see "polio" almost completely eliminated from the United States and most other developed nations, and a vaccine made available which would permit its worldwide eradication.

Poliomyelitis as a mass disease phenomenon in large populations appears to pass through three—or perhaps four—major phases, with the inevitability of a biological law. Polio is first found as a rare and sporadic endemic disease in any premodern society where the virus is present; it remains such for as long as the level of sanitation and personal hygiene is low enough to assure intense and continuous fecal contamination of the environment, requiring only a population large enough to permit uninterrupted transmission. In the second phase of its evolution, epidemics of infantile paralysis make their appearance, becoming more extensive as environmental improvement continues and as the disease gradually enters its next stage. In the third phase, intermittent epidemics continue, but progressively greater proportions of older children and adults are involved, and the more severe "bulbar" and encephalitic cases become more frequent. The fourth phase was never quite attained naturally but suggested itself as a possibility; poliomyelitis would have disappeared as an endemic disease in highly sanitated societies. Scientific understanding and technical skill preceded such a level of cultural development, however, and polio was eliminated instead by prophylactic immunization.

The explanation of this evolution, and of the apparent exceptions to it, required a knowledge of the virology, immunology, pathogenesis, and epidemiology of this disease, and this knowledge, the gathering of which is the subject of Paul's book, was prerequisite to its control.

Poliomyelitis is an infrequent result of infection with one of the three poliovirus types. After ingestion by a person not immune to the serotype, the virus establishes asymptomatic infection in the intestinal tract that may last many weeks, with fecal excretion in high titer. Most strains are nonpathogenic, however, and infection usually terminates spontaneously with the development of solid, long-lasting immunity. In a small proportion of infections, the virus enters the bloodstream and secondary foci of multiplication may be established in certain lymphatic and neuronal tissues, accompanied by general constitutional symptoms. Depending upon the number and location of motor neurons that are affected and destroyed, transient or permanent paralyses result, and death may occur if vital respiratory or circulatory centers are severely damaged. Permanent paralysis results, generally, from no more than one in a hundred infections, and is even less likely following infection with strains of lesser pathogenicity. All three poliovirus types have the same epidemiologic characteristics and similar paralytogenic potential; the proportion of pathogenic strains is greatest within type 1, however, explaining the greater frequency of its isolation from clinical cases. Man alone plays natural host to these comparatively resistant viruses, and person-to-person transmission is the most frequent mechanism of dissemination, although flies may be passive carriers and common-source outbreaks have been traced to food and water contamination.

With little more than these facts, the evolutionary stages of poliomyelitis become understandable. In the endemic phase, intense fecal contamination assures infection at a very early age, often under cover of transplacentally acquired maternal antibodies—which are virtually assured because all mothers have been repeatedly exposed. Babies so infected are at little risk of disease but become immune for life. Only rarely does unusually delayed infection combine with unusual viral pathogenicity and unusual individual sensitivity to produce the sporadic case of paralysis. The endemic man-virus balance is disturbed when, with modest improvements in environmental sanitation, the intensity of fecal contamination is relieved and transmission is delayed. Gradually, the number of susceptible children increases and an epidemic potential is established. Waves of infection pass through communities. Most often these go unnoticed, because nonpathogenic virus strains are involved. Occasionally, however, a pathogenic strain is introduced, an epidemic of infantile paralysis occurs, and phase 2 is upon us. Phase 3 is ushered in gradually, as infection is delayed longer and longer with further environmental cleanup. Older age groups are affected, and cases are often more severe because of the as-yet-unexplained localization of secondary virus multiplication in more vital neuronal centers among older people. Phase 4 has never happened, but the prevalence of nonimmune older individuals in some social groups in otherwise endemic areas suggests that the disease might have disappeared spontaneously in a thoroughly scrubbed civilization.

Exceptions to general rules often provide critical clues for epidemiological understanding. In small, isolated communities, as of Eskimos and on some Pacific islands, transmission cannot be sustained indefinitely because there are too few susceptibles available. When infection is introduced into such unimmunized societies, explosive outbreaks affecting all age groups occur. Sometimes, cruelly fascinating incidence patterns appear, with numerous cases among all ages up to some sharp limit, which defines the years elapsed since the last introduction of the same poliovirus type.

In this book, the author carries us through the long and often painful story of the accumulation of this knowledge, and of much more, and introduces us to the men and women who labored to acquire it. Although it ends on a justifiably triumphant note, this is no simple, maudlin history of success. The false trails, the mistakes of interpretation and judgment, the sometimes bitter competition, the exploitation of science by publicity seekers, the tragedies resulting from error or haste—they are all here, told in frank, intimate, occasionally almost gossipy style. But all does end well, effective vaccines were developed despite nature's and man's obstacles, and poliomyelitis has all but disappeared from many countries of the world. The job is not finished, however, for in others infantile paralysis is just emerging.

HENRY M. GELFAND
6911 Strata Street,
McLean, Virginia

Aromatic Amine Oxides

Chemistry of the Heterocyclic N-Oxides. A. R. KATRITZKY and J. M. LAGOWSKI. Academic Press, New York, 1971. xii, 488 pp., illus. $28.50. Organic Chemistry series.

Although the first heterocyclic *N*-oxides were prepared a century ago, relatively little interest developed in these compounds, with the exception of the work of Meisenheimer and Bobranski, until the classic studies of Eiji Ochiai and his students in Japan in the early 1940's. Owing to the lack of communication and inadequate abstracting during the years of World War II and for some time thereafter,

this outstanding Japanese work did not gain the attention of chemists in the Western world until well into the 1950's. Thereupon there was a tremendous proliferation of interest and scientific activity in the chemistry of heterocyclic *N*-oxides. In 1967, Ochiai published a monograph entitled *Aromatic Amine Oxides*, which became the definitive work on the subject, covering the literature through about 1964.

In the present monograph Katritzky and Lagowski survey the literature on heterocyclic *N*-oxides through March 1970. To avoid duplication and in line with their own research interests, the authors place less emphasis on historical development and spectral and biological properties of *N*-oxides than did Ochiai in his monograph. After an introductory chapter, Katritzky and Lagowski present methods of preparation of heterocyclic *N*-oxides and then, in the two succeeding chapters, deal with the reactions of *N*-oxides. The fact that a volume of this magnitude is appropriate so soon after Ochiai's work is testimony to the intense current activity in this field.

The style of the authors is quite terse, with heavy reliance on structural formulas and the use of tables, much in the manner of *Organic Reactions*. The tables are intended to be comprehensive, and my own testing in areas of particular interest shows them indeed to be so. There is a strong emphasis on a theoretical understanding of the physical properties and the role of the *N*-oxide function in the various heterocyclic *N*-oxides. Mechanistic interpretations, often original with the authors, are provided for the reactions exhibited by the *N*-oxides. Although one has to keep in mind that frequently these interpretations are only speculations, they are one of the real attractions of the monograph.

The authors use a novel system for references. Each reference is given a code number conveying the year of publication, the title of the journal, the volume number where necessary, and the page number. The references are cited by these numbers in parentheses in the text. The bibliography, which contains an explanation of the code, then compiles the references in order by code number (in effect, by year of publication), with a complete citation in conventional form. Clearly, this provides a great convenience for the authors, but it also cuts down the likelihood of introducing errors in compiling the bibliography. I did not find that this style of reference citation detracted from readability, and I would think other authors might wish to copy this device.

In conclusion this is a very useful monograph, presented in an imaginative and attractive manner, that brings up to date the published work in the fast growing field of *N*-oxide chemistry. It is an appropriate companion piece to Ochiai's authoritative work on the subject.

VIRGIL BOEKELHEIDE
Department of Chemistry,
University of Oregon, Eugene

Excited States

Photophysics of Aromatic Molecules. JOHN B. BIRKS. Wiley-Interscience, New York, 1970. xiv, 704 pp., illus. $29. Wiley Monographs in Chemical Physics.

Interactions between physicists, chemists, and biologists studying the physical and chemical properties of nonionic electronically excited states of molecules have been particularly fruitful in the last decade. Photophysics—which Birks defines as the science of measurement of physical (as opposed to chemical) properties of electronically excited states of molecules—has contributed to photochemistry and photobiology not only an essential body of data about excited states but an invaluable language for discussing those processes which occur before or in competition with photochemical transformations. Photochemistry in turn has contributed much to photophysics—for instance, kinetic methods for determining many excited-state parameters for molecules which do not exhibit luminescence often greatly simplify measurement of excited-state parameters for luminescent molecules also. Neither the photophysicist nor the photochemist/photobiologist can today afford not to be conversant with major developments in the other field. Therein lies a problem; despite their shared interests in common phenomena, photophysicists, photochemists, and photobiologists have still very different scientific backgrounds. Interdisciplinary education requires patience and hard work from both instructor and student. When the photophysicist teaches it is important for him to emphasize physical insights using an approach as strong as possible on intuition as opposed to mathematics. Conversely, the teaching chemist or biologist must help the photophysicist through the complexities of large molecules and systems which are from any fundamental point of view poorly understood by theory (and perhaps also experimenter). Recently, the photophysicists have provided several excellent texts describing selected aspects of photophysics of molecules.

Birks's book is known to me because I used it extensively last spring while teaching a course in photochemistry at the Bell Laboratories to physicists and electrical engineers involved in laser science and related fields. I found it to be an invaluable source of information about both photophysical theory and experiment. Explanations of theory seemed to be reasonably rigorous without demanding mathematical sophistication beyond that which should be acquired by the modern photochemist or photobiologist. But the chief value of this text to the practicing photochemist or photobiologist will be the extensive documentation and very clear presentation of the data available in this field. The 100 or so tables in the book range from a very useful presentation in the first chapter of structures of typical photophysical substrates—a task all too often omitted in original papers—to compilations of luminescence data which give results from 100 original sources or more. This book should prove extremely useful to anyone concerned with the properties of electronically excited states of molecules.

DONALD VALENTINE, JR.
Hoffmann-La Roche, Inc.,
Nutley, New Jersey

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Elementary Human Physiology. Labo-

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