analysis of civic science and scientists he even transforms social history of science into urban history. Despite occasional signs of hasty revision, this book is therefore essential reading for those interested in science in its urban locale while it also reveals how by 1906 Schuster could justly affirm to Rutherford that "Manchester is not at all a bad place."

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## Science für das Volk

**Scientific Materialism in Nineteenth Century Germany**. FREDERICK GREGORY. Reidel, Boston, 1977. xxiv, 280 pp., illus. Cloth, $28; paper, $13.50. Studies in the History of Science, vol. 1.

Historians of science normally take little interest in the German Revolution of 1848. It was a straightforward political episode in which middle-class liberals riding a wave of popular social discontent tried to wrest a share of power from Germany's entrenched aristocracy. The movement failed—some say it was talked to death by lawyers and professors—and authoritarian governments cracked down. For the next decade, politically minded liberals were left with little to do, but many of them apparently chose to spend their time reading about science. During the 1850's, a number of popular science journals were founded, and several writers made national reputations by expounding scientific ideas before a general audience. The tone of this literature, skeptical and irreverent toward established belief, was often materialistic in a philosophical sense. However, the authors were not philosophers, and they had little interest in philosophy for its own sake; they were scientists or scientifically trained men who hoped to forge their special knowledge into an ideological weapon against the status quo. Ludwig Büchner, the most popular of these writers, explained the matter simply: "The public is demoralized by the recent defeat of national and liberal aspirations and is turning its preference to the powerfully unfolding researches of natural science, in which it sees a new kind of opposition against the triumphant Reaction."

This scientific materialism of the 1850's, typically German in its origins and motivation, has attracted little attention from American scholars. Now, however, Frederick Gregory has produced a thorough study of the intellectual leaders of the movement, detailing their lives and careers and analyzing the significance of their ideas. His *Scientific Materialism in Nineteenth Century Germany* focuses first on Ludwig Feuerbach, the philosopher whose assault on Hegel's idealism set the stage for the materialists. Gregory then concentrates on three men, Karl Vogt, Jacob Moleschott, and Ludwig Büchner, the most prolific and most characteristic representatives of the materialist school. He indicates some of the variety possible in materialist thinking by describing the atypical views of Heinrich Czolbe. Finally, he discusses at length the implications of this German materialism for philosophy, biology, and social thought. Throughout the book, Gregory is sensitive to the political background of his subjects' thinking, and he offers a wealth of personal detail about each of them. The emphasis, though, is on polemical argument, the ideology that the German materialists fashioned out of the science of their day.

The doctrines worked out by Vogt, Büchner, and Moleschott assumed the form of a naive realism that regarded the things of this world to be very largely what they seem to be. The materialists bridled at Kant's notion that the ultimate constituents of the world might remain in principle unknowable; for them, there existed no *Ding an sich*, no category of being that was inaccessible to empirical investigation. One had only to experiment and observe, and all truth would eventually be perceived. Confident in this faith, the materialists brought the average German reader a world picture of mechanistic determinism in which rigorous laws of cause and effect governed all things from the motions of atoms to the thoughts of men. In doing so, they paid special attention to the biological sciences. All the materialists had studied medicine and were engaged in either medical practice or biological research. Those were years in which German physiologists were making rapid progress in relating life phenomena to physical and chemical processes. The materialists naturally made much of these developments. For them, physiological research proved that all human activities could ultimately be explained in terms of physical causation, a position summed up in Karl Vogt's blunt assertion that the brain produces thought much as the kidneys produce urine. Most practicing physiologists were far more cautious, preferring to restrict their comments to known mechanisms and declining to speculate about the ultimate basis of life and thought. Still, in spite of their crudity—or perhaps because of it—the materialists contributed much to the widespread enthusiasm for science that existed in mid-19th-century Germany.

When measured against their ideological goals, the accomplishments of the materialists seem more uncertain. Vogt, Büchner, and Moleschott were concerned not merely to popularize science but to harness it to an ideological purpose, the cause of radical liberalism and democracy in Germany. Here they faced the objections of philosophical critics who wondered how any moral purpose could truly be derived from the materialistic determinism they espoused. Even more concretely, they were challenged by the Prussian Army physician Heinrich Czolbe, who proceeded with a rigor that matched their own to derive a conservative, authoritarian message from his view of science. Gregory also observes that German socialists have paid more attention to scientific materialism than liberals have. He might further have noted the materialistic influence on technocratic *nur-Wissenschaftler*, who have indiscriminately served successive German regimes, unconcerned about the political uses made of their scientific work. In practice, then, scientific materialism has been turned to many ends that would have appalled Vogt, Büchner, and Moleschott. The ease with which science can be reconciled with diverse ideological positions suggests a notable weakness in the thought of the materialists and underlines the perennial value of alert philosophical criticism—precisely the kind of criticism Gregory offers in this book.

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## Miescher and Successors

**A Century of DNA**. A History of the Discovery of the Structure and Function of the Genetic Substance. FRANKLIN H. PORTUGAL and JACK S. COHEN. MIT Press, Cambridge, Mass., 1978. xiv, 384 pp., illus. $17.50.

The authors of *A Century of DNA* set themselves the ambitious task of tracing the long history of investigations surrounding "the greatest discovery in biology in this century." They have followed the development of knowledge of the chemistry of DNA from the initial discoveries by Friedrich Miescher in 1869 to Watson and Crick's famous achievement establishing a three-dimensional structure that provided also a compelling

molecular explanation for the genetic role of that substance. In order to show how the genetic function that DNA was eventually recognized as filling came itself to be clearly defined, they have described in addition the origins of knowledge of the function of the nucleus in cells, the early theories that postulated a material basis for inheritance, and the foundations of Mendelian genetics, among other topics. In a chapter on the genetic code they extend the story almost to the present day, and, not stopping even here, they finish with a "prologue to the second century." Portugal and Cohen have attempted to tell this story so that it will be comprehensible to readers with an elementary knowledge of chemistry and biology.

The general objective of this book, to elucidate the historical roots of scientific developments that are still at the center of current research, is laudable. Historians of science have devoted a disproportionate amount of their effort to earlier stages in the emergence of modern science, leaving conspicuous gaps between their concerns and the memories of living scientists. Portugal and Cohen's book demonstrates, however, that closing such gaps can be a difficult undertaking. The most prominent characteristic of *A Century of DNA* is its unevenness. Not only do the chapters vary considerably in quality, they differ in approach and style. Chapters that concentrate on the work of a single individual, such as those on Miescher and on Albrecht Kossel, integrate the scientific work with biographical details in such a way as to provide vivid portraits of the scientific personalities of their subjects. Other chapters, however, are almost entirely summaries of the flow of investigations, with personal recollections too sparse to provide real insight into science as "a human exercise in which individuals act and interact."

The broad early chapters—on the role of the nucleus, early theories of heredity, and the evolution of modern genetics—are the least satisfactory parts of the book. In most respects these accounts are less coherent and less cogent than previously existing historical treatments. They reveal the thinness of the authors' knowledge of 19th-century biology. Later chapters are better focused, based on more comprehensive arrays of primary sources, and more persuasive in their interpretations.

As the preface of *A Century of DNA* indicates, its subject matter overlaps that of two other recent historical studies. Robert Olby's *The Path to the Double Helix* provides more detailed accounts of some aspects of the story, especially the development of the concept of the macromolecule, the use of x-ray diffraction techniques, and the events immediately related to Watson and Crick's discovery. On these subjects Portugal and Cohen contribute only a more compact, somewhat simplified story. They do, however, supplement Olby's account by devoting considerably more attention to investigations of the chemistry of the nucleotides composing DNA, especially to the work of Phoebus Levene and Alexander Todd. A chapter of another recent book, Joseph Fruton's *Molecules and Life*, covers most of the subject matter of *A Century of DNA*. Although much shorter, Fruton's treatment is more authoritative and more even in its treatment of the various periods. Fruton, however, gives none of the biographical details that enliven Portugal and Cohen's narrative.

Portugal and Cohen's chapter "The three-dimensional structure of DNA" is an eclectic summary of recent versions of the history of the double helix as told by Watson himself, by Anne Sayre in defense of the late Rosalind Franklin, by Olby, and by others. Concerning the disputes over the roles of the participants in these events, the book balances opposing statements without attempting to resolve the differences.

In their preface Portugal and Cohen make the admirable declaration, "We have tried to present [the] ideas as scientists at the time regarded them, rather than evaluating them with hindsight. Our purpose is to show the important developments in the area and their effect regardless of whether subsequent events proved them to be in error." Just prior to this, however, they have written, "The organization of our book is based on the answer to a single question: why did it take more than a century of research before scientists properly understood what DNA was and what it did within the cell?," and in fact the text is replete with the kind of hindsight evaluations the authors reject. Haeckel, for instance, is described (p. 33) as having "redeemed himself" for proposing the erroneous monera hypothesis by suggesting that the nucleus provides for the transmission of hereditary characters, and the chapter "Early theories of heredity" consists largely of a selection of those views of 19th-century biologists that can be seen in retrospect as partial statements of principles that became established after 1900. Hindsight comments are less conspicuous in the chapters on more recent developments but are not altogether absent.

With the starting point Portugal and Cohen took it was almost inevitable that they would select and analyze events of the earlier periods from the perspective of how they would cumulatively contribute to the climactic developments of the 1950's. Scientific events are shaped, however, not by what is to come long afterward but by what has preceded them. The way in which Portugal and Cohen posed their central question ruled out in advance a truly historical interpretation of the early stages in their story.

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## Researches in Denmark

**The Carlsberg Laboratory, 1876–1976.** H. HOLTER and K. MAX MØLLER, Eds. Published by the Carlsberg Foundation. Rhodos, Copenhagen, 1976. 448 pp., illus. Dan. Cr. 125.

The Carlsberg Laboratory in Copenhagen, although a relatively small institution, has been one of the world's great centers for research in such fields as protein chemistry, cytochemistry, and genetics of yeast. This handsome and substantial volume, celebrating the centennial of the laboratory, contains much that is significant for historians of science. The laboratory was a direct outgrowth of the Carlsberg Brewery and was established in 1876 by the highly successful brewer J. C. Jacobsen, who set it up under the Carlsberg Foundation, with a board of trustees elected by the Royal Danish Academy of Sciences and Letters. Jacobsen emphasized the commitment of the foundation to the advancement of fundamental science and stipulated that "no result of the activities of the institute which is of theoretical or practical importance may be kept secret." This liberal policy has always remained in force. The laboratory in fact closely adjoined the brewery, and Jacobsen correctly expected that the work of the latter would benefit greatly by the discoveries and the advice of the researchers in the laboratory.

From the beginning there were two major departments, of chemistry and physiology. The first director of the chemistry department (1876–1900) was Johan Kjeldahl, now remembered chiefly for his widely used method of nitrogen analysis. His successor, S. P. L. Sørensen, profoundly influenced chemists and biochemists everywhere by developing the theory of the *p*H scale and