Book Reviews

Fisher's Ideas

R. A. Fisher: An Appreciation. Papers from a seminar and lecture series, Minneapolis, 1978, S. E. FIENBERG and D. V. HINKLEY, Eds. Springer-Verlag, New York, 1980. xii, 208 pp., illus. Paper, $14. Lecture Notes in Statistics, vol. 1.

Statistical science impinges on most fields of science and many areas of human endeavor. It has been more powerfully influenced by R. A. Fisher than by any other single person. His thought was subtle, he expressed himself carefully, and his ideas are not always well represented in our current textbooks. The subject of statistics is itself subtle and puzzling, whereas textbooks try to persuade the reader that all is clear and straightforward. Anyone much concerned with statistics should not miss becoming acquainted at first hand with Fisher's statistical writings, both the books and the research papers. There are, however, several impediments to doing so. Fisher writes in a conservative Victorian style that now seems remote. He often manages to be simultaneously lucid and obscure. Relevant mathematical arguments are sometimes omitted and when not omitted often seem imprecise. And at times his peculiar personality comes through in ways likely to irritate the reader. But after accommodation to these idiosyncrasies, the reader is rewarded. Fisher had a greater measure of understanding, insight, and imaginative energy than anyone else in the field.

This book presents a series of short papers on Fisher's principal statistical writings. Written by the editors and other faculty and student members of the University of Minnesota and by three guest lecturers, Joan Fisher Box, William Cochran, and David Wallace, the papers summarize contents, outline controversies, and sometimes express Fisher's material in more modern terms or relate it to later developments. The editors say in the preface: "The lectures were not intended as authoritative critiques of Fisher's work, but rather as introductions to and reviews of the key ideas in his writings. . . . We hope that the lectures here will help to introduce others to Fisher's work, so that yet another generation of statisticians can gain an appreciation of the relevant impact that his ideas still have on the way scientific research is conceived, carried out, and understood." Topics covered include early work on the correlation coefficient and degrees of freedom in the χ^2 test, development of analysis of variance and design of experiments, the brilliant and difficult discoveries in estimation and fiducial inference, discriminant analysis, distributions on the sphere, and Fisher's interventions in the debate on smoking and lung cancer.

The book seems to meet its objective well. Anyone contemplating browsing for the first time in Fisher's *Collected Papers* will find it a helpful guide. Anyone already somewhat familiar with Fisher's writings may find it less interesting and should perhaps turn elsewhere for inspiration. Joan Fisher Box's biography of her father (*R. A. Fisher: The Life of a Scientist*, Wiley, 1978) presents much fascinating, little-known information, calculated to encourage the reader to return to Fisher's writings with fresh interest and insight. And in Jimmie Savage's article "On rereading R. A. Fisher" (edited by John Pratt, *Annals of Statistics*, 1976) we see one powerful intellect savoring and evaluating the work of another powerful intellect, with splendid results. Among the contributors to the book under review there are fine intellects, but they have kept too closely to their stated purpose for that kind of magic.

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Gauge Theories

Field Theoretical Methods in Particle Physics. Papers from a NATO Advanced Study Institute, Kaiserslautern, Germany, Aug. 1979. WERNER RÜHL, Ed. Plenum, New York, 1980. x, 598 pp., illus. $69.50. NATO Advanced Study Institutes Series B, vol. 55.

During the last five years there has been extensive study of gauge theories, which are currently regarded by a number of experts as a correct mathematical description of the laws of nature governing both the macroscopic universe and the microscopic world of elementary particles. Gauge theories are not new to theoretical physics. The classical theory of electromagnetism is a gauge theory with an Abelian gauge group, as is the great edifice of space-time as geometry built by Einstein in his general theory of relativity. In the latter case the gauge group is the general linear group that arises by allowing arbitrary coordinate transformations. In 1954, Yang and Mills proposed that the fundamental laws for elementary particles should be described by a gauge theory with a non-Abelian gauge group, and results over the last decade and a half lend considerable support to this view.

The present volume contains a series of 21 lectures covering various aspects of the mathematical and physical development of gauge theories as applied, with one exception, to particle physics. The exception is H. Römer's contribution, which deals with attempts to fashion a quantum theory of gravity by means of a Euclidean Feynman-Kac integral for the gravitational action. The discussion in the main concerns the gravitational analogs of instantons, which have played a central role in studies of Yang-Mills theories by t'Hooft, Atiyah *et al.*, Singer, and others. Clearly future work should have much to say about the Euclidean version of Einsteinian gravitation.

The 20 remaining papers are concerned for the most part with the quantum field theoretic aspects of gauge theories, either on a lattice or as quantum chromodynamics. My own involvement has been with the rigorous existence theory for gauge fields within the framework of constructive quantum field theory. In this vein there is an excellent paper by J. Fröhlich on the geometry of gauge theories, particularly on the lattice, and recent work directed at proving the existence of the two-dimensional Abelian Higg's model by taking the limit of zero lattice spacing in a gauge-invariant finite-size lattice approximation. Fröhlich gives a broad account of the ideas and techniques needed for this work as well as a nice example of a principal bundle—a ball rolling on a fixed plane. Aspects of lattice gauge theories more in the direction of statistical mechanics are dealt with by F. Guerra in a paper concerning cluster expansions, recursive equations, and duality. Such techniques are essential for development of the lattice theories as dynamical schemes in their own right rather than just as a convenient cutoff for the continuum theory that maintains gauge invariance. One other paper that complements the lattice picture is by S. Yankielowicz, who discusses the

Hamiltonian aspect of the lattice devised by Kogut and Susskind within the framework proposed by Wilson. For much of the discussion the gauge group is discrete and the relation between phase transitions and confinement of static quarks is viewed in terms of Wilson-type area laws. The Coulomb gas representation also appears, but no mention is made of the rigorous results on Debye screening obtained by Brydges. In all, these three papers give a good overview of the lattice approach in the study of gauge theories.

At the other end of the scale, the relation of gauge theories to particle physics, there are seven papers in which quantum chromodynamics is the central topic. J. S. Ball deals with infrared problems related to the definition of an effective coupling constant in perturbation theory, and H. Leutwyler presents some interesting ideas on quark-bound states related to a nonvanishing expectation value for gluon contributions to products of quark currents. G. Kramer discusses the experimental picture, particularly perturbation theory calculations on jet formulation in electron-positron annihilation. For a mathematical physicist there is the welcome news that the data on jets are consistent with a quark-gluon view of hadron physics. As one of their main features non-Abelian quantum gauge fields should exhibit asymptotic freedom—the effective interaction strength between quarks and gluons should be energy dependent and become weaker at higher energies, at least if the gauge symmetry is not spontaneously broken. Asymptotic freedom makes gauge theories particularly attractive in that it may allow a more successful approach to the renormalization of the theories. This, of course, remains to be seen. Nevertheless asymptotic freedom is key to the incorporation of the parton model in quantum chromodynamics, wherein the quark and gluon constituents of hadrons appear to behave independently at high enough energy. A paper by B. Humpert and W. L. van Neerven discusses the dependence of parton cross sections upon the renormalization scheme chosen. It is clear that this aspect of quantum chromodynamics lacks the precision that perturbation theory has in quantum electrodynamics.

Other papers deal with instantons and the problem of quark confinement in gauge theories as well as the Ising model treated as a lattice gauge theory. These topics are well discussed here, as they have been elsewhere. A final paper I should like to mention is by K. D. Rothe and B. Schroer on the definition of various infinite determinants that arise in the mathematical analysis of gauge theories. The authors discuss the zeta function definition and its relation to two-dimensional models, which is probably different from the renormalized determinant that is studied in the constructive approach. E. Seiler has written on this difference very recently. In summary, the book gives a balanced overview of the main subjects of study at present in gauge theories and will be a useful reference, though with the pace at which developments take place it is hard to predict in which direction the field will turn in the next five years.

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Plant Reproduction

Reproduction in Flowering Plants. Papers from a symposium, Christchurch, New Zealand, Feb. 1979. Science Information Division, Department of Scientific and Industrial Research, Wellington, New Zealand, 1979. ii, 262 pp., illus. Paper, NZ$7.50. *New Zealand Journal of Botany*, vol. 17, No. 4 (pp. 425–686).

The biology of plant reproduction is one of the focal points of research in plant evolution and ecology. Matters of prime concern include plant-pollinator interactions in single- and multispecies arrays, the phenology of flowers and inflorescences and of populations, the characteristics and efficiency of pollen dispersal, breeding systems, gametophyte competition and selection, seed dispersal and dormancy, and the characteristics of seed pools. These issues are being addressed through observation and to lesser extents through experimentation and theory. There has been no attempt at a broad synthesis of plant reproductive biology, perhaps as a result of the degree of specialization of researchers in the field and the paucity of communication across disciplines.

The 15 papers collected in *Reproduction in Flowering Plants* are reviews of several aspects of plant reproduction, all but one involving the prezygotic phase. The treatment is weighted heavily in favor of pollination ecology and breeding systems; Australian and New Zealand plants are highlighted. In the main, the papers are comprehensive and of high quality and have something new and interesting to say. They speak to the vitality of the area. We see a shift in emphasis from almost pure natural history toward experimentation in several papers. Questions of "what" are being augmented by questions of "why." On the negative side, the reader is infrequently challenged by novel concepts or approaches. Moreover, there are no attempts to link traditional areas of study or to focus on common problems or issues. We are left with a group of related papers each going its own way. Nevertheless, the proximity of so many good papers is a stimulus for creative thinking.

The relationships of flowers and their vertebrate pollinators is one of the emerging concerns of pollination biology. Papers by Armstrong and by Ford, Paton, and Forde treat the subject in fascinating detail. Armstrong describes the pollination biology of flowers pollinated by marsupial and placental mammals, especially rodents, and suggests that such flowers are derived from bird-pollinated flowers. Functional aspects of breeding systems are reviewed from several vantage points by Bawa, Connor, Ganders, and Godley. Why do so many species have specialized outbreeding mechanisms? Godley argues that the relatively high proportion of dioecious species in New Zealand (which has often been interpreted in terms of immediate, special adaptation) is a function of the taxonomic affinities of the immigrants to New Zealand. Dioecy also is relatively common among the trees of some tropical communities. Bawa observes that dioecy is related to animal pollination, but why animal pollination would favor or be associated with dioecy remains to be determined. In his review of heterostyly, Ganders proposes that floral dimorphy increases effective pollination and seed-set over the levels occurring in comparable homomorphic systems. He suggests that the ancestors of heterostylous plants were self-compatible and when selected for incompatibility may not have had a choice between diallelic heteromorphic and multiallelic homomorphic incompatibility. Perhaps dioecy also evolved from self-compatible ancestors as a path of least resistance to outcrossing. Whatever the advantages (or are they consequences?) of different outcrossing mechanisms, it is becoming apparent that the payoff is now. In a thoughtful commentary on reproductive strategies, Lloyd contends that the "evolution of self- and cross-fertilization, sexual and asexual reproduction . . . must be sought in selective forces affecting individuals in each generation." He advocates the interpretation of reproductive systems in terms of the success of plants as seed and pollen parents.

The reviews of breeding systems in the