Social Interests and Statistical Theory

Statistics in Britain, 1865–1930. The Social Construction of Scientific Knowledge. DONALD A. MACKENZIE. Edinburgh University Press, Edinburgh, 1981 (U.S. distributor, Columbia University Press, New York). viii, 306 pp. $25.

Although scientific organization has long fallen within the purview of sociological analysis, it has traditionally been assumed that the antecedents of theory in natural science are exclusively philosophical and empirical. Donald MacKenzie is one of a new generation of sociologically oriented historians of science who are calling this old premise into question. The social interpretation of scientific knowledge has been systematically expounded in numerous recent works, not least conspicuously or successfully by MacKenzie's colleagues in the Science Studies Unit at Edinburgh, Barry Barnes, David Bloor, David Edge, and Stephen Shapin. MacKenzie's object in the present work is to enrich the generalities in which the sociology of scientific knowledge is often couched with some compelling examples from a case study. The episode he narrates is one in which ideological considerations were integral to the transformation of scientific ideas. Their effect was not to corrupt science but to fertilize it.

The subject of this case study is British mathematical statistics from 1865 to 1930, the period during which it assumed its recognizable modern form. Few areas of mathematics or natural science could be more promising as locations in which to seek out interactions between scientific doctrine and social dogma, for statistics has been closely bound to the social sciences and even to political movements for at least two centuries. Indeed, the very title statistics was almost synonymous with social science—the science of the "statist"—during the early 19th century, and it has more recently been celebrated as a vehicle for the quantification of sociology. MacKenzie has seized upon a particularly conspicuous social link, that between statistics and eugenics. Francis Galton, Karl Pearson, and R. A. Fisher, the three greatest statisticians of this period, were also among the most influential and dedicated advocates of racial improvement through selective human breeding. To a large extent, their interest in statistics was subsidiary to this social purpose.

Among the strongest features of MacKenzie's book is the success with which he ties together a wealth of disparate subjects. He explains the attractiveness of eugenics to the professional middle-class people who endorsed it in terms of the positions it promised to furnish for men with advanced scientific training, and also its implicit celebration of their expertise as evidence of biological superiority. His work makes clear the importance of this eugenic creed, and the social context that motivated it, for the technical history of statistics. MacKenzie also discusses at some length the organization of statistics during the first decades of the 20th century, and even surveys the various figures who contributed significantly to statistics during this period. To some extent, however, MacKenzie sacrifices the explicit subject of his book, British statistics during the late 19th and early 20th centuries, to its thematic subtitle, the "social construction of scientific knowledge." Innovations in the theory of statistics are treated only insofar as they illustrate the theme of social influence. This gives the work a certain episodic character and obliges the reader to supply the mathematical context. In no case does the importance of a particular technical development for the general history of statistics receive explicit attention.

MacKenzie focuses his attention on three examples of theories or procedures for which he is able to say: "we have here an instance of the effect of social interests on the conceptual development of statistical theory" (p. 72). The first of these is Galton's idea of correlation, which emerged from his eugenic studies of the transmission of variation between generations. The second instance is the debate between biometricians such as Karl Pearson and Mendelians such as William Bateson. Finally, MacKenzie argues that Pearson's proposed measure of correlation for noncontinuous variables manifested the intrusion of eugenic concerns into scientific matters.

MacKenzie's illustrations are reasonably persuasive, but perhaps less impressive than other familiar instances from other sciences. Whereas the Weimar physicists portrayed by Paul Forman incorporated indeterminism into the quantum theory as a direct reflection of their ideology, Francis Galton's correlation was simply the solution to a problem that was ultimately motivated by eugenic concerns. More generally, MacKenzie's labored distinction between social circumstances that inspire interest in a subject and those that affect its content has limited usefulness for a methodological discipline like statistics, whose object is not to represent nature but to provide effective techniques for analyzing data.

Thus MacKenzie might have done better to focus less sharply on these three specific episodes. A more comprehensive history of British statistics from Galton to Fisher, informed by MacKenzie's exceptional understanding of the influence of eugenics, not only would be welcomed by historians of science with a more technical bent but might also provide a more potent illustration of social construction than do these particular instances. MacKenzie can hardly be faulted, though, for failing to produce so large and complex a book as would be entailed in fulfilling this desideratum. We can be grateful to him for the book he has written, for the moderation and insight he brings to this important set of issues regarding the relation of science to ideology. MacKenzie succeeds in establishing the importance of eugenics for the development of statistics, and his book, though making no pretense of completeness, is the best work we have on the creation of statistics as a branch of modern mathematics.

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History of the Calculus

The Origins of Cauchy's Rigorous Calculus. JUDITH V. GRABINER. MIT Press, Cambridge, Mass., 1981. xii, 252 pp. $25.

In *The Origins of Cauchy's Rigorous Calculus* Judith V. Grabiner explores the "commonplace among mathematicians" that Cauchy provided the "first essentially rigorous treatment of the calculus." Cauchy deserves historical attention for his participation in the establishment of rigorous analysis and for his influence on other mathematicians. But in Grabiner's view Cauchy's work is equally important for his creative transformation of 18th-century attitudes and techniques. "Mathematics may often grow smoothly by the addition of methods," Grabiner argues, "but it did not do so in this case. The conceptual difference between the eighteenth-century way of looking at and doing the calculus and nineteenth-century views was simply too great" (p. 2). In investigating the difference, Grabiner focuses on the threads of 18th-century mathematical thought that Cauchy wove into a new basis for the calculus. They include the body of results that made up the calculus, and concepts and techniques of inequalities and approximations, onto which Cauchy imposed the rigorous proof structure of Greek geometry. He taught his new brand of analysis to "all of Europe" through his courses at the Ecole Polytechnique and his widely used textbooks, thereby laying the groundwork for the complete "rigorization" of calculus by the Weierstrass school.

Grabiner first demonstrates the difference between Cauchy's "revolutionary" understanding of rigorous analysis and his predecessors' attitudes toward the foundations of calculus. She then explores theory and practice in 18th-century algebra, with special attention to those methods of approximating roots and computing error bounds that Cauchy would transform into the basis of his calculus. With this as background, Grabiner investigates the origins of the basic concepts of limit, continuity, and convergence (as they appeared in Cauchy's 1820 *Cours d'analyse*) and his theory of the derivative and the definite integral (from the 1823 *Calcul infinitésimal*). The exposition draws equally from Cauchy's work and that of such notable predecessors as Euler, d'Alembert, Ampère, Poisson, and especially Lagrange. Indeed, Grabiner takes particular pains to demonstrate that Cauchy needed a large body of mathematical results for his innovation and that "the mathematics he needed came from the work of the major mathematicians of the eighteenth century" (p. 165).

The book is directed toward an audience with enough mathematical background to follow the proofs and to appreciate the argument regarding creative deployment of algebraic techniques in the rigorization of analysis. But Grabiner asks her readers to think historically—to distinguish between an implicit mathematical concept and a conscious statement of the same result, and to recognize the historical connection between two fields usually treated separately. Her sensitivity to changing definitions, for example, permits a reasoned reevaluation of 18th-century attitudes toward "convergence."

The reader might wish that Grabiner had not limited the book so strictly. There is little indication of where Cauchy's rigorous calculus fits into the whole of his mathematical work. Moreover, footnote material on the transmission of mathematical ideas might well be integrated into the text. By contrast, Grabiner's objections to Ivor Grattan-Guinness's contention that Bolzano influenced Cauchy interfere with the flow of her argument. The organizational pattern chosen for this book—with the story weaving back and forth between Cauchy and Lagrange—also leaves an impression of repetition. The thematic approach has its virtues, however, especially compared to chronological catalogues of mathematical results. The history of mathematics could use more such thoroughly researched and insightful studies of key themes and developments.

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Conceptions of Space

Much Ado About Nothing. Theories of Space and Vacuum from the Middle Ages to the Scientific Revolution. EDWARD GRANT. Cambridge University Press, New York, 1981. xiv, 456 pp. $59.50.

In Aristotle's physics, the whole cosmos was supposed to be finite. Its outer limit was a spherical shell containing the fixed stars. Inside this shell there were no vacuums and outside there was nothing, not even empty space. In Antiquity and the Middle Ages this view triumphed over the Stoic view, which placed the finite spherical cosmos within an infinite empty space, and also over the atomists' view, which postulated the existence of infinite numbers of atoms moving throughout an infinite vacuum. In the scientific revolution of the 17th century a revived version of the atomists' view defeated the long-held Aristotelian system.

In his classic book, *From the Closed World to the Infinite Universe*, Alexandre Koyré attempted to trace the change from Aristotle's closed spherical world to Newton's infinite universe. He pictured this change as the geometrization of space or, in other words, as "the replacement of the Aristotelian conception of space—a differentiated set of innerworldly places—by that of Euclidean geometry—an essentially infinite and homogeneous extension—from now on considered as identical with the real space of the world." Koyré pictured this geometrization of space as part of a general mathematization of physics whereby qualitative Aristotelian physics was replaced by the exact quantitative work of Descartes, Newton, and modern physics in general.

In *Much Ado About Nothing* Edward Grant resurveys territory already covered by Koyré and adds much new besides, most importantly by examining the theories of space of late medieval and early modern scholastics, a subject almost entirely neglected by Koyré. Grant argues that Newton's concept of infinite homogeneous space could not have derived from the geometrization of space, as Koyré believed, because in fact Euclid's geometry itself did not presuppose the existence of a separate, three-dimensional, infinite void space in which to locate its geometrical figures. By contrast, in the period just preceding the 17th century the discussions that one does find of the possibility of space outside the finite cosmos are frequently connected with the issue of God's omnipresence. Grant concludes (p. 263), "From the fourteenth century on, numerous medieval scholastics would associate extracosmic space with God's assumed extracosmic existence. Without the assumption of God beyond the world, the Stoic arguments about the necessity for extracosmic spatial existence would have proved of no avail against Aristotle. . . . The exclusion of scholastics from previous histories of space has limited our perspective and prevented genuine comprehension of the developments that eventually produced the fundamental frame of the Newtonian universe."

The history of late medieval and early modern concepts of space is tremendously complicated and intriguing. This book contains more than 150 pages of small-print notes, and even so often refers elsewhere for texts of the arguments under consideration. Grant does not try to show through examination of medieval and early modern geometrical works that these did not contain the concept of geometrical space needed for Koyré's argument, but his assertion that the mathematical tradition did not influence concepts of physical space is not prima facie implausible, given that medieval mathematics operated within a context shaped by Aristotelian physics. From an Aristotelian viewpoint geometry derives its concepts by abstraction from the attributes of physical bodies. Extensions are supposed to be the extensions of physical substances. According to this