years a reorientation has occurred in elementary particle physics. From a general point of view the most interesting consequence of recent progress is the resurgence of belief in the general principles of relativistic quantum field theory. As recently as five years ago disenchantment with the latter was so great as to foster a widespread belief that field theory was completely wrong, or at best, of only allegorical significance.

Perhaps the most puzzling empirical fact of particle physics is the disparity of strength between the strong, electromagnetic, and weak interactions (leaving aside the much weaker gravitational forces). Efforts to construct a unified theory of these interactions have always failed. While such a theory remains to be found, hopeful steps in this direction have been made. The decisive idea was the proposal of M. Gell-Mann that the operators for generalized weak and electromagnetic current densities of the hadrons (short for strongly interacting particles) possess a simple and elegant algebraic structure. The current densities in question carry not only electromagnetic currents but quantities such as isospin and strangeness. Strictly speaking this (Lie algebra) structure implies no commitment about the perplexing problem of whether some particles are more elementary than others. Nevertheless, the simplest interpretation of the situation is that three elementary "quark" fields exist.

Application of the "current algebra" technique has solved many previously unapproachable problems, an outstanding example being the calculation of the strength of the effective pseudovector current in neutron beta decay. Many new relations have been derived and experimentally verified for processes involving low-energy pions. These calculations make use of the *PCAC* hypothesis (Goldberger-Treiman relation), which relates the lack of conservation of the pseudovector current to the existence of a massive pion field operator.

These developments have been described with clarity and depth by Jeremy Bernstein. Although some very important advances concerning high-energy limits have not been included, the book is very contemporary.

The development of the subject matter is inductive but not reckless, leaving the reader with the (correct) impression that there is considerable flexibility remaining in the foundations of the subject. An especially attractive feature of the book is that many delicate conceptual points are carefully gone into without conveying an impression of encyclopedic heaviness. As could be expected, the price is somewhat high for the advanced graduate students who comprise the most likely readers of the book.

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