contributors and their relatives, and has read numerous contemporary newspaper articles and other popular and semi-popular publications. It is difficult to believe that he might have left some stone unturned in his quest for understanding.

The contents of Badash's book reflect its diversity of source materials. Its main thread, of course, is the scientific work. Badash discusses—to touch on only one or two points—the dubious evidence for the complexity of thorium reported by Charles Baskerville of the University of North Carolina; the painstaking and high-quality researches of B. B. Boltwood of Yale, H. N. McCoy of Chicago, and R. B. Moore and H. Schlundt of Missouri to unravel, especially, the decay chain of the uranium series; and the pre-World War I ionization and absorption studies on α and β particles by S. J. Allen of Cincinnati and A. F. Kovarick of Minnesota. Badash regards Boltwood's 1907 discovery of the parent of radium, "ionium" (now $^{230}_{90}$Th), as representing the mark of maturity of the American efforts. At each stage of his discussion, however, he is careful to place these efforts within a broad international context, and thus he avoids elevating American contributions above their actual contemporary importance. His deft biographical sketches throughout are a delight to read.

Interwoven with the main scientific narrative are accounts, for example, of W. J. Hammer's popular lectures on radioactivity; the radium dances of Miss Loie Fuller, America's "serpentine lady"; the only-in-America scheme to produce ready-made hard-boiled eggs by lacing chicken feed with radium; G. F. Kunz's careful radium-ray bombardment of gemstones in the priceless Morgan-Tiffany collection; the transition of radium therapy efforts from optimistic to pessimistic to realistic; the ill-fated use of radium on watch dials; attempts to exploit and control Colorado's uranium deposits; researches on radioactive dating and atmospheric radioactivity; the quest for instrumentation of increasing precision; and the definition and preparation of the first International Radium Standard in the period 1910–1912.

Not content to stop there, Badash also discusses the dynamics of scientific research from the perspective of his study of radioactivity in America. He sees personal contacts and correspondence on an international level, and the extraordinary influence of Rutherford especially, as dominating over national or local scientific traditions in America at the time. He notes the refusal of chemistry departments to embrace the pioneers in the new field of radioactivity. He identifies Yale, Chicago, and Minnesota as the only universities in the country where research traditions in radioactivity, albeit weak ones, were established in the period under study. Finally, he finds that his study more or less supports Derek J. de Solla Price's growth curve of scientific activity, Thomas S. Kuhn's theory of scientific change, and Gerald Holton's model of internationalism in science, involving communication through travel, congresses, publication in foreign journals, and the like.

(Perhaps I should note for the record that Badash has missed a key link in the close intellectual and personal ties of the period between Yale and Minnesota—the appointment in 1885 of Frederick S. Jones, B.A. Yale 1884, as Minnesota's first full-time physics teacher and Jones's subsequent return to Yale in 1909 as dean. And on p. 270 he states, incorrectly, that Henry A. Erikson never studied abroad—Erikson actually went to Cambridge in 1908–1909.)

Badash's book is exceptionally well written, though the inherent difficulty of some of the concepts treated, the paucity of figures, and the unavoidable use of some outmoded terminology and symbols do not always make reading easy. This masterly study, nonetheless, will be prized by scholars from a broad range of disciplines for many years to come.

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Ostwald as Philosopher

Forschen und Nutzen. Wilhelm Ostwald zur wissenschaftlichen Arbeit. GÜNTHER LOTZ, LOTHAR DUNSCH, and UTA KRING, Eds. Akademie-Verlag, Berlin, 1978. xlviii, 278 pp., illus. + plates. 38 M. Beiträge zur Forschungstechnologie, Sonderband 1.

Best known today as one of the founders of modern physical chemistry, Wilhelm Ostwald (1853–1932) was a scientist of exceptionally broad ambition and far-ranging interests. During a career that took him from Germany's Baltic provinces to a chair at the University of Leipzig and then to a free-lance existence as a scientist and philosopher, Ostwald was obsessed with the desire to reform ever widening circles of knowledge. Initially he confined his ambition to chemistry, where he sought to rekindle interest in the problem of chemical affinity. In the 1870's and 1880's, Ostwald wrote his monumental *Lehrbuch der allgemeinen Chemie*, cofounded the *Zeitschrift für physikalische Chemie*, and organized an extremely productive and influential research school in physical chemistry. During the next decade, he enlarged his horizons, both by writing significant texts on analytical, inorganic, and electrochemistry and by launching a campaign to set the physical sciences on a new foundation that would eliminate unproven hypotheses, such as the atomic theory, and instead be based on the principles of thermodynamics. Finally, following his retirement from teaching in 1906, Ostwald devoted himself to philosophy and a variety of social causes, believing that the entire theory of knowledge was in need of reform and that social institutions and conventions as diverse as language, coinage, the printing industry, education, and our way of measuring time were in need of rationalization.

Ostwald was an enormously prolific writer. Apart from his editorial labors and translations, Ostwald wrote over 20 books, hundreds of scientific papers, and nearly 5000 reviews. The problem of selecting a representative sample from this large corpus is formidable. *Forschen und Nutzen*, a volume published to commemorate the 125th anniversary of Ostwald's birth, consists of three dozen selections drawn from Ostwald's published works together with two brief essays taken from his unpublished papers. The three East German editors chose to include extracts from Ostwald's writings that they thought would be of relevance today. This criterion results in a rather odd collection when applied by dialectical materialists to Ostwald, a figure well known as a monist and antimaterialist. Included are Ostwald's Nobel lecture of 1909, several earlier papers on scientific instruments, articles and portions of larger works dealing with education, scientific organization, scientific creativity, and the history of chemistry, and, inevitably, selections treating the relationship between theory and practice. Inclusion of Ostwald's lecture of 1895, "The Conquest of Scientific Materialism," would have made this a far more interesting collection, but the editors apparently wish to rehabilitate Ostwald and not to bury him.

Although the editors' standards of selection are wanting, the volume possesses several redeeming features. The index is meticulous and contains biographical facts about people mentioned

in the text; there is an appendix with a valuable roster of Ostwald's unpublished manuscripts held by the Central Archives of the East German Academy of Sciences; and the bibliography following the editors' introduction is useful as a guide to secondary literature on Ostwald.

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Quantitative Genetics

Quantitative Genetic Variation. JAMES N. THOMPSON, JR., and J. M. THODAY, Eds. Academic Press, New York, 1979. xiv, 306 pp., illus. $19.50.

During the 1950's quantitative characters were the paradigm of population genetics, the component of genetic variance having almost the status of a conceptual primitive. All phenomena were to be explained by reference to variance components rather than genes. This heyday did not last long, as mathematical approaches based on components of variance reached their limits of usefulness and as electrophoresis and the study of human genetic diseases provided a source of single loci to study. As might have been expected, the glamour of these new pursuits pushed the study of quantitative characters into an undeserved obscurity.

With increased concern with human quantitative traits and with increased attention to polygenic characters in evolution and ecology, the balance is now changing. In this timely book Thompson and Thoday have collected 18 papers on methods of analyzing quantitative characters. The papers tend to be concise and to the point. They are predominantly experimental or discuss experimental methodology in a qualitative fashion. Though there is some mathematics, the emphasis is decidedly nontheoretical.

The contributors include Thoday, Mather, Parsons, Jinks, Rendel, Milkman, and Mukai. Many of the major theoreticians of quantitative genetics are noticeably absent, including the groups at Edinburgh, Iowa State, and North Carolina State. This may be due partly to the empirical emphasis, but perhaps also to the lack of concern in this volume with problems of animal and plant breeding, where quantitative genetic theory has been most elaborate and successful.

The range of organisms covered is wide, from mice to wheat to fungi, with an equally wide range of approaches. We hear a great deal about the mapping of polygenes, a Thoday specialty. A number of papers use or explain the "biometrical" approach, in which two inbred lines are crossed and the means and variances in the subsequent generations can be expressed in terms of quantities differing from the usual Fisherian additive, dominance, and environmental variance components. This approach is due to Mather and Jinks. It suffers from having its own notation and far too little explanation of how quantities like D, H, and E relate to the three components of variance found in outbred populations.

After reading the papers in this collection, one is vaguely uneasy. It is not at all clear what questions are being asked. Much effort is devoted to reminding us that these methods tell us only about those genes affecting the trait that are actually segregating in our populations or crosses. It is repeatedly emphasized that variation of a quantitative character may be largely due to a few segregating loci. Well and good, but there is no discussion of what biological questions are to be resolved by these studies, aside from questions arising from our interest in the particular characters under study.

I am being unfair. Many of the contributors to this volume believe themselves to be addressing general questions—it is just that I have difficulty in believing that these studies can resolve them. Quantitative genetics has passed through periods of enthusiasm in which it was imagined that rather murky studies at a highly aggregated level would provide insight into molecular processes. Thirty years ago it was often asserted that polygenes were more equal than other genes, and they were imagined as hiding in that repository of mysticism, the heterochromatin. Heterosis was likewise imagined to be a general biological principle, resulting directly from heterozygosity rather than from the phenotypic effects of the two particular alleles.

The belief that in quantitative genetic studies we obtain insights into molecular processes has been accompanied by a tendency toward nonmaterialist holism. This has been most visible in the belief in interactions so strong as to make effects of individual genes uninvestigable.

This volume shows those particular tides as having receded, but shows also that there is no less enthusiasm than before for the prospect of discovering general principles from data on quantitative characters. That quantitative variation may be due to only a few loci is indisputable, but I see no reason to believe that there is any general principle to that effect. It should depend entirely on the sort of character under consideration. It is unlikely that a character like body weight has most of its genetic variation at a few loci but quite plausible that sternopleural chaeta number in *Drosophila* will show such a pattern.

Interestingly enough, the very latest wave of enthusiasm is not much represented in the book. This is the suggestion that quantitative traits are varying as a result of variation at "regulatory" loci, with protein polymorphism mostly a result of structural loci. This is in effect the old polygene theory come back to haunt us. Perhaps the contributors to this volume are skeptical of this particular notion, if not of others.

It is to the credit of Thompson and Thoday that they have assembled a volume that gives a reasonably broad view of quantitative genetic studies, one capable of giving rise to such a degree of skepticism on the part of the reader.

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Vestibular Neurophysiology

Mammalian Vestibular Physiology VICTOR J. WILSON and GEOFFREY MELVILL JONES. Plenum, New York, 1979. xii, 366 pp., illus. $32.50.

In recent years, there has been a heightened interest among neurophysiologists in the workings of the vestibular system. The reasons are fairly obvious. The kinds of sensory information handled by the vestibular labyrinth are relatively simple, so that it has been possible to specify most aspects of the sensory coding process. There is a wealth of detail concerning the intrinsic structure and connections of the vestibular nuclei, and this has provided a challenge to the neurophysiologist interested in correlating structure and function. The vestibular nuclei are heavily interconnected with the reticular formation, the spinal cord, the oculomotor pathways, and the cerebellum. To many workers, the central vestibular pathways have seemed a particularly fruitful focus for the study of sensorimotor integration. Much of vestibular function is expressed in reflex pathways, which are particularly amenable to neurophysiological analysis. Many of the reflexes can be specified in