Probabilistic Thinking

The Empire of Chance. How Probability Changed Science and Everyday Life. GERD GIGERENZER, ZENO SWIJTINK, THEODORE PORTER, LORRAINE DASTON, JOHN BEATTY, and LORENZ KRÜGER. Cambridge University Press, New York, 1989. xviii, 340 pp. $44.50. Ideas in Context.

The increasing role of mathematical probability in modern life has finally attracted the attention of historians of science to the subject. Eight monographs and several collections of papers on the history of probability and statistics have appeared in this decade—more than during the preceding century. Six authors who have contributed to this burst of activity have now tried to summarize the results for a broader audience. Beginning with the inception of probability theory in the 1650s and speaking with one voice—they do not identify their contributions to individual chapters, and they used a lottery to determine the order of their names on the title page—the authors attempt to explain the ways in which probability and statistics have "transformed our ideas of nature, mind, and society."

The first five chapters of this book will be useful to statisticians, philosophers, scientists, and other historians of science who want to understand the roots of the probability-based statistical methods we use so widely today. Chapter 1 summarizes Lorraine Daston's prize-winning *Classical Probability in the Enlightenment* (Princeton University Press, 1988), covering the philosophy and applications of probability from 1660 to 1840. Drawing heavily on Theodore Porter's *The Rise of Statistical Thinking, 1820–1900* (Princeton University Press, 1986), chapter 2 deals with 19th-century social statistics, Francis Galton's work in biometry and mathematical statistics, and aspects of the 19th-century discussion of determinism. Chapter 3 covers R. A. Fisher's work in agricultural experimentation and statistical theory, Jerzy Neyman and E. S. Pearson's mathematical elaboration of Fisher's work, and the institutionalization of this work in the modern statistical profession. This chapter is an unusually broad and judicious treatment of its topic, and it succeeds in presenting it in a less technical way than the other treatments of which I am aware. Nevertheless, the general reader will find it much more difficult than the preceding chapters. Chapter 4 is the most original and detailed in the book; it surveys the various ways in which chance and determinism cropped up in 19th-century biology. Chapter 5 covers the various roles of probability in physics, from Laplace to quantum mechanics. Its tone is philosophical rather than mathematical, but it will be even more difficult for the general reader than chapter 3.

The remaining chapters—which summarize parts of Gerd Gigerenzer and D. J. Murray's *Cognition as Intuitive Statistics* (Erlbaum, 1987), discuss impressionistically the role of statistics in contemporary life in the United States and wax philosophical on chance and determinism—are a good deal less valuable.

In the general introduction, the authors present their book as a coherent narrative for a general audience. The chapters are too uneven in style, level of difficulty, and purpose to hold the interest of many laymen, however, and the book will be most valuable as an entry point into the current literature for scholars. Unfortunately, in their attempt to provide a coherent narrative, the authors have weakened its value in this regard, as readers are given no clue which parts are summaries of earlier works and which represent new research.

In the general introduction the authors say they are less interested in the mathematical theory of probability and statistics than in its impact on broader thinking. This leads them to concentrate on their own work and to slight important recent writing of Stigler and Schneider. Yet the first three chapters are concerned more with the evolution of theory—a balanced account of which would have to include topics emphasized by Stigler, notably the invention of least squares—than with its impact on contemporary thinking.

This neglect of important authors extends to important topics as well, so the presentation as a whole is incomplete. The role of probability and statistics in psychology, biology, medicine, and physics is treated in some depth, but their role in other social sciences, meteorology, engineering, and business is treated shallowly or not at all. The authors seem to be unaware of the role probability has assumed in economic theory during the past three decades, and overlook the decisive influence of economic theory as an explanation for the recent interest in probability as a model of rationality in psychology.

Many of these problems might have been avoided, but I fear that overall the venture of producing a coherent general history of probability and statistics is premature. In the case of the 17th, 18th, and 19th centuries, we have a wealth of information about the evolution of the mathematical theory and much new information, from Daston, Porter, and Stigler, about the scientific and cultural context of this evolution, but these streams of inquiry have not yet fully merged. Consequently, a narrative at a distance from the mathematical details, such as we do find in most of this book, becomes misleading. For instance, chapter 1 presents the early concept of mathematical probability as a legal concept, even though the mathematical structure of the theory was based on games of chance and owed little to the concept's connections to legal rhetoric. Non-specialist readers could not know that all the books written on mathematical probability during the first century of its existence were concerned almost exclusively with games of chance. When they move into applications of statistical theory in the 20th century, the authors have little historical research on which to draw, and consequently their discussion remains superficial and impressionistic. In chapter 3, for example, the authors note that our standard statistics textbooks present a compromise between Fisher's views and those of Neyman and Pearson, and they denounce this compromise as unsatisfactory. But they are not able to tell us anything about how it came to prevail.

Overall, *The Empire of Chance* is a valuable book, but its greatest contribution is its research agenda. The authors have asked the right questions, and their efforts to answer them show us how much more work there is to be done. Unprecedented as it may be, the activity of the past decade is only a beginning.

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Marine Protozoa

Modern Planktonic Foraminifera. CH. HEMLEBEN, M. SPINDLER, and O. R. ANDERSON. Springer-Verlag, New York, 1989. xiv, 363 pp., illus. $98.

During my undergraduate years, earth science instructors often used the adage "The present is the key to the past." For paleoceanographers, biological oceanographers, and geologists studying the planktonic foraminifera, this idea has never been more important. With a growing need to understand the environmental parameters responsible for global warming and the greenhouse effect, scientists have turned to the geological record in an attempt to understand the causes of climate change in the past. Research involving fossil planktonic foraminifera has played a key role in this effort. However, it has become clear that interpretation of data from the fossil record is dependent on numerous assumptions about the ecology and biology of the organisms as they lived in ancient oceans.

Given this impetus, a number of research-

ers have turned toward the study of living planktonic foraminifera. In *Modern Planktonic Foraminifera*, Hemleben, Spindler, and Anderson provide a synthesis of over two decades of field and laboratory research on these organisms. The authors introduce the subject with an excellent review of the planktonic foraminiferal species found in today's oceans. Current knowledge of morphology, ontogeny, nutrition, and habitat distribution is presented for each species, along with excellent scanning electron micrographs. The second chapter reviews the collection and culturing of planktonic foraminifera for laboratory study.

By far the strongest focus is on biological aspects of these marine protozoans. Hemleben *et al.* provide an excellent review of shell ontogeny and aspects of chamber formation and calcite secretion. Researchers studying biomineralization will find these chapters enlightening. Foraminiferal ultrastructure is examined in detail, and a sense of the complexity of these organisms is conveyed. The section on symbiotic associations points out that different foraminiferal species may be obligate or facultative hosts of either dinoflagellate or chrysophyte algae. Planktonic foraminiferal ecology and trophodynamics are covered in detail. An interesting finding is that a number of species may reproduce on a lunar cycle. Since reproduction results in the termination of the life of the foraminiferan and subsequent settling of the empty shell to the sediment, this observation may have significant implications for studies examining carbonate flux in the ocean.

Hemleben *et al.* conclude their synthesis with a summary chapter that relates the subject matter to questions of paleoceanographic importance. Given the impetus for the book, it is disappointing that this chapter is so short.

Overall, the book is well written, well referenced, and relatively easy to read. Figures from the primary literature have been included throughout the text, and many of the chapters cite "in press" articles as well as unpublished data collected by the authors. Sufficient detail is provided in each section to give the reader a broad background on the subject matter. Paleoceanographers and micropaleontologists will find *Modern Planktonic Foraminifera* a valuable reference to consult when interpreting fossil foraminiferal data. In addition, biologists will find a large body of information on a range of subjects as diverse as biomineralization, protozoan cell biology, and zooplankton trophic interactions.

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Information Issues

Biomolecular Data. A Resource in Transition. RITA R. COLWELL, DAVID G. SWARTZ, and MICHAEL T. MACDONELL, Eds. Oxford University Press, New York, 1989. xiv, 367 pp., illus. Paper, $64. Based on a workshop, Gaithersburg, MD, May 1987.

Biotechnology is now an important part of virtually all biological fields from agriculture to medicine, from basic research to industry. The field as a whole is moving into the "big science" mode with the advent of the Human Genome Project. With this dramatic growth in both scope and size is coming an equally dramatic explosion in information. The Committee on Data for Science and Technology (CODATA) of the International Council of Scientific Unions recognized the urgency of addressing this phenomenon by helping sponsor the First CODATA Workshop on Nucleic Acid and Protein Sequencing Data in May 1987. *Biomolecular Data: A Resource in Transition* is a result of the workshop. The papers it contains were clearly written independently and vary widely in length, style, breadth of view, and subject, but the editors have managed a reasonable organization of them and have provided introduction and summary sections that aid considerably in extracting the general issues.

The subtitle, "A Resource in Transition," accurately portrays the situation of biotechnology information. Unfortunately this transitional character also makes many of the specifics given in the book out of date already. The BIONET resource described in one paper no longer exists. The lag time for sequence entry into the GenBank database has been greatly decreased from the lag times quoted in the book. The three papers from the National Library of Medicine make no mention of the large National Center for Biotechnology Information created at the library by Congress in 1988. Several papers discuss the possibility of journal editors' encouraging submission of sequence data to the databases as part of the publication process when, in fact, dramatic progress in this direction has been recently achieved.

However, the more general themes raised in the book are still very much issues today. There is still no generally accepted format for sequence data exchange. The difficult sociological issues raised by public scientific databases are still very much with us. Should scientists who publish articles interpreting their research data be required to make the data themselves available in a public database? How could meeting of such a requirement be facilitated or enforced? How can standards for data exchange be established when the structures of the data themselves are still changing? Who is responsible for controlling scientific vocabularies? If such groups can be identified, how can official nomenclature be distributed and its use enforced? How can scientific software and databases retain their usefulness as the hardware and software platforms on which they were developed become obsolete? How can databases created in diverse disciplines be linked and integrated in a flexible, biologically meaningful way?

The discussions of these issues and the points of view expressed in the papers are still as germane to the current moment as they were in 1987. In order to move into the computer age, the way science is done must change. The notion of what constitutes publication will change. The parts of one's daily work that become open to public scrutiny will change. In return, the world of information at the scientist's fingertips will expand and deepen dramatically. *Biomolecular Data* offers a good opportunity to acquaint oneself with the issues and to share some visions of what the future may hold.

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Books Received

Acquired Immunodeficiency Syndrome. Current Issues and Scientific Studies. Pascal James Imperato, Ed. Plenum Medical, New York, 1989. x, 155 pp., illus. $39.50. Reprinted from *New York State Journal of Medicine*, 1987–1988.

Ada. The Design Choice. Angel Alvarez, Ed. Cambridge University Press, New York, 1989. x, 275 pp. $39.50. The Ada Companion Series. From a conference, Madrid, June 1989.

The Aharonov-Bohm Effect. M. Peshkin and A. Tonomura. Springer-Verlag, New York, 1989. vi, 152 pp., illus. $21.10. Lecture Notes in Physics, vol. 340.

AIDS and the Allied Health Professions. Joyce W. Hopp and Elizabeth A. Rogers. Davis, Philadelphia, 1989. xxii, 311 pp., illus. Paper $16.95.

Alternatives to Asbestos. The Pros and Cons. A. A. Hodgson, Ed. Published for the Society of Chemical Industry by Wiley, New York, 1989. xiv, 195 pp., illus. $89.95. Critical Reports on Applied Chemistry, vol. 26.

Alzheimer's Disease and Related Disorders. Khalid Iqbal, Henryk M. Wisniewsky, and Bengt Winblad, Eds. Liss (Wiley), New York, 1989. xxii, 1338 pp., illus. $295. Progress in Clinical and Biological Research, vol. 317. From a conference, Las Vegas, NV, Sept. 1988.

American Teachers. Histories of a Profession at Work. Donald Warren, Ed. Macmillan, New York, 1989. xvi, 472 pp., illus. $34.95.

American Warblers. An Ecological and Behavioral Perspective. Douglass H. Morse. Harvard University Press, Cambridge, MA, 1989. xiv, 406 pp., illus. $30.

Arguing and Thinking. A Rhetorical Approach to Social Psychology. Michael Billig. Cambridge University Press, New York, and Editions de la Maison des Sciences de l'Homme, Paris, 1989. vi, 290 pp. Paper, $16.95. European Monographs in Social Psychology. Reprint, 1987 ed.

Atomistic Simulation of Materials. Beyond Pair Potentials. Vaclav Vitek and David J. Srolovitz, Eds. Plenum, New York, 1989. x, 469 pp., illus. $95. From a symposium, Chicago, IL, Sept. 1988.

Biochemistry and Physiology of Plant Hormones. Thomas C. Moore. 2nd ed. Springer-Verlag, New York, 1989. xvi, 330 pp., illus. $49.

Modern Planktonic Foraminifera. Ch. Hemleben, M. Spindler, and O. R. Anderson. Springer-Verlag, New York, 1989. xiv, 363 pp., illus. $98

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