Book Reviews

Gas Chromatography—The Art and the Science

Gas Chromatography. John H. Knox. Methuen, London; Wiley, New York, 1962. viii + 126 pp. Illus. $3.25.

Gas Chromatography. Principles, techniques, and applications. A. B. Littlewood. Academic Press, New York, 1962. xi + 541 pp. Illus. $15.

Gas-Liquid Chromatography. Theory and practice. Stephen Dal Nogare and Richard S. Juvet, Jr. Interscience (Wiley), New York, 1962. xviii + 450 pp. Illus. $13.95.

Gas Chromatography. Howard Purnell. Wiley, New York, 1962. vii + 441 pp. Illus. $12.

Gas Chromatography. A symposium held at Michigan State University, June 1961. Nathaniel Brenner, Joseph E. Callen, and Marvin D. Weiss, Eds. Academic Press, New York, 1962. xxiv + 719 pp. Illus. $22.

Gas Chromatography Abstracts, 1961. C. E. H. Knapman and C. G. Scott, Eds. Butterworth, Washington, D.C., 1962. x + 219 pp. $8.50.

"Compromise in apparatus and conditions is, in fact, the art of gas chromatography, an art which is acquired by an appreciation of the important parameters of the process and their optimization with respect to practical problems." Thus Dal Nogare and Juvet introduce their chapter on practical gas-liquid chromatography. Progress in the art as well as in the underlying science received a major impetus during 1962 with the publication of the textbooks reviewed here.

In considering the impact that gas chromatography has made on chemical analysis during the single decade of its existence, few perhaps would go so far as Purnell (p. 3) in saying that "the erstwhile established techniques of mass spectrometry, infrared and ultraviolet spectroscopy have been almost entirely superseded." However the literature of the subject runs to 4338 entries in the latest compilation of Seaton Preston's bibliography which is published in the proceedings of the symposium held in 1961 at Michigan State University, and there has been an obvious need to make this material available in textbook form for students, practicing chromatographers, and research workers. That these new books have not appeared earlier is a tribute to the quality of Keulemans and Verver's well-known book, published in 1957.

In each book the authors attempt to provide an adequate introduction for the novice together with some of the more recent details of theory and technique. The books are all well-produced and excellent works written by active contributors to the field, and, although they cover much the same ground, they also reflect in the detailed choice of material the particular interests of the different authors.

Knox's small book, the least ambitious of the four, gives a clear, well-written, relatively nonmathematical, general presentation, in addition to excellent chapters on detectors and on columns and column packing. It includes a surprising amount of useful, practical detail but says little about specific separations. This book is a worthy addition to the excellent Methuen Monograph series and will be particularly useful as an inexpensive introduction to the subject.

Of the other three, the text by Littlewood and the one by Dal Nogare and Juvet are most comparable. Dal Nogare and Juvet follow the pattern of Keulemans by giving a practical description of gas chromatography in the first two chapters and then providing more detailed, theoretical treatments of particular subjects. In Littlewood's presentation both theoretical and practical aspects are carried along in parallel developments. His book is outstanding in its clear style and organization; each topic is set forth so plainly that the rudiments are as accessible here as in Dal Nogare and Juvet. This clarity of presentation and his more profound treatment of theory make Littlewood's book my own preference for a single, general text. It should be pointed out, however, that Dal Nogare and Juvet offer certain advantages for the North American reader in that their subject emphasis is rather more in tune with current apparatus and practice— for example, more thorough discussion of trace analysis, capillary columns, and preparative work. In addition, there is a list of commercial instruments available in 1961, and useful tables of relative retention volumes on a number of common stationary phases.

Purnell writes with a strong emphasis on theoretical aspects; his book is subjective and challenging. The experienced chromatographer will find it an exciting and stimulating treatment that presents many original ideas, useful details of technique, and interesting suggestions for future developments. Included are good discussions of nonideal solutions and nonlinear isotherms, gas flow through packed beds, gas-solid-liquid chromatography, and the possibilities for ultrahigh-speed analysis. However, it is difficult for me to recommend this book to the beginner, for, unless he is inclined toward physical chemistry or theoretical chemical engineering, a beginner will find the first half of the book—70 pages of physicochemical background and 160 pages related to chromatographic theory—a difficult introduction to the subject, one that is much more likely to be appreciated after practical experience and possibly study of one of the other books. A table of symbols (one is provided in the other three books) would be a distinctly helpful addition.

A major aspect of chromatographic art, which is strongly dependent on experience and but slightly assisted by science, is the choice, from the hundred or so stationary phases that have been reported, of a suitable column packing for any particular analysis. "A multiplicity of liquid phases from which to choose only makes the process of selection more tedious without giving any better result than can be achieved by the intelligent use of a much smaller number" (Knox, p. 47). Knox and Purnell discuss the general principles of column selection in terms of a few stationary phases only, whereas the other authors tend to be more comprehensive

in their listings of columns suitable for various separations. All of the authors emphasize that some of the most powerful techniques, both for quantitative separation and for compound identification, depend on the comparison of chromatograms from two stationary phases of widely different types.

Much research has been devoted to the causes of band broadening in gas chromatography, but it is not yet fully possible to predict, from a knowledge of the packing and flow conditions, the efficiency that will be obtained with any given column. Purnell gives the most complete account; the other authors are more selective in their treatments. Resistance to mass transfer in the gas as well as in the liquid phase are recognized and so is the importance of the detailed geometrical distribution of the liquid on the support, even though it is not yet known how to control this latter factor with any assurance. With respect to the many contributions to band broadening, Littlewood points out (p. 143), "When a good column is used in bad conditions it is the badness of the conditions that determines the performance, not the excellence of the column and when a bad column is used in good conditions it is the badness of the column and not the excellence of the conditions that determines the performance."

All of the authors discuss the special features of capillary columns, the use of temperature programming, preparative work, methods of sample introduction, and fraction collection. The discussions on detectors range from 100 pages by Littlewood to 30 pages by Knox. Littlewood provides particularly clear presentations of ionization detectors and of the quantitative aspects of the thermal conductivity detector, and he and Knox give the best descriptions of the electron capture detector. None of the authors cover the microcoulometric detector, of current interest in insecticide analysis, although Dal Nogare and Juvet mention Liberti's earlier coulometric method.

The three larger textbooks devote considerable space to applications. Littlewood organizes these by type of compound—for example, fatty acid esters, sulfur compounds, and an outstanding section on permanent gases and methane. Dal Nogare and Juvet discuss the type of analysis—such as trace analysis, food and flavor, and the like. Purnell selects a few difficult analytical problems, and gives them detailed treatment that will be much appreciated by experienced chromatographers.

Apart from a number of errors in the references given in Purnell's book, the only mistake that I noted was on page 183 of Littlewood's volume where he gives the temperature coefficient for gaseous diffusion as the 0.3 to 0.5 power of temperature instead of approximately the 1.8 power.

The proceedings of the 1961 East Lansing symposium, part of the continuing original literature of gas chromatography, contains 37 papers, Preston's previously mentioned bibliography, and a short but stimulating introduction by M. J. E. Golay. Except for two papers on the theory of programmed temperature gas chromatography, all contributions deal with experimental work. The discussions are included, but unfortunately, they are in a separate appendix at the back of the book rather than with the relevant papers.

Gas Chromatography Abstracts, 1961, contains 883 abstracts and, although Preston's biibliography shows about twice as many references for this period, Preston includes all papers where gas chromatography was used at all; it is unlikely that the abstractors have missed any significant developments. As those who use the abstracts already know, one of their most attractive features is the detailed and thorough index. One is happy to read in the introduction that future volumes of the abstracts are likely to appear even more promptly.

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Jesup Lectures

New Patterns in Genetics and Development. C. H. Waddington. Columbia University Press, New York, 1962. xiv + 271 pp. Illus. $10.

This volume is based on the Jesup lectures delivered at Columbia University in 1961. The title has a double meaning, insofar as the book deals with the origin of new patterns in development. Waddington applies to this problem the new patterns of thought which have arisen in genetics and biochemistry and tries to arrive at new patterns of thought applicable to the baffling problems of morphogenesis. The book is not a textbook, and it does not attempt to treat the vast literature in the field systematically. It is mainly concerned with presenting and discussing new ideas, which are introduced and developed on the basis of factual data, most of them taken from the most recent literature and from work in the author's laboratory.

Four of the six chapters deal essentially with developmental phenomena at the cellular level. The first chapter discusses the relation of genes and macromolecules and the possible ways in which the action of genes may be controlled in developing systems. In the next three chapters these ideas are related to the changes observed in developing cells under the electron microscope (amphibian notochord, retinula of *Drosophila)* and to other information concerning morphogenetic processes in single cells. The concepts of gene action developed in microorganisms are found to be insufficient to account for all the observed phenomena. A particularly difficult problem arises from the fact that an organization of cells—that is, a differential localization of substances in the cytoplasm—can be clearly demonstrated and indeed is necessary to account for differentiation, despite the free flow of cytoplasm seen in living cells. Thus the question of the material substratum for cellular organization becomes difficult to conceive. The final two chapters deal with multicellular systems, particularly with the problems of specific cell aggregation, morphogenetic fields and competence, and pattern formation.

The book is stimulating and interesting throughout, and full of brilliant analyses and ideas. Nevertheless, large parts leave me somewhat disappointed because the great complexity of the phenomena is emphasized and no clear new pattern of thought seems to emerge. Fortunately, chapter 6 reverses this trend; in that chapter's brilliant analysis of the genic determination of the *Drosophila* leg, and in its discussions of the banding of the snail shell and of the lepidopteran wing pattern, the possibility of an interpretation of developmental processes in molecular terms becomes conceivable, even though it has not yet been demonstrated.

The great variety of phenomena described in the book, and the manifold suggestions for their interpretation, raise the question of whether it will be possible, in principle, to describe embryology in terms of general validity, as has been possible in genetics and