child. Almost no one has used them. Betty LeBlanc surely would not. She is Catholic and opposes abortion.

Few biologists are likely to read these books, which are aimed at a popular audience. Perhaps they should. They may not learn much science. But they would learn something important about how their science is packaged and sold. Nonspecialist readers would be better off with *Proceed with Caution*, a superb analysis of the science and social implications of genetic testing by Neil Holtzman, professor of pediatrics at Johns Hopkins. Although it is not about the genome initiative, it covers much the same ground as the books reviewed. And it is far better value for the money.

DIANE B. PAUL
Department of Political Science, University of Massachusetts, Boston, MA 02125

Between Bosons and Fermions

Fractional Statistics and Anyon Superconductivity. FRANK WILCZEK. World Scientific, Teaneck, NJ, 1990. x, 447 pp., illus. $68; paper, $28.

The fundamental particles of physics have long been divided into two classes, bosons and fermions. They differ in their statistics, which are, roughly speaking, +1 for bosons and −1 for fermions. For the last 20 years or so, there has been a current of speculation that there might exist other particles with statistics somewhere in between. Since this might be anywhere in between, such particles were called anyons. In the mid-1980s, these particles were indeed found as excitations in the fractional quantum Hall effect system. This is the first book to appear on the topic of anyons in condensed matter physics, a topic now very fashionable because of its possible relevance to high-temperature superconductivity. It consists of 100 pages of introductory material followed by 340 pages of reprinted articles.

Wilczek's way of giving us fractional statistics departs a bit from the usual style of scientific exposition. The book is organized not only into main sections but also into numbered subsections. This sort of organization is more familiar to philosophers than to physicists. One does discern the rarefied and slightly mysterious atmosphere of the *Tractatus Logico-Philosophicus* at times, beginning with the ethereal Japanese print on the dust jacket and noticeable throughout in occasional shifts in orthography (David Bohm acquires an umlaut) and terminology ("average field theory" for "mean field theory"). The articles apparently each represent a separate insight and contribute to the impression of physics as a succession of epiphanies rather than as the progressive accumulation of knowledge. You get used to it after a while and discover that this approach serves the author well most of the time. The explanations are clear and to the point; the format concentrates the mind. Sometimes things don't work out so well, since a linear development is not enforced by this style; pages 44–46 are identical, word for word, to pages 89–91.

The basic ideas of the subject are well laid out. A very good job is done on certain points that are glossed over in the reprints, such as why two-dimensional space is special, what is an actual field configuration that typifies a topological equivalence class, and what happens to generally accepted theorems connecting spin and statistics when the latter is fractional. I was particularly pleased to see that certain shaky assumptions that are usually not mentioned by practitioners in the field are stated and discussed. In particular, the tricky question of the boundary conditions that must be applied before topological arguments can even begin is treated in the chapter on the Hopf invariant. Also, the usually unstated condition that particles cannot pass through one another, at the basis of the braid group classification of two-dimensional trajectories, is discussed and critiqued. The topological approach does have a certain amount of dirty linen to be washed. Wilczek does it here in public, and I, for one, am all for it.

There are a number of points in the introduction that are original and bear reading several times, as they don't appear in the reprints. The two best examples are a very pretty chapter on the question of domain walls between degenerate anyon ground states and some considerations on what the anyon picture implies for the stability of various fractional quantum Hall effect states. There is one section that I did read several times without being sure whether I was any the wiser or not—this was on the idea of a generalization of spontaneous symmetry breaking to something called spontaneous projectivization. (No space to explain that here, I'm afraid.) A very few bits didn't bear reading at all. This seemed to happen when the author went into condensed matter physics background material. The paragraph on the integral quantum Hall seemed to miss the point entirely. In general, however, the beginner should be able to read straight through the introduction with some effort and much profit and be ready for the reprints.

The reprints are a rich mine of stuff. The original paper of Aharonov and Bohm is there, as is a remarkable paper by Finkelstein and Rubinstein from 1968 that already contained many of the ingredients of the modern theories. Wilczek's papers from the early '80s are not slighted and lead directly on to a number of papers under the headings of Foundations and Anyons in Model Field Theories. By this time the reader is happy with Chern-Simons terms and is prepared to enter the modern history of the subject, which begins with the fractional quantum Hall effect in 1984. The final hundred pages or so are devoted to high-T_c superconductivity. If the reader is only interested in the last topic, three of the reprints themselves contain excellent introductory material, namely Laughlin's paper from *Science*, a paper by Chen, Wilczek, Witten, and Halperin, and a paper by Canright and Girvin. Nothing is missing.

And yet something *is* missing. The strong interest in anyon theory today is due almost entirely to its application to high-T_c superconductors. But none of the papers makes a really serious attempt to show that the theory is applicable to these materials. The reader is treated only to arguments by analogy when what he or she really wants is an argument from energy. The anyon excitations need a certain type of ground state to support their existence, and that ground state must minimize the expectation value of the microscopic Hamiltonian of certain compounds made with yttrium, barium, copper, and oxygen. I make that statement here because the point doesn't get much attention in the book. While reading, I often felt as if I was watching a foot race that had begun even though the starter's gun had not sounded. The most urgent thing for anyon theorists to do now is to face this issue. The whole point of condensed matter theory, after all, is to connect the microscopic with the macroscopic. It cannot afford to have such wide gaps. Surely there is a philosopher out there who wants to write the *Tractatus Empirico-Microscopicus*.

ROBERT JOYNT
Department of Physics, University of Wisconsin, Madison, WI 53706

Fisher's Letters

Statistical Inference and Analysis. Selected Correspondence of R. A. Fisher. J. H. BENNETT, Ed. Clarendon (Oxford University Press), New York, 1990. xviii, 380 pp., illus. $90.

The year 1990 marked R. A. Fisher's centenary, and many sessions were held by statistical societies in his honor. The present volume of correspondence on statistical topics is an especially noteworthy contribution. Its publication appears to complete the valu-

able scholarly undertaking of J. H. Bennett to assemble Fisher's writings in more accessible form, earlier works being five volumes of *Collected Papers* (University of Adelaide, 1971–74) and another volume of correspondence, *Natural Selection, Heredity and Eugenics: Selected Correspondence of R. A. Fisher with Leonard Darwin and Others* (Oxford University Press, 1983).

The present collection of statistical correspondence is organized into a long "chapter" on statistical inference (pp. 1–244), another substantial chapter on statistical theory and method (pp. 245–306), and a grab bag of short chapters on topics such as history, philosophy, teaching, and scientific research (pp. 307–360). The correspondence, arranged in each section alphabetically by name of correspondent, covers the full 40 years up to Fisher's death in 1962 but has only two main contributions from the 1920s and is weighted to the mid-1950s, when Fisher was preparing the short summing-up volume *Statistical Methods and Scientific Inference* that appeared in 1956.

Fisher's originality and genius sparked a major share of the statistical developments of the 20th century. His most productive period began in the 1910s with analytical representations of sampling distributions and continued through the 1920s with key conceptual and technical developments in estimation theory. The middle of the decade saw the publication of the first of many editions of the pathbreaking *Statistical Methods for Research Workers*. In parallel with these works, Fisher made major contributions to genetics, leading to the 1930 publication of *The Genetical Theory of Natural Selection*. The flow of innovative papers on statistical theory and methods continued through the 1930s and included the 1935 publication of *Design of Experiments*.

Although he was widely recognized and honored, for example by election to Royal Society fellowship in 1929, Fisher's career was marred by animosities directed at individuals who criticized him, often not understanding his radically new ideas. Frictions with Karl Pearson developed early and continued through Pearson's death despite wide acceptance of the merits of Fisher's positions. In the 1930s, Fisher increasingly interacted with the British-American school of mathematical statisticians who took his ideas as a starting point, and he became embroiled in bitter controversies, especially with theoreticians led by Jerzy Neyman, who in Fisher's eyes distorted his positions and substituted unsound and dangerous theories in place of his own. Fisher returned with vigor to statistical controversies in the 1950s but achieved quite limited success in persuading theorists to stay on his side. A few months before his death, he would refer to "that darkest Continent, N. America!" (p. 215).

I find few important revelations in Fisher's letters, but there are many pungent statements of attitudes and positions that can deepen understanding of applied statistics and the logic of statistical inference, especially if read in conjunction with the well-signposted papers and books that Fisher was writing, revising, and discussing with friendly colleagues. Along with having direct teaching value, the letters will be an enormous resource as statisticians and other scholars increasingly seek to research, revalue, and place in scientific context the development of 20th-century statistics. It is never too soon to start, but the dust has not entirely settled on the arguments of 35 years ago, and it is only in recent years that we have achieved balanced views of the period up to 1900 in distinguished books by Theodore Porter (*The Rise of Statistical Thinking*, Princeton University Press, 1986) and Stephen Stigler (*The History of Statistics*, Harvard University Press, 1986).

The most prominent themes throughout the letters concern the gradual evolution of Fisher's thought on probability and related concepts of what he called the logic of uncertain inference. Large fractions of the text are devoted to lengthy exchanges with H. Jeffreys (9% of the text) in the 1930s, French colleagues G. Darmois (4%) and M. Fréchet (7%) centering on 1940, and British colleagues G. A. Barnard (12%) and D. J. Finney (6%) over the final 15 years but peaking in the mid-1950s. The exchanges with N. Campbell in 1922 give a look at Fisher's early, mainly frequency-based ideas on probability. The long series with Bayesian geophysicist Jeffreys says much about both men and may be the most important part of the book, including Fisher's interpretation of Bayes's prior probability as "a value averaged over objective frequencies" (p. 167), which was not accepted, or perhaps understood, by Jeffreys, and containing illuminating discussions of Laplace's concept of "equally possible" cases and Fisher's concept of a "hypothetical infinite population." Fisher put much effort into elaborating his "fiducial argument" and distinguishing its logic from the simpler Neymanian concept of confidence limits that developed from the earliest of Fisher's writing on fiducial intervals. Technical aspects of the fiducial method were discussed in correspondence with D. A. S. Fraser, L. J. Savage, and J. W. Tukey, occupying 10 to 13 pages each in this volume, and are reflected in many of the other letters in the long chapter 1.

Fisher was broad in his outlook toward probability and came to regard fiducial probability as very much in the spirit of classical writers such as Bayes. He did not oppose Keynes's "measure of rational belief" interpretation, which he called "penetrating" and "needed" (p. 56), but he regarded it as too all-embracing and attempted to formulate a system of logical varieties appropriate to varying circumstances. The interpretation of significance tests and the explanation of concepts related to likelihood are frequently discussed in the letters.

I am slighting in this review the many illustrations of practical statistical thinking that Fisher generously provided in response to inquiries from far and wide. The correspondence shows little of the irascible nature that made Fisher's jousts with opponents in published discussions famous. He is mainly polite and occasionally shows a jocular and fun-loving side. He was barely tolerant of able young statisticians such as M. S. Bartlett, S. S. Wilks, and J. Wishart, whom he would berate, I believe unfairly, in the early 1930s, suggesting they had not read his original papers when they attempted alternative derivations and elaborations of his models. Fisher did not always attempt to follow the technical arguments that correspondents bounced off him, even when they nominally concerned his own fundamental principles, being more concerned to repeat and polish his own formulations. And for this concern subsequent generations will be grateful, for Fisher expresses deep ideas with brevity and penetration. Although they do not make easy reading, the effort of following his arguments is always repaid.

ARTHUR P. DEMPSTER
Center for Advanced Study in the Behavioral Sciences, Stanford, CA 94305

Books Received

Bioactive Compounds from Plants. Derek J. Chadwick and Joan Marsh, Eds. Wiley, New York, 1990. xii, 242 pp., illus. $63.50. A Wiley-Interscience Publication. Ciba Foundation Symposium 154. From a symposium, Bangkok, Thailand, Feb. 1990.

Biochemical and Structural Dynamics of the Cell Nucleus. Eugenia Wang *et al.*, Eds. Academic Press, San Diego, CA, 1990. xii, 269 pp., illus. $49.95. From a meeting, Taipei, Taiwan, June 1989.

Biodegradable Polymers as Drug Delivery Systems. Mark Chasin and Robert Langer, Eds. Dekker, New York, 1990. x, 347 pp., illus. $99.75. Drugs and the Pharmaceutical Sciences, vol. 45.

Biological Trace Element Research. Multidisciplinary Perspectives. K. S. Subramanian, G. V. Iyengar, and K. Okamoto, Eds. American Chemical Society, Washington, DC, 1991. xii, 363 pp., illus. $84.95. ACS Symposium Series, 445. From a symposium, Honolulu, HI, Dec. 1989.

Biology of Mammalian Germ Cell Mutagenesis. James W. Allen *et al.*, Eds. Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, 1990. xviii, 461 pp., illus. $95. Banbury Report 34. From a conference, Cold Spring Harbor, NY, Nov. 1989.

The Cohen Diabetic Rat. A. M. Cohen and E. Rosenmann, Eds. Karger, New York, 1990. xii, 206 pp., illus. Paper, $49.75.

The Computer and the Decision-Making Process. Terry B. Gutkin and Steven L. Wise, Eds. Erlbaum,