Overthrowing the Established Order

REVOLUTION IN SCIENCE
By I. Bernard Cohen.
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By Joshua Lederberg

"TODAY we take it almost for granted that science and its associated technology progress through a series of revolutionary leaps — giant steps forward that give us altogether new perspective on the natural world," I. Bernard Cohen writes. Mr. Cohen, a professor of the history of science at Harvard University, reminds us, however, that the traditional image of revolution was astronomical — the orderly and cyclic circulation of celestial objects. Through the 17th century, the term connoted restoration more than upset. A century later, the revolutions in America and in France firmly established the contemporary meaning: as Mr. Cohen puts it, "a change that is sudden, radical, and complete, often accompanied by violence or at least the exercise of force."

The main narrative content of "Revolution in Science" is the history of physical science from the 17th through the 20th centuries, culminating in the theory of relativity, quantum theory and the theory of plate tectonics. These stories are compiled in many other places, but I know of no other comparable anthology, carefully documented and told in a straightforward, comprehensive style. Throughout, Mr. Cohen teases out what is revolutionary, or rather what was said to be revolutionary about the people whose works have become milestones — Kepler, Galileo, Newton, Lavoisier, Faraday, Maxwell, Einstein and many others. (His critical animus against Copernicus's membership in that company is pronounced. He even gives a full chapter to a critique of misinterpreters of Kant — who thought the philosopher had compared his own achievements in philosophy to a "Copernican Revolution" in science, thus endorsing the notion that there had been a Copernican revolution — in the kind of detail that would be more appropriate for the aficionados' journals. From now on, no one is likely to refer to the "Copernican Revolution" without shielding himself from Mr. Cohen's wrath.)

Biology receives less attention from him; perhaps it has had fewer, if no less consequential, revolutions. He has a particularly fine account of Harvey's elucidation of the circulation of the blood. Vesalius had dissected the heart before, but dared not contradict the weight of traditional authority; the septum of the heart had to be porous, despite the evidence of his eyes. DNA research is too recent, perhaps too intricate in detail, to be treated in similar breadth. I am startled, nevertheless, to read that it has had no large ideological fallout. In fact, DNA research has brought an end to a long history of vitalistic speculation, namely the expectation that new principles transcending the existing framework of physics and chemistry would be needed to explain living phenomena. That expectation was entertained even by heroic figures in the physical sciences like Niels Bohr and Max Delbruck, and it was especially rampant in French philosophy as any reader of Henri Bergson will recall.

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The history of scientific revolutions was made popular by the well-known work of Thomas S. Kuhn in 1962; his main concern was with the psychology of belief and how it governed people's acceptance of challenging innovation. Other more objectivist historians, notably George Sarton, had downplayed discontinuities in scientific advance and emphasized the cumulative impact of innumerable small contributions. Against this background, Mr. Cohen's work is part of what he calls a "broad research program with a double aim: exploring . . . creative processes by which a practitioner in one discipline uses the ideas (concepts, methods, theories, tools) of another discipline. The second goal of my research is to define and analyze the interactions between the natural and exact sciences and the social and behavioral sciences."

He says he had long thought historical references to revolutions in science were simply anachronistic, used only by relatively recent historians to describe the work of pioneers in past centuries. "Could such innovative scientific thinkers as Kepler, Galileo, Harvey conceive of their own work as being revolutionary?" Then he expresses "astonishment as my research began to produce examples of discussions of revolution in science from each of the past four centuries."

The organizing theme of Mr. Cohen's book, then, is the use of the term "revolution" by scientists and historians; he is pursuing the history of an idea. In examining linkages to external affairs, he also asks "What effect have such social and political upheavals as the French Revolution and the rise of Marxism had on the way scientists, philosophers and historians think about revolutions in science?"

He notes that there is some reason for linking scientific revolutions and those in the political or social sphere. The rapid advance of scientific ideas — notably the iconoclasms of Freud, Darwin, Mendel and Einstein — have occurred at times of political upheavals and have been discussed as current events together with them in literature and in the popular media. The rising expectation that the world can be changed in its political and social structure may indeed be associated with the aspiration to change its scientific ideas. Conservative societies tolerate scientists who challenge the prevailing order much more readily than they tolerate other thinkers who do the same. Science has flourished when social class rigidity loosens in the face of economic demand for technological expansion. Indeed, the scientific career is itself an effective vector of social mobility. On the other hand, extreme radicalism has stifled scientific progress, as we have seen with the imposition of official state science under Hitler and Stalin.

Mr. Cohen asserts his identity as historian, not philosopher or sociologist, and he means it. He makes use of Mr. Kuhn's ideas (including some Mr. Kuhn has changed since he first wrote about them), but he is much more interested in how both scientists and historians have looked at scientific innovation during the last 400 years. I first encountered him about 30 years ago when I consulted him about the authenticity of a scientific anecdote. My query was amply rewarded, and so will the reader of the present work be rewarded — in the content of the stories Mr. Cohen tells and the meticulousness with which he documents them.

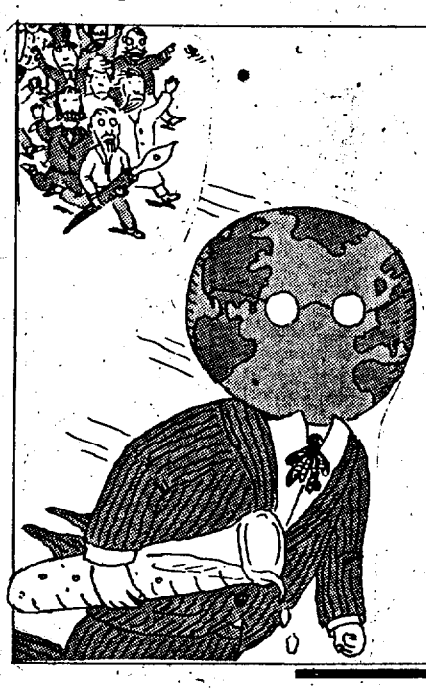
Mr. Cohen delineates four stages in a revolution. It begins with an intellectual insight. The scientist then makes a private record of his commitment to its pursuit. He then communicates his ideas privately with colleagues before he formally publishes them. Finally, his theory is incorporated into the theoretical fabric and practice of consensual science. Instead of giving a precise definition of a revolution in science (as he notes, historians and scientists alike disagree about calling many scientific innovations revolutionary), he lists four tentative criteria for identifying one: There must be testimony of contemporary witnesses that a revolution has occurred. Later documentary history has to support their notion that a really fundamental change has occurred. There has to be a judgment by historians that the change was revolutionary. Finally, he looks for "the mythology that is part of the accepted heritage of practicing scientists." Indeed this is a historian's history; it all depends on what you emphasize — his guild's attitudes are objective judgments, my guild's are myths. That is not meant to be an invidious remark, but rather an appreciation of the role of such reflections in the education and motivation of my scientific colleagues.

SOME of Mr. Cohen's most interesting anecdotes concern scientists' evaluations of their own work. He could find only a dozen examples where the researcher has publicly boasted about a revolution. Einstein, in particular, resisted the revolutionary label. He did not wish to be thought immodest; more importantly, he wished to stress the philosophical continuity of his physics with Newton's. Moreover, an evolutionary model of the development of science leaves more room for further change in a theory. Nevertheless, if Einsteinian physics is not revolutionary, what is?

At the end of the book Mr. Cohen also discusses briefly the element of quasi-religious conversion in the responses of scientists to revolutionary ideas in science. Belief cannot be ignored, but historians should pay more attention to what scientists do, what experiments they perform, in the face of challenge, rather than to the beliefs they voice. If they focused on the work, they would find that many examples of unwonted resistance reveal in scientists a serious internalized struggle to understand newly presented facts and to accommodate existing theoretical structures to these facts.

"Revolution in Science" amply fulfills its author's prospectus as history. It neither promises nor delivers on the thrilling hopes that creative revolution will be better understood from biographical, sociological or philosophical perspectives. I would have liked to see a recipe for how to create a scientific revolution. The closest I read was how to make historians believe you have made one — advertise that you have done it. □

Joshua Lederberg, the president of Rockefeller University, received the Nobel Prize in Medicine in 1958 for his research in microbial genetics.



Einstein the Incomprehensible

Every scientist has a vested interest in the preservation of the status quo to the extent that he does not want the skills and expert knowledge which he has acquired at great cost in time and learning energy to become obsolete. But despite this natural resistance to change, there is no organized conservative party within the scientific system — as is found in the sociopolitical system — that seeks to keep things as they are and to suppress revolutionary movements within the sciences. . . .

Because the scientific revolutionary produces an innovation within the sciences that primarily affects other scientists, the radical new science does not need to be comprehensible to nonscientists. It may be beyond the understanding of many other scientists. . . . This was certainly the case for Einstein's theory of relativity, the alleged general nonintelligibility of which was enshrined in the popular saying that only eight (or twelve) people understood it. But its nonintelligibility to the public affected neither the acceptance of relativity by the scientific community nor the general lay opinion that . . . [Einstein's] incomprehensible and revolutionary theory was one of the great intellectual creations of the twentieth century. — *From "Revolution in Science."*

ROBERT REINHOLD
I. Bernard Cohen.