consistency; [p. 47] the explanation of tests is incomplete; [p. 67] the central limit theorem is stated incorrectly; [p. 130] it should be added for clarity that when $\hat{\hat{x}}$ is unbiased with minimum variance as an estimator for x, it has those properties only in general in the class of linear estimators.

FRANKLIN A. GRAYBILL
Statistical Laboratory, Colorado State University, Fort Collins

Techniques in Biochemistry

Separation Methods in Biochemistry. C. J. O. R. Morris and P. Morris. Interscience (Wiley), New York, 1964. viii + 887 pp. Illus. $17.50.

Separation methods have always been important in the advance of chemistry. Prior to a time beginning less than 20 years ago, biochemists looked to organic chemists, physical chemists, and chemical engineers for advice in regard to their separation problems. More often than not this advice was of little help and the results obtained by the biochemist were considered, by organic chemists in particular, to be of inferior reliability, scarcely even of scientific value. A fundamental tenet of organic chemistry has always been that investigations must be carried out on "pure" preparations—that is, on preparations properly documented with respect to purity. But, for most biochemicals, methods suitable for doing this were not available. Most of the substances could not be crystallized.

Fortunately there was a period of intense research on separation methods suitable for biochemicals, which was sparked by a number of different groups of workers, particularly by Martin and Synge and their collaborators. Their theories extended chromatography so that it was effective for separating not only substances soluble in organic solvents but those soluble in water as well. Ion exchange chromatography, countercurrent distribution, zone electrophoresis, and various modifications played a role in extending fractionation procedures to an efficiency far beyond that previously considered sufficient for the study of simple organic substances. It was no longer necessary to crystallize a preparation to prove its purity, and a much wider range of naturally occurring substances could be brought under structural study. A single book treating the various methods available is a welcome addition to the literature.

In the preface the authors state that their objective in writing the book is to "give a reasonably complete coverage of the wide range of methods now available for the separation of biochemically important substances." In my opinion they have succeeded to a degree worthy of great admiration. In a total of 871 pages, including the index, the ideas and suggestions derived from a total of more than 1900 references are presented. Many of these references presented theories as well as procedures and description of equipment. A rough idea of the diversity and complexity of fractionation methods now available in biochemistry, to say nothing of the labor of considering all the ideas, can thus be derived.

The subject, in its entirety, is treated in a logical way in 22 chapters, with some aspect of chromatography as the subject of discussion in 14 of the chapters—that is, in about 65 percent of the book. Chapters on countercurrent distribution, electrophoresis, and membrane separation methods and a short chapter entitled "Miscellaneous separation methods" make up the remainder. It could be argued with justification that in comparison with the other methods the wider use of the various forms of chromatography justifies this allotment of the space. However, the treatment of such methods as sedimentation, differential solubility, and salting out, all of which are treated together in the short chapter on miscellaneous methods, may be a point of criticism. The short treatment of thin layer chromatography certainly is not proportional to the current interest in that method as compared, for instance, to paper chromatography.

In chapter 2 the classification of the various separation methods on the basis of the various parameters responsible for the separation is discussed and presented in tabular form. It seems to me that the view presented in this table is far too simplified. Thus, the impelling force causing the movement of solute for all forms of chromatography is listed as hydrodynamic, but the relative retarding influence is given as surface energy, Van der Waals forces, and steric specificity for adsorption chromatography in contrast to osmotic (diffusion), dipole interactions, associations, and dissociation for so-called partition chromatography. Such clear distinction between the two goes well beyond the probable true state of affairs. The parameters listed for each, and other parameters as well, are present in both cases, in different degrees.

On page 605 there seems to be a certain lack of clarity. Although the term *countercurrent extraction* is an old one that includes many types of processes the term *countercurrent distribution* (CCD) is more recent and much more specific. I proposed the term in 1944 to designate a stepwise multiple extraction process carried out in such a way that the terms of a binomial expansion could be directly applied to give the fractional parts found in each extraction unit of the system. No assumptions are required to make this correspondence valid. The distinction is not "purely arbitrary" (p. 605) but results from the fact that a strictly discontinuous process and a continuous process are based on different principles.

If it is desirable to remove the solute contained in a solution in a vessel but leave the vessel filled with solvent, the operation can be done in either of two ways: (i) the solution can be drained and the vessel filled with fresh solvent, or (ii) the solvent can be allowed to flow into one side of the vessel and out the other until the solute is all washed out. Although the difference may be overemphasized by this analogy, the mere fact of large numbers of units can never erase the difference between CCD and a continuous process. Contrary to the statement made on page 4, CCD remains strictly true to the binomial expansion, regardless of the number of units. Approximate methods of calculation (the normal curve of error) are used only to save labor in calculating a theoretical curve, not because a similarity to the continuous process is approached. The reasoning of calculus would predict that for high numbers of transfers the discontinuous and continuous should merge, but experience has shown that in actual practice involving thousands of transfers the differences often become more marked, not less.

It seems probable that the physical basis for all continuous column processes is much more complicated than any explanations yet offered. The complex interplay of the many factors is not necessarily reduced by those particular conditions (usually found by empirical means) which give sharp bands corresponding to a narrow Gaussian distribution. In the last analysis most interpretations are based on analogy to an idealized discontinuous process. But this requires simplifying assumptions. Thus, the stage is set for as many different opinions as there are investigators.

Separation Methods in Biochemistry is highly recommended to anyone who wishes to become more informed about the possibilities and complexities of fractionation.

LYMAN C. CRAIG
Rockefeller Institute, New York

Dantzig's Simplex Method

Linear Programming and Extensions. George B. Dantzig. Princeton University Press, Princeton, N.J., 1963. xviii + 625 pp. Illus. $11.50.

Linear programming is applicable to many large-scale problems of optimization from economic, industrial, military or administrative situations. It provides specific techniques for the maximization or minimization of linear functions subject to linear constraints and is closely related to game theory, although with different emphasis. Some of its mathematical foundations were laid in Motzkin's 1936 dissertation (Basel, *not* Zurich) on linear inequalities, and its industrial importance was recognized by Kantorivitch in Russia in 1939, but the full-scale development of the subject should probably be dated from Dantzig's introduction of the simplex method in 1947. In recent years, the field has grown tremendously and has given rise to many books, some of a general nature and others restricted to a particular area of application (economic theory, transportation, electrical networks, portfolio selection, and the like). Dantzig's long-awaited book is of the general sort, striking a nice balance between theory and applications.

When one of the "fathers" and recognized leaders in a field writes a book on his specialty, he has reason to hope that it will become *the* book on the subject. He also has reason to fear that, in aiming at a definitive treatment, his book may become unreadable to all but the experts. In my opinion, Dantzig's book comes very close to realizing the hope, and it does pretty well in skirting the danger by designing a certain set of chapters to serve as an introductory text. By almost any measure—number of pages, completeness of bibliography and index, variety of applications, completeness of theoretical discussion, scope of the exercises, or list of acknowledgements in the preface (which is a virtual *Who's Who* of the subject)—Dantzig's book seems to compare favorably with its predecessors.

With the praise, a word of caution. Although the book will be of great value to research workers in the field and to *serious* students of the subject, it does not seem suitable for the reader who wants only a routine working knowledge of the simplex method. For such a reader, less detailed treatment is preferable, but it might well be supplemented by material from Dantzig's book.

Space does not permit a technical discussion of the many strengths and the very few weaknesses of the book, but the chapter headings will indicate its contents: "The linear programming concept" (11 pp.); "Origins and influences" (20 pp.); "Formulating a linear programming model" (31 pp.); "Linear equation and inequality systems" (25 pp.); "The simplex method" (18 pp.); "Proof of the simplex algorithm and the duality theorem" (27 pp.); "The geometry of linear programs" (26 pp.); "Pivoting, vector spaces, matrices, and inverses" (28 pp.); "The simplex method using multipliers" (17 pp.); "Finiteness of the simplex method under perturbation" (13 pp.); "Variants of the simplex algorithm" (13 pp.); "The price concept in linear programming" (23 pp.); "Games and linear programs" (21 pp.); "The classical transportation problem" (17 pp.); "Optimal assignment and other distribution problems" (19 pp.); "The transshipment problem" (17 pp.); "Networks and the transshipment problem" (16 pp.); "Variables with upper bounds" (17 pp.); "Maximal flows in networks" (19 pp.); "The primal-dual method for transportation problems" (9 pp.); "The weighted distribution problem" (20 pp.); "Programs with variable coefficients" (15 pp.); "A decomposition principle for linear programs" (23 pp.); "Convex programming" (28 pp.); "Uncertainty" (15 pp.); "Discrete variable extremum problems" (37 pp.); "Stigler's nutrition model: An example of formulation and solution" (17 pp.); and "The allocation of aircraft to routes under uncertain demand" (24 pp.). There are a 19-page bibliography and an 11-page index.

VICTOR KLEE
University of Washington, Seattle, and *Boeing Scientific Research Laboratories*

New Books

Mathematics, Physical Sciences, and Engineering

Acta Imeko, 1964. Proceedings of the Third International Measurement Conference. vols. 1–3. Ing. S. Kovács and J. Solt, Eds. Hungarian Scientific Society for Measurement and Automation, Budapest, 1964. vol. 1, 498 pp.; vol. 2, 475 pp.; vol. 3, 530 pp. Illus. $30. Contain the full text of 105 papers in their original languages followed by abstracts in three languages—German, English, and Russian

Analysis. vol. 1. Einar Hille. Blaisdell (Ginn), New York, 1964. 640 pp. Illus. $10.

Atlas of Electron Spin Resonance Spectra. vol. 2, *Theoretically Calculated, Multicomponent, Symmetrical Spectra*. Ya. S. Lebedev, V. V. Voevodskii, and N. N. Tikhomirova. Translation from the Russian. Consultants Bureau, New York, 1964. 201 pp. Illus. $15.

Atomic Migration in Crystals. L. A. Girifalco. Blaisdell (Ginn), New York, 1964. 174 pp. Illus. $3.75.

Azeotropic and Extractive Distillation. E. J. Hoffman. Interscience (Wiley), New York, 1964. 336 pp. Illus. $14.

Bailey's Industrial Oil and Fat Products. Karl F. Mattil, Frank A. Norris, Alexander J. Stirton, and Daniel Swern. Daniel Swern, Ed. Interscience (Wiley), New York, ed. 3, 1964. 1117 pp. Illus. $25.

The Binary Stars. Robert Grant Aitken. Dover, New York, 1964 (corrected reprint of 1935 edition). 319 pp. Illus. Paper, $2.

Chemical Engineering. Paul P. De Rienzo. Macmillan, New York, 1964. 253 pp. Illus. $7.

A Collection of Problems on Mathematical Physics. B. M. Budak, A. A. Samarskii, and A. N. Tikhonov. Translated from the Russian edition by A. R. M. Robson. D. M. Brink, Translation Ed. Pergamon, London; Macmillan, New York, 1964. 782 pp. Illus. $11.50.

The Constitution of Glasses: A Dynamic Interpretation. vol. 2, pt. 1, *Constitution and Properties of Some Representative Glasses*. Woldemar A. Weyl and Evelyn Chostner Marboe. Interscience (Wiley), New York, 1964. 486 pp. Illus. $15.

A Course of Higher Mathematics. vols. 1–5. vol. 1, *Elementary Calculus* (557 pp., $12.50); vol. 2, *Advanced Calculus* (634 pp., $12.50); vol. 3, pt. 1, *Linear Algebra* (334 pp., $9); vol. 3, pt. 2, *Complex Variables-Special Functions* (710 pp., $15); vol. 4, *Integral Equations and Partial Differential Equations* (825 pp., $17.50); vol. 5, *Integration and Functional Analysis* (649 pp., $17.50). V. I. Smirnov. Translated from the Russian editions (Moscow, vols. 1 and 2, ed. 16, 1958; vol. 3, pts. 1 and 2, 1957; vol. 4, 1959; vol. 5, 1960) by D. E. Brown. I. N. Sneddon, Translation Ed. Pergamon, London; Addison-Wesley, Reading, Mass., 1964. Illus.

Electromagnetic Fields and Interactions. vols. 1 and 2. Richard Becker. Fritz Sauter, Ed. vol. 1, *Electromagnetic Theory and Relativity* (453 pp., translated from the

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