The Idea of Revolution

Revolution in Science. I. BERNARD COHEN. Belknap (Harvard University Press), Cambridge, Mass., 1985. xx, 711 pp., illus. $25.

I. Bernard Cohen is concerned, not with what may be said about revolutions in science, but with what has been said, by contemporaries and by later commentators. His book is a work of intellectual history. The title is bound to raise the question of the relation of his treatment to the position of Thomas S. Kuhn, whose *Structure of Scientific Revolutions* has done more than anything else to give the notion currency. Discussion has continued unabated since publication of that book in 1962. Cohen observes that the locus has been largely in philosophy, sociology, and related disciplines and that historians of science have made little use of the scheme in their actual work, even though the argument turns on history of science. He regards his book as oblique to Kuhn's. The matters he has chosen to handle intersect with the latter's propositions at certain junctures. Cohen agrees on some points, disagrees on others, and disclaims any intention to address the central issues systematically.

The sense is widespread today that technical progress has largely occurred in a series of revolutionary changes. One sort is associated with great protagonists such as Copernicus, Newton, Lavoisier, Darwin, Freud, and Einstein. Another type involves major transformations such as that of science in the 16th and 17th centuries, that of industry in the 18th and 19th centuries, and that of communications in our own century. The question Cohen does address is how the revolutionary mode in science has been perceived throughout history, on the part of scientists who took part in the developments, of historians who have recounted and interpreted them, and of members of the modern scientific community who preserve a view of their own past in their professional mythology.

The first qualification to be made of present-day perspectives arises from the manner in which the word "revolution" has been employed. The modern usage is not found in antiquity or in the Middle Ages. Changes that we would call revolutionary occurred, certainly, both in intellectual and in political affairs, and they were recognized to be of extraordinary magnitude and suddenness. They were recorded and analyzed in various ways, however, rather than gathered into a common class under the rubric of a single term.

A further complicating factor is the significance the word had in the late Renaissance, when it gained a certain currency. The meaning was then the literal one, pertaining to cyclical change, the rolling of the wheel of time through the recurrent course of history. The most noted scientific example occurs in the title of Copernicus's treatise, *On the Revolutions of the Celestial Orbs*. When science began to internalize that notion from the operations of nature to its own, it retained for a time the cyclical connotation. In science as in humanism, the instinct that the achievements of Renaissance man were a return to an earlier and purer knowledge was widespread in the 16th century and persistent in the 17th, even if attenuated by the concurrent belief in novelty. Cohen is acute in noticing that the same thing was initially true after the idea of revolution migrated from scientific into political discourse, for so it clearly did and not the other way about. Proponents of rebellion in the English civil wars of the 17th century, and also among American colonists in the 18th century, urged that revolution would restore the good laws and usages of a previous and a better time.

Unlike their successors and their historians, Copernicus and Newton did not speak of themselves as leaders of scientific revolutions. In their self knowledge, their work grew out of roots in a distant past. It is not easy to be categorical about chronology, however, for in Newton's lifetime the belief was also current that a radical and unprecedented change in knowledge of nature had indeed occurred. By the early 18th century, it was beginning to be said that all this amounted to a revolution in science. Political usage still showed a lag. Replacement of James II by William and Mary in 1688 was called "The Glorious Revolution" precisely in order to convey that nothing radical had happened and that securing Protestant succession was a return to the traditional basis of English monarchy.

Lavoisier was the first major figure to claim for himself leadership of a revolution in science involving a radical break with the past and creation of a new body of theory resting on new methods. Even so did the founders of the French Republic purport to repudiate all that had gone before and to reconstitute the nation on a new basis. The entire movement of culture constituting the Enlightenment, and prior to that the scientific legacy of the 17th century informed by the philosophical radicalism of Descartes and Bacon, have to be seen as the preconditions for such ambitions. The near coincidence of the Chemical Revolution and the French Revolution makes a profound conjuncture in the interrelations of scientific and political developments. For the modern concepts of revolutionary change of both sorts were initially defined with reference to those exemplars, even though the transformation of chemistry may have been of lesser scope than the changes wrought by Newton and Darwin in their sciences.

Cohen deliberately abstains from attempting a comprehensive definition of revolutions in science. He takes license from the example of biology for the proposition that knowledge of phenomena can advance in the absence of precise definitions that cover all cases. Nevertheless, he does see his revolutions transpiring in four stages. First occurs the creation of the new idea or set of ideas. Second, the novelty has to be worked out, still largely in private but fully enough to embrace the phenomena on which it bears and to offer the prospect of convincing specialists other than the innovators. Third comes dissemination in professional circles, by correspondence, by circulation of preprints, eventually by publication. Cohen calls this phase the revolution on paper. He thus adapts to his purposes the felicitous phrase "A World on Paper" that Enrico Bellone takes for the title of his book (1980) on the so-called second scientific revolution of the 19th century, which Cohen discusses appreciatively in connection with that concept. Cohen uses the phrase in a more restricted sense, however. The revolution on paper still has to become a revolution in science in a fourth and final stage, that of acceptance of the new theory by qualified scientists (a process characteristically involving conversion rather than persuasion), followed by its incorporation into the practice of the discipline.

In deciding whether a set of changes is to be considered revolutionary, Cohen consults the testimony of the leaders and participants, of the later documentary

tradition, of historians expressing their judgment after the fact, and finally of the living tradition in the science concerned. Among these criteria, he attaches the greatest importance to the evidence given by contemporary witnesses.

So much for the analytical scheme. Cohen employs it in discussion of the two main types of revolutionary change, the one associated with great leaders and the other with great movements. These are not, obviously, mutually exclusive categories, and Cohen groups episodes of both sorts by century, beginning with the 17th and continuing through the 20th. He is a scholar of extraordinary erudition, widely and deeply read in the secondary literature no less than in the scientific texts. The thought has crossed my mind, indeed, that he may well know more history of science than any scholar now alive.

His organization gives him principles of selection for the wealth of material that he adduces in elucidating the relevance of the evolving concept of revolution to our understanding of the development of science itself. It is one of the signal merits of his book, however, that the reader need not keep the scheme constantly in mind in order to profit from the many discussions. One test of the value of a work of historical scholarship may be to consider what can be learned by readers who, for whatever reason, remain unconvinced by the author's argument. In making that remark, I do not mean to imply anything dismissive or negative about Cohen's. But the chapters are essays that can be, and I think will be, read for what they convey about their subjects in general, and not only in relation to the topic of revolution.

It is notable, for example, that a scholar who has devoted much of his career to Newton should be able to distill from his knowledge 15 pages that constitute as lucid a summary of Newton's importance in science as can be found in the enormous literature. The succeeding chapter on Vesalius, Paracelsus, and Harvey can serve equally as an introduction to the study of those figures and as a summary of the present state of knowledge of their work. It can do so, moreover, quite apart from any need to share the author's conclusion about the extent to which their innovations were instances of revolution in the life sciences prior to Darwin.

Cohen himself may feel that the important thing is to write history of science rather than to argue a thesis about it. He appends a supplement consisting of some 29 notes on attributions of revolutionary significance to a great miscellany of people and episodes, many of them little known, that are sometimes extraneous to and sometimes enlargements upon his central chapters.

One possible effect of assembling so vast an array of allusions to revolutions in science I do find troublesome, or slightly so. Since no provision is made for the role of nonrevolutionary science, the possibility of a cheapening or even a trivialization of the notion of revolution exists. The force of the word, at least in its modern meaning, derives from the implication that it connotes an extraordinary event. If quite as many changes as are discussed in this book were revolutionary, they cease to be unusual and become almost mundane. But perhaps a conscientious application of Cohen's criteria will obviate this danger, if it is one, and will serve to distinguish effective revolutions from the claims advanced by many an innovator, would-be or real.

However that may be, the scheme as a whole appears to particularly good advantage in the last substantive chapter, which I find especially informative. It deals with the recent revolution in earth sciences that has established the theory of continental drift and the study of plate tectonics. For one thing, the material treated as history of science is quite new, at least to me. In another, and more important, respect, Cohen's account of the resistance to the former of the two sets of ideas, the notion of mobile continents advanced by Alfred Wegener between 1915 and 1930, is admirably clear and dispassionate. So long as Wegener and his few adherents were the only proponents, the revolution remained on paper. It is quite conceivable that its fate might have been to languish forever in the limbo of abortive or failed innovations. The interval prior to its passage into the stage of revolution in science seems surprisingly long, given the pace of modern research. For only in the 1950's and 1960's did the theory of continental mobility begin to prevail, and then in consequence of two lines of evidence quite different from anything imagined by Wegener, and also from each other. The study of paleomagnetism by Blackett, Runcorn, and others strongly suggested that the southern continents had once been joined, and Harry Hess's theory of seafloor spreading on either side of mid-ocean ridges explained how they had moved apart.

Cohen points out very nicely that modern plate tectonics represents as great a transformation of Wegener's theory of mobile continents as did the Newtonian world picture of the Copernican theory of a moving earth. The treatment has the further interest that it exhibits one of the junctures at which Cohen's historical approach intersects with Kuhn's philosophical analysis, although in a somewhat unexpected way. The discussion of Kuhn's theory of scientific revolutions in the 1960's largely coincided with the adoption of plate tectonics. Participants in the latter, notably J. Tuzo Wilson, have testified that their thinking was stimulated and encouraged by their sense of living through just the kind of changes that Kuhn was simultaneously elucidating.

CHARLES C. GILLISPIE
Program in History of Science,
Princeton University,
Princeton, New Jersey 08544

Oogenesis

Developmental Biology. A Comprehensive Synthesis. Vol. 1, Oogenesis. LEON W. BROWDER, Ed. Plenum, New York, 1985, xiv, 632 pp., illus. $75.

This is the first volume of a new series in developmental biology. Three more volumes, on the cellular basis of morphogenesis, the cell surface in development and cancer, and manipulation of mammalian development, will be forthcoming. If the forthcoming volumes are as well done as this one, the series will be a great contribution. The book demonstrates, as it sets out to, that oogenesis is an exciting and rapidly advancing subject of research. Each chapter is an in-depth treatment of oogenesis from the point of view of morphology, physiology, cell biology, or molecular biology. Each concludes with a statement of the major experimental questions and the avenues of research that may lead to their resolutions. The volume is light on the endocrine control of oogenesis and heavy on the cell biology, biochemistry, and molecular biology. It is written by cell, developmental, and molecular biologists for an audience of similar persuasion. It is not a book for clinicians or reproductive endocrine physiologists. There are only five entries in the subject index on human oocytes.

The volume is divided into two sections, the first being Physiological and Morphological Aspects. "Local control mechanisms during oogenesis and folliculogenesis" by A. W. Schuetz is an excellent, up-to-date, and comprehensive treatment written from the viewpoint of comparative zoology and covering echinoderms, mollusks, and the ma-