Giorgio Israel and Ana Millán Gasca. The World as a Mathematical Game: John von Neumann and Twentieth Century Science.
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partly because the changing nature of the discipline makes some of the results border on the postmodern. Nevertheless, he has distinguished a sense in which mathematical developments of a hundred years ago can be thought of as modernist in tone. The analogy with modernism in the arts is difficult to make conclusive when there is so little consensus on what constitutes modernism *tout simple*. Nevertheless, what Gray has done is to give a sense to terms like "modern algebra" that is dependent on more than just chronology.

THOMAS DRUCKER

Giorgio Israel; Ana Millán Gasca. *The World as a Mathematical Game: John von Neumann and Twentieth Century Science*. Translated by **Ian McGilvay.** (Science Networks: Historical Studies, 38.) xii + 207 pp., illus., bibl., index. Basel/Boston: Birkhäuser Verlag, 2009. $129 (cloth).

John von Neumann (1903–1957) is no doubt one of the most intriguing and emblematic scientists of the first half of the twentieth century. Born to a well-to-do Jewish family in Budapest, he was educated within a vibrant local scientific atmosphere from which many other important figures emerged, among them Edward Teller, Leo Szilard, and Eugene Wigner. His research career started in the 1920s at Göttingen, then the most important and effervescent hotbed of scientific ideas in the entire world. His early works, dealing with the foundations of set theory and of quantum mechanics, are outstanding, mature examples of the magnificent tradition that developed there under the leadership of David Hilbert. Von Neumann's next major contribution was in the field of economics, as he published in 1928, together with Oskar Morgenstern, the celebrated seminal article on game theory where the minimax theorem was proved. The list of additional mathematical topics to which he contributed is daunting. It includes functional analysis, ergodic theory, differential equations, continuous geometry, the theory of cellular automata, numerical analysis, hydrodynamics, and statistics.

Von Neumann immigrated to the United States in 1930 and joined the Institute for Advanced Studies at Princeton. In his new homeland he became intensely involved in large-scale projects such as the Manhattan Project, the Atomic Energy Commission, the design and construction of the first electronic calculators, and many national security projects. He worked as a consultant for organizations like IBM, Standard Oil, the RAND Corporation, and the FBI. He was both admired for his unusual mathematical skills and attacked for what many saw as extreme right-wing views.

Giorgio Israel and Ana Millán Gasca have written a highly readable account of the life and work of John von Neumann. Far from attempting to be a detailed biography, the book presents an insightful synthesis of the many fields of scientific and public activity of this unique genius. In doing so, it examines the far-reaching changes undergone by science at large in the relatively short period in which Von Neumann was active. These changes range from philosophical aspects related to the conceptual foundations of mathematics and natural science to those issues pertaining to funding and to the complex relations among science, industry, and the military. Von Neumann was at the center of many processes related to such changes, and the authors present a compact and at the same time convincing account of the main threads intertwined in his work that were also part of those processes.

A main idea stressed by Israel and Millán Gasca to describe the philosophical changes related to Von Neumann's work is that of "panmathematicism." To quote the authors, this idea differs from "the classical Galilean idea according to which the physical world has been written (by God) in mathematical language, leaving it as a task for the scientists to decipher this writing in order to discover the essence of reality. . . . For Von Neumann, mathematics is a language: the privileged language of logic, not the language of reality. . . . Moreover, this (non-ontological) panmathematicism is more pervasive than the Galilean view, as it is not restricted to the physical world but projects its constructs onto all other aspects of reality: in particular, onto the living world and the world of social relations" (p. 50). Perhaps, with some oversimplification, the purpose of the entire book may be described as an attempt to come to terms with the meaning of this view, to explain how it developed with Von Neumann, starting from his early work under the influence of Hilbert's axiomatic method and the impact of Gödel's theorem, and how, by permeating his multifarious work, it was instrumental in leading to new vistas on science and on the role of mathematics in it.

One particularly commendable aspect of *The World as a Mathematical Game* is the cautious approach it takes when it comes to the political views and public activities of Von Neumann, as well as some aspects of his personality that have become lore and are repeated in many of the existing biographical treatments. The authors refuse to base their account on undocumented anecdotes, while attempting to offer a balanced picture of his complex personality. They also tend to avoid an oversimplifying view of his strategic thinking as a simple extension of game-theoretic theorems, as has been the case elsewhere (see, e.g., p. 94).

The book is intended for a nonspecialized readership. Writing such books is usually a very tricky business. In terms of the topics that are explained and those that remain unexplained, however, most of the authors' choices seem to me to be essentially reasonable. Still, as the book moves to its later chapters, mathematical terms and concepts tend to be used with less restraint and fewer explanations than in earlier ones. Perhaps this is unavoidable, and one may hope that this will not deter nonspecialist readers. What is more likely to become a real obstacle in reaching those readers, however (and this is my only point of real criticism, though it is admittedly a very subjective one), is the venue of publication. Birkhäuser's "Science Networks" series is notorious for the outrageously exorbitant prices the publishers charge and the scant promotional effort they invest (having published in the series, I am myself well aware of this). As a matter of fact, the series brochure explicitly states that it "is aimed primarily at historians of science and libraries." If the publisher decided this time to take a different approach and would like to help the book reach "as large a reading public as possible" (p. xii), as the authors intend, then one wonders whether charging $129 for it is really an appropriate marketing strategy.

Whether or not it reaches wider audiences, anyone with an interest in the history of science in the twentieth century is certainly advised to read this excellent book.

LEO CORRY

Patrick M. Malone. *Waterpower in Lowell: Engineering and Industry in Nineteenth-Century America.* xii + 254 pp., illus., index. Baltimore: Johns Hopkins University Press, 2009. $25 (paper).

I was looking for this book years ago, when doing research on the history of energy systems, and found to my surprise that it did not yet exist. While much was written about Lowell, Massachusetts, there was no authoritative synthesis that pulled together the various threads of scholarship about the first planned industrial city in the United States. There were excellent studies exploring the subject from the perspectives of business, labor, and urban history, but the story of Lowell's hydraulic technology that made the whole enterprise possible was scattered in various sources and incomplete. Now Patrick Malone has supplied the missing volume, providing not merely a synthesis of what went before but a short book that is well grounded in rich primary source materials. His interest in Lowell began four decades ago and has culminated in a highly readable volume. Specialists will find the outlines of this history familiar, but many important details have not been covered before. Its subject is not the experience of textile workers, whom many others have dealt with, though Malone always includes them as part of the picture, from the Irish who built the locks and canals to the young women who worked in the mills.

The chapters move chronologically from 1820 to 1885. Malone begins by explaining why a navigation canal was built to get around Pawtucket Falls but proved economically unsuccessful. The thirty-foot fall in the Merrimack River was extremely attractive to Boston entrepreneurs, however, who invested a small fortune to transform the canal into the backbone of a water-powered industrial city, an overnight boomtown that grew from two hundred inhabitants in 1821 to more than thirteen thousand twelve years later. It soon became a tourist destination and a symbol of democratic industrialization that was seen as a stark contrast to Britain's smoke-ridden industries.

Malone emphasizes the technologies that made Lowell possible and their central place in the spread of engineering expertise to other water-powered enterprises, which supplied most U.S. factories with energy until 1850 and remained central to industrialization until after the Civil War. This book intertwines many themes, notably the role of technology transfer from the United Kingdom to the United States in the creation of canals and railroads and the development of a practical, experimentally based understanding of hydraulics and water-driven horsepower. Malone focuses particularly on the talented English immigrant James B. Francis (1815–1892), who served as chief engineer for the locks and canals system in Lowell for half a century until his retirement in 1884. Francis played a central role in the creation of a practical engineering of hydraulics that served not only Lowell but also other industries. His volume *Lowell Hydraulic Experiments* (1855) brought together hard-won knowledge for other engineers—for example, in "rules for proportioning turbines." It went through multiple editions and was used at MIT as a text as late as 1885. Before