objective is not only to bring together a mass of research literature into a single volume but to clarify conceptual difficulties, reduce certain of the more intuitive arguments to rigorous deductions, and tie together the considerable diversity of theoretical and experimental work into an integrated whole. In the process, the author brings new approaches into the textbook field and presents experiments, some of them his own, which are not widely known in the United States.

I regard the early introduction of Hamiltonian and Hamilton-Jacobi procedures for later use as a tool that provides a powerful, unifying approach to plasma particle dynamics. The chapters on relativistic plasmas and on radiation interactions are also strong and relatively new offerings. The author himself is the first to disavow originality in these efforts and is generous in citing references. The clarified and integrated presentation, however, merits comment. I particularly like the chapters on magnetic compression and on confinement of charged particles (the latter chapter contains some of the author's own work referred to above).

For use as a textbook, *Dynamics of Charged Particles* is more advanced than Rose and Clark's *Plasmas and Controlled Fusion* (1961) and requires a greater background knowledge and familiarity with experimental and instrumental developments in the field. The presentations are sometimes lengthy and seemingly intricate but may in time become accepted as the standard, rigorous proofs of basic theorems.

The author gained much of his experience in the Department of Electronics at the Royal Institute of Technology in Stockholm. He served as editor of the International Astronomical Union's symposium volume *Electromagnetic Phenomena in Cosmical Physics,* thereby adding breadth to his first-hand knowledge of experimental plasma physics. The present work, in contrast with recent books written from backgrounds of thermonuclear studies, of microwave discharges, or of aerodynamic plasmas, is based on this background of astrophysical interests.

At its level, the book should command a wide and appreciative student audience and serve as a standard reference for more advanced users.

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For Laboratory Scientists

Statistics in Physical Sciences. Estimation, hypothesis testing, and least squares. Walter Clark Hamilton. Ronald, New York, 1964. xii + 230 pp. Illus. $10.

In the preface of this book the author sets forth quite clearly his reasons for writing this text. "The writing . . . was motivated by the need for a comprehensive treatment of the methods of least squares, linear hypothesis testing, and multivariate analysis in a form easily assimilated and put to use by the laboratory scientist. Although the emphasis is on least squares and associated techniques, it is hoped that the introductory sections are so complete that the mathematically mature scientist with little experience in statistical problems will become familiar enough with the concepts of elementary statistical estimation to be able to apply the methods with confidence and to read the more specialized statistical texts for treatment of the problems with which we do not deal here." A brief and excellent summary of each chapter is also presented in the preface.

The basic ideas of probability and statistics used in subsequent chapters are introduced in chapter 1. The concepts of probability distributions, expected values and moments, statistical estimation, and hypothesis testing are discussed at length, and the theory of matrices and linear equations without which a discussion of multivariate least-squares techniques becomes unnecessarily cumbersome are treated briefly.

In chapter 2, Hamilton discusses the estimation of parameters from univariate populations and introduces the basic distributions in common use: the normal, Student's, chi-square, and the variance ratio F; in chapter 3, he treats briefly the classical methods of the analysis of variance: the estimation of population means and their differences from several samples. Chapter 4, in which he presents the theory of linear least-squares adjustments, the error distribution of quadratic forms, and the theory of linear hypothesis tests, is in his own words, the "real heart of the book."

Discussions of a number of miscellaneous statistical problems, most of which are related to the applications of the least-squares method, are presented in chapter 5. Because some of the problems considered—for example, nonlinear least-squares and hypothesis tests and optimum experimental design—are the subjects of vigorous work by statisticians at the present time, the discussions are necessarily incomplete and perhaps speculative. Hamilton writes that "In this connection, it might be remarked that physical data and experimentation rarely conform in every respect to the idealized conditions implicit in every rigorous statistical test, and the scientist must therefore be prepared to use approximate methods and tests, realizing that his statements regarding probability of error are often more qualitative than they might appear." In chapter 6 the author presents more extended numerical examples of the least-squares method than was possible in chapter 4. "In particular, application to crystallography, radiochemistry, and infrared spectroscopy are illustrated."

Least squares is a very important topic for any scientist who is interested in the construction of mathematical models, curve fitting, and other similar topics. Since the community of physical scientists makes great use of these techniques, it is desirable for them to have a better understanding of the mathematical structure and background of the subjects. This well-written book, which will provide a good beginning toward such a goal, requires only an understanding of calculus and matrix algebra. In fact, what is generally taught in the sophomore year in college calculus will be sufficient for that subject. A course in matrix algebra is desirable, but those who have a working knowledge of the elementary concepts of the arithmetic of matrices and have done some work in the solution of systems of linear equations should encounter no unusual difficulty in this book. Although the book seems to be essentially self-contained, one or two courses in statistics would probably be most useful to the reader. I consider the book a contribution to the teaching literature for the engineer and others in the physical sciences and believe that the author has achieved his objectives.

The following are typical among the errors and misprints noted—[p. 9, 8(a)] the statement "P(A) is a *positive* real number not greater than 1" should read "a *non-negative* real number not greater than 1"; [p. 20, in the last formula on the page] the exponent 2 should be a negative 2 in the exponent; [p. 38, line 6 from the top] unbiasedness is not necessarily a stronger property than 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.

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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