Book Reviews

Struggles Toward Rationality

The History of Statistics. The Measurement of Uncertainty before 1900. STEPHEN M. STIGLER. Belknap (Harvard University Press), Cambridge, MA, 1986. xviii, 410 pp., illus. $25.

The Rise of Statistical Thinking, 1820–1900. THEODORE M. PORTER. Princeton University Press, Princeton, NJ, 1986. xii, 334 pp. $35.

Stephen Stigler's *History of Statistics* is an exceptionally searching, almost loving, study of the relevant inspirations and aberrations of its principal characters James Bernoulli, de Moivre, Bayes, Laplace, Gauss, Quetelet, Lexis, Galton, Edgeworth, and Pearson, not neglecting a grand supporting cast. For over a decade, Stigler, himself a statistician, has been making the rounds of library archives and getting to the mathematical heart of the matter in a variety of languages. He has now crafted his discoveries into a form that is much more than narrative description; it is a convincing reconstruction of how the important impulses of statistical thought eventually came together, to press so decisively on the door into the 20th century. The author has used his knowledge of mathematical statistics and its applications to interpret sympathetically the difficulties encountered in the creative process by even the sublimest genius. We are, for example, led to understand the reasons for the prolonged hiatus between the early achievement, in astronomy and geodesy, of the "combination of observations" and its reemergence as regression. That particular exposition culminates with a delightful analysis of how Galton's conceptual insights about regression were stimulated by a simple piece of machinery, the quincunx. The book turns out to be a string of such revelations. For each, source material is explored with an eye for significant detail, modern notation is used to help the reader to see what is going on, and the original work is allowed uncensored self-expression.

Part 1 traces the fascinating origins of the least-squares theory for the linear models of astronomy and geodesy that arise, without any forcing, from first-order approximation coupled with small error variance. Long before Gauss could present the theory of best linear unbiased estimation in essentially its modern form, we find Laplace toying with inverse probability without the benefit of Bayes's theorem, and, before that, Boscovich attacking the method of least moduli. Also entwined in the least-squares story is the subplot of how the normal distribution was weaned from strict dependence on de Moivre's binomial.

In part 2, entitled The Struggle to Extend a Calculus of Probabilities to the Social Sciences, we see how it came about that Quetelet the astronomer gave Quetelet the statistician the normal distribution as a seal of approval of causally determined social regularity, whether of heights of individuals or incidences of criminality. Stigler shows that, for many decades, the success of this very limited apparatus acted, paradoxically, as a block to the discovery of the appropriate mathematical tools for the analysis of relationship in cross-tabulated data. The necessary breakthrough (part 3) came with Galton's collection of data on the inheritance of weight in pea seeds and of height in humans. Galton was no mathematician, but his powerful intuitions based on models such as the quincunx gave him the role of catalyst of those who were. It is a measure of Galton's genius that his two best reagents—Edgeworth and Pearson—would be the ones to bring about the flowering of statistics in this century.

Stigler writes from an uncompromisingly mathematical, albeit eclectic and applied, viewpoint. Without a sound mathematical-statistical background, the reader is likely to experience difficulty in following some of the argument. But the book is nicely illustrated and is well furnished with graphs and tables of original data. It is to be hoped that it will gain a wide readership, since its perceptions might reinforce the case for "statistics" at a time of vigorous expansion in the science of systems, stoked by the power of the computer and all its works. We are, it seems, at the dawn of a new age of heady labels—"artificial intelligence," "expert systems," "fuzzy logic," to name but three—in which it is possible to hear probability described as any user-friendly number between 0 and 1. Indeed, one wonders whether statistical thinking may not be ultimately submerged in the hyperactive microcosms of a network of computers. The pages of Stigler's book may then come to be seen as the definitive record of an intellectual Golden Age, an overoptimistic climb to a height not to be maintained.

The broader historical coverage of Porter's interesting and scholarly review offers a modicum of reassurance against such fears. The misinterpretation of statistics is not a particularly modern phenomenon. Indeed, as Porter reveals, the best example of the genre may have been the futile but long-running 19th-century debate in which free will was counterposed to the supposed determinism implied by what Quetelet had playfully described as the "frightful regularity" of statistical averages for large numbers of measurements. The debate was fueled by the overstatements and exaggerated claims of Buckle's *History of Civilization in England*. There must have been times when those who, like Fitzjames Stephen, quoted by Porter, or Robert Campbell, studied by Stigler, fought the good fight for rationality despaired of the fate of sound statistical thinking. Quetelet, however, was not among the faint-hearted—and, in the end, he was right. Quetelet wrote: "I have given particular attention to statistics—a science which is far from being understood, although its utility is generally recognized in proportion as it is cultivated with discernment"—an opinion that may be reinforced by inspection of the recurrent statistical arguments that are to be found in the letters pages of this very journal.

Porter, a historian, writes for a less technically oriented readership; only a few mathematical formulas, some of them ill printed, adorn the pages of his book. In its excellent coverage of many topics, touching on the delicate issues of historical priority and intellectual pecking order, we meet an account of the influence of Quetelet and Buckle on Clerk Maxwell in the development of probabilistic thinking about ensembles of large numbers of gas molecules. The story of this influence appears to be well known to historians of science but was new to your reviewer. Concisely stated, it goes thus. Scientist John Herschel uses the occasion of a review of a book by Quetelet to present a two-dimensional, axiomatic derivation of Quetelet's favorite distribution, the normal. Quetelet's disciple Buckle writes his *History* (1857). Maxwell, who has read both the Herschel piece and Buckle, presents, without acknowledgment, the three-dimensional analogue of Herschel's derivation, which becomes the kernel of his statistical thermodynamics.

Does this imply that statistical physics is indebted to sociology? The publisher's blurb of Porter's book quotes a reviewer who might seem to say yes: "The author shows with great clarity how statistical thinking arose in applied, not basic, science or mathematics, and from social, political, reform, and social science sources." But if we enlarge the story to take into account, from Stigler, (i) the mathematician de Moivre's derivation of the normal, (ii) Gauss and Laplace's work on it, based on the needs of astronomy and geodesy, and (iii) Quetelet's background as mathematician and astronomer and the arguable irrelevance to substantive sociology of his dedication to the normal, we may feel that theories about influence at a distance in matters of ideas should be regarded as no more than entertaining conjectures.

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Microscopy Enhanced

Video Microscopy. SHINYA INOUÉ with contributions by ROBERT J. WALTER, JR., MICHAEL W. BERNS, GORDON W. ELLIS, and ERIC HANSEN. Plenum, New York, 1986. xxviii, 584 pp., illus. $65.

The capabilities of the light microscope in partnership with closed-circuit television and, sometimes, digital computers have dramatically expanded in recent years, enabling the capture and recording of formerly inaccessible images. A biologist or other researcher who wishes to obtain a clearer view of microscopic structures by using a television system must achieve a degree of competence in several diverse technologies. Shinya Inoué has done a superb job in conveniently packaging detailed information about these technologies in one volume. He covers the operation of light microscopes, television cameras and monitors, video tape and disk recorders, and analog processors and analyzers. A chapter by Walter and Berns treats digital image processing and analysis, a technique that harnesses the power of the computer to heighten image contrast and extract quantitative information from images. Appendices by Ellis, Hansen, and Inoué treat video line removal, modulation transfer function and the optical diffraction pattern, and biological polarization microscopy.

As well as presenting the background and essential features of television and light microscopy and describing the human visual system in relation to these instruments, Inoué compares the performance of competitive equipment, thereby providing information vital for deciding what components to purchase. Names and addresses of commercial suppliers are listed.

A researcher who reads this book from cover to cover will be exposed to a wealth of information about the video microscope and its applications. More likely, however, the book will be used as a reference manual for learning about individual details. To this end Inoué has provided a detailed table of contents and a 40-page glossary to help the reader through the jargon of these technologies. Entries in the glossary are keyed to sections of the text.

In my opinion, the book has only two flaws. The first is that in presenting a huge quantity of information it fails to highlight what is most essential to a researcher with a problem to solve within a limited time. The second flaw, obsolescence, is common to such books. Video and especially computerized imaging are changing so rapidly that a manual is obsolete the day it is published. Inoué has reduced this problem by presenting the operational principles of the devices and by including a "last minute before press" appendix on computerized video image processors.

This book is a necessary addition to the libraries of biological researchers or industrial engineers who are engaged in video microscopy or who wish to master the basics and explore applications of this powerful combination of techniques.

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Atmospheric Science

Atmospheric Chemistry. Fundamentals and Experimental Techniques. BARBARA J. FINLAYSON-PITTS and JAMES N. PITTS, JR. Wiley-Interscience, New York, 1986. xxx, 1098 pp., illus. $59.95.

Atmospheric Chemistry and Physics of Air Pollution. JOHN S. SEINFELD. Wiley-Interscience, New York, 1986. xxvi, 738 pp., illus. $59.95.

For years there has been only one comprehensive textbook for students of atmospheric chemistry: C. E. Junge's *Air Chemistry and Radioactivity*, published in 1963. Although that marvelous book, which defined the field, is still valuable, there has long been a need for a new textbook. Two books have appeared to help fill the void, though in different ways. Both are much larger than Junge's book, reflecting the explosion of knowledge in the field. Both present material at the level of graduate students and above. Although both contain more material than could be covered in a one-semester course, most students would want to keep them as reference books. Despite their greater sizes, neither is as comprehensive as Junge's book; both focus on urban-scale problems, with only brief coverage of the "clean" troposphere or the stratosphere. Both books contain a chapter on acid deposition, but neither chapter is particularly good; however, Seinfeld's book contains the background needed for a detailed treatment.

In view of their history of outstanding research on gas-phase atmospheric chemistry, it is not surprising that Finlayson-Pitts and Pitts focus on that subject. Taking full advantage of the massive database on kinetics and photochemistry developed in studies of photochemical smog and stratospheric ozone over the past decade or so, they treat smog chemistry in great detail, including smog-chamber and modeling studies. Unlike many authors of reviews, they follow reactions of examples of various organic compounds all the way to the final products rather than merely showing how these reactions relate to ozone formation. Their treatments of polynuclear aromatic hydrocarbons and related classes of compounds are valuable in view of the increased attention being paid to airborne mutagens today. Researchers and modelers will find the tables and appendixes on reaction rates, spectral light intensities, and the like useful.

Finlayson-Pitts and Pitts's book is not ideal as a textbook, however, since it has no problem sets and the order of chapters is not very logical. Even in their own field of gas-phase chemistry, they do not present the fundamentals adequately for the uninitiated. To its credit, the book covers experimental methods of laboratory kinetics and smog-chamber studies and of field measurements and sample collections. It gives rather short shrift to airborne particles, atmospheric structure, meteorology, and dispersion and deposition phenomena.

Seinfeld's more general book is a true textbook; most chapters have problem sets, which are essential for teaching and learning the subject. Seinfeld's treatment of gas-phase kinetics, though less extensive than Finlayson-Pitts and Pitts's, is quite adequate and probably easier for students to follow. He provides thorough coverage of aerosol physics, dynamics of particle interactions, atmospheric structure, turbulence and mixing, dispersion and deposition, and source-based air-pollution models. These subjects are treated with more physics and engineering rigor than needed for most courses, but researchers will be delighted to find the derivations and equations collected in one book. The thermodynamics and kinetics of water droplets in contact with gases are explained thoroughly. Seinfeld makes no attempt to cover experimental methods.

Neither book devotes much space to the newer receptor modeling approaches to source apportionment, unfortunately, but Seinfeld includes a brief section on the most widely used example, chemical mass balances. Although he does not proceed to