Book Reviews

Dimensions of a Scientist

Lavoisier and the Chemistry of Life. An Exploration of Scientific Creativity. FREDERIC LAWRENCE HOLMES. University of Wisconsin Press, Madison, 1985. xxiv, 565 pp., illus. $39.50. Wisconsin Publications in the History of Science and Medicine, No. 4.

This book examines Lavoisier's investigations into respiration, fermentation, and plant and animal chemistry from 1773 until 1792. The restricted topic and period and the painstaking examination of manuscript sources might suggest that here is a book for the specialist in the history of science; and indeed such specialists will learn a good deal from Holmes's account. But the work's subtitle indicates another dimension that invites a much wider readership, for Holmes has succeeded admirably in exploring and revealing how Lavoisier worked, how he made his discoveries, even how he thought about his problems. Given the magnitude of Lavoisier's achievement, this confronts us with scientific creativity in action. The author has written a work of fine historical scholarship and is careful to eschew unsupported generalizations, but he does raise the question whether similar attributes may not "recur in different combinations in different individuals" (p. 502). Those interested in scientific creativity, in the interface between the history and the philosophy of science, in the history of chemistry, or in the history of physiology will find this a work of major significance.

Holmes has concentrated upon Lavoisier's investigations, rather than upon the development of his ideas in isolation from the laboratory or upon the social matrix in which those ideas were developed, because he sees this as the best way to understand Lavoisier's problems and their resolution. His principal sources are Lavoisier's manuscript notebooks, supplemented by informal notes, memoranda, and drafts; he has made sensitive and exemplary use of these materials, using Lavoisier's revisions and corrections as indications of the growth of his ideas.

Lavoisier is recognized as the dominant figure in the chemical revolution of the late 18th century, a revolution based upon the analysis of water, a new understanding of the nature of combustion, and the development of a new system of elements. The revolution was most visible for its successes in inorganic chemistry, and Lavoisier's contributions to organic chemistry are generally thought of as a later phase of his work, of lesser distinction, and interrupted before fruition by his execution during the Terror. One of Holmes's achievements in this book is to force a revision of that picture. Lavoisier is revealed as a founder of physiological chemistry whose study of the physiological process of respiration was an integral part of his investigative program from the early 1770's, organic and inorganic chemistry being interdependent and part of a methodological whole. In particular, respiration and combustion shed light upon one another; inorganic thermochemistry and the heat balance of physiological processes came under the same purview; and the chemistry of gases and the analysis of water were both crucial to and illuminated by Lavoisier's researches in organic chemistry.

Lavoisier was the master of quantitative analysis and was guided by the principle of the balance sheet. "Mastery" and "guidance" are key words here, for Lavoisier was in control of his data, wise in adjusting them when the balance sheet was imperfect and also in judging when an approximate result sufficed to carry the investigation forward and when real precision was essential. One of the most fascinating aspects of this book is the way in which Holmes explores Lavoisier's mastery and manipulation of quantitative data. It is crucial to recognize that such imaginative and intuitive manipulation of data was constructive rather than fraudulent, was often overt, and has characterized the work of some of the greatest scientists.

Also striking is the revelation of what everyone knows but often forgets, the distance between the actual course of an investigation and the logical, tidy way in which it is reported in the published paper that follows. Lavoisier often presented his ideas as if he had known precisely where he was going. There is indeed, as Holmes shows, a remarkable long-term coherence to his multiform research program. But Holmes also reveals the gradual, piecemeal exploration of conceptual regions, with clarity emerging here and there while contradictions and confusions persist elsewhere. The length of the process, covering years, is stressed, and Holmes argues that in the case of Lavoisier the idea of a passage rather than a Gestalt switch provides a helpful metaphor for the process.

The revelations Holmes provides concerning the subtlety and fluidity of Lavoisier's reasoning in the course of an investigation, Lavoisier's success in bringing quantitative methods to a qualitative science, the benefits of crossing fields in science, the significance of imaginative innovations in instrumentation, and many more matters not only contribute vitally to an understanding of Lavoisier's work but also raise wider questions about the nature of scientific creativity.

This is an important and penetrating study and will repay careful reading by scientists, historians of science, and philosophers.

TREVOR H. LEVERE
*Institute for the History and Philosophy of Science and Technology,
University of Toronto,
Toronto, Ontario M5S 1A1, Canada*

Influences on Einstein

The Young Einstein. The Advent of Relativity. LEWIS PYENSON. Hilger, Bristol, 1985 (U.S. distributor, International Publishers Service, Accord, Mass.). xiv, 255 pp. + plates. $28.

No single set of historical events has attracted more attention from historians of modern physics than Einstein's creation of the theories of relativity. Indeed, perhaps only Newton's route to his *Principia* and Darwin's to his *Origin of Species* have attracted as much attention within the history of modern science. From late 1919, when Einstein first came onto the world stage, there has been an unceasing number of articles and books, both popular and academic, about his life and work. It is no easy task to say something fresh about Einstein and the coming of relativity.

Lewis Pyenson's approach to this well-tended subject explicitly eschews historical discussion of such technical matters as simultaneity or the purported role of the Michelson-Morley experiment. Nor does Pyenson seek to offer a complete, definitive biography of the young Einstein. Instead, he concentrates on three themes: the nature of Einstein's education and the socioeconomic condition of the young Einstein's life, non-Einsteinian attempts to resolve problems in the foundations of physics in the late 19th and early 20th centuries, and the circumstances in which relativity was received by the German physics community.

Pyenson argues that it was Einstein's secondary-school teachers in Munich and Aarau rather than his professors at the Federal Institute of Technology in Zürich who most influenced his scientific outlook. From the former he received a sound education in the fundamentals of mathematics and learned, above all, to appreciate the importance of careful observation and experiment in science. From his professors in Zürich, especially from Hermann Minkowski, Einstein received a heavy (and distasteful) dose of highly abstract mathematics that had little to do with physical reality. This issue of the physical versus the mathematical approach to nature became an irritating and eventually a haunting one for Einstein. It is also one of the leitmotifs of Pyenson's study.

Einstein's education took place while his father and uncle pursued their electrotechnical business, a business that went from great promise to unmitigated failure. Pyenson's detailed account of the fate of the Einsteins' firm rewards the reader with increased understanding about a number of Einstein's well-known attitudes: his seemingly natural feel for electrical instrumentation and processes, his hostility toward capitalism and despisal of those enamored of material things in life, and his disdain for a Germany that led to economic failure and exile for the Einstein family. That failure, along with the Einstein family's membership in the Jewish community of Munich, Pyenson argues, were important elements in giving Einstein a sense of being an "outsider."

The second of Pyenson's three themes—his analysis of non-Einsteinian attempts to unite mechanics, electromagnetism, and gravitation—ranges far beyond the expected recapitulation of important scientific papers. For Pyenson believes that challenges to the educational importance of mathematics and classical languages in an industrializing Germany and certain beliefs about the epistemological relationship of mathematics and physics played important roles in the attempt to lay secure foundations for physics and in the interpretation of relativity theory. The center of these non-Einsteinian attempts was Göttingen, where mathematicians and mathematical physicists like Felix Klein, David Hilbert, and Hermann Minkowski held sway at the turn of the century. Pyenson argues that Minkowski's formalistic interpretation of special relativity was actually an attempt to develop a new theory of matter that reflected the mathematical "harmony" of the world. Whereas Einstein's approach emphasized conceptual clarity and allowed experimental testing, Minkowski's favored mathematical rigor and elegance at the price of empirical verification. By 1914 the attempt of men like Einstein and Max Planck to build a picture of the physical world was, Pyenson claims, largely replaced by a mathematical instrumentalism. Most of Minkowski's mathematical colleagues as well as a number of mathematical physicists and philosophers, Pyenson states, allowed pure mathematics "to dictate the form of physical reality." The result, he claims, was that for many "relativity was understood to concern abstract, unphysical, absolute space—all that its creator Albert Einstein had originally laboured to dispel" (p. 139).

Pyenson's third and final theme concerns the circumstances of relativity's reception. In addition to discussing different interpretations of relativity theory, he recounts the editorial practices of the *Annalen der Physik* and the character of Einstein's early scientific collaborations. Between 1905 and 1918 Planck and Wilhelm Wien edited the *Annalen*, Germany's leading physics journal. These "gatekeepers," as Pyenson calls them, sought to publish papers that illuminated the physical meaning or concepts of relativity; they left manuscripts that stressed mathematical interpretations to their mathematician colleagues in Göttingen. Pyenson concludes his study by examining Einstein's collaborations with Jakob Laub, Walther Ritz, and Erwin Freundlich, each of whom had studied at Göttingen. Their support of Einstein's work and approach led them to become, Pyenson concludes, "victims of the rejection of his thought by the Wilhelmian physical science establishment" (p. 238).

This handsomely produced and highly detailed book is not for newcomers to Einstein studies. Those who have yet to read some of the numerous important studies of Einstein and his route to special relativity will profit little from Pyenson's work, most of which has previously appeared in article form. This is, instead, a book for Einstein aficionados: for those who want to learn more about what textbooks he used in school, what the family business was like, what Einstein's peers thought of his work, and so on. Pyenson's diligent research illuminates many aspects of these and other subjects. Though some of his conclusions (concerning, for example, the influence of educational reform in mathematics and of philosophical predispositions on theoretical physics), will probably be controversial, he brings fresh and interesting information to support them. With the help of Pyenson's study and the eagerly awaited first volume of Einstein's papers, scholars and scientists of all varieties will be able to extend our knowledge of the young Einstein and the advent of relativity.

DAVID CAHAN
Department of History, University of Nebraska, Lincoln 68588-0327

Motor Control of the Hand

Hand Function and the Neocortex. A. W. GOODWIN and I. DARIAN-SMITH, Eds. Springer-Verlag, New York, 1985. x, 314 pp., illus. $34.50. Experimental Brain Research Supplementum 10. From a symposium, Melbourne, Aug. 1983.

Intricate use of the hand for tactile explorations and precise manipulations of the environment characterizes primates and is exceptionally well developed in humans. Efforts to understand the neural basis for this complex behavior necessarily lead to an analysis of the sensorimotor areas of the cerebral cortex devoted to the hand. In the absence of general principles as a guide, how can this difficult subject be approached? What emerges from this book, which resulted from a satellite symposium of the 29th congress of the International Union of Physiological Sciences, is an overview of cortical physiology as revealed, primarily, through the recording of the responses of single cortical neurons while a monkey explores and manipulates its surroundings. Sensory and motor aspects of this behavior are discussed, including the areas of the cortex that are activated by different kinds of somatic sensory stimuli, the way in which sensory signals influence cortical activity that is responsible for hand movements, and the kinds of movements that correlate with activity in different cortical motor areas. The results will be familiar to those intimately acquainted with these subjects; for others, this volume, although not comprehensive, offers a succinct introduction to several important issues. The style and quality of the papers in the volume vary.

The hands are used in making tactile discriminations of textured surfaces. How and where these discriminations are represented in the cortex is unknown. Carlson emphasizes that cortical