few will ever be able to see the phenomena, let alone understand them. Eloquence is in part a matter of writing so that the truth, as experienced by the author, can scarcely be challenged. At that first crisis, Newton seemed simply not to acknowledge that there would be opponents with their own expectations, filled with doubt either about the experiment or its interpretation. Newton's great paper was a rhetorical failure, which taught the next generation what to do to succeed.

The writing up of experiments had to change so as forestall opposition and establish verisimilitude. How it did that is the topic of this book. There's lots more, for example a careful study of the evolving interplay of theoretical and experimental elements in publishing experimental results. There is also some examination of social and human sciences. American psychology has a writing style very different from American physics. Its professional association has a fat book of rules on how to write. In 1929 they consumed less than seven pages of print; in 1983 they demanded about 200 "oversized pages." They have been a vehicle for a behaviorist ideology of experiment. I know psychologists who sum up those 200 pages in four words: "new data or nothing." Bazerman moves on to political science, whose practitioners don't agree on how to codify. Some will find that Bazerman himself is too much of an empiricist reporter; he makes little judgment on the relation between distinct rhetorics and the natures of the several sciences. But for a gentle, well-informed, unpretentious, and unpolemical attempt to raise our consciousness about scientific writing, this book is a good read.

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Einstein Getting Established

The Collected Papers of Albert Einstein. Vol. 2, The Swiss Years: Writings, 1900–1909. JOHN STACHEL, editor. David C. Cassidy, Jürgen Renn, and Robert Schulmann, associate editors. Princeton University Press, Princeton, NJ, 1989. xxxvi, 656 pp. $85. English translation (Anna Beck, translator), xvi, 399 pp. Paper, $25.

In 1895, at the age of 16, Albert Einstein left Germany, by himself, for Switzerland. He began his independent life by failing the entrance examination to the prestigious Swiss Federal Polytechnic School (ETH), renouncing his German (more precisely, Württembergian) citizenship, and becoming a stateless person for the next five years. Yet during the 14 years that followed Einstein gradually transformed these inauspicious Swiss beginnings into a career of great brilliance. In 1896 he received a leaving certificate from a Swiss secondary school that entitled him to enroll at the ETH and in 1900 an ETH diploma that qualified him to teach high school physics. In 1902, following a shaky two-year period of short-term employment, he found a more permanent position at the Swiss Patent Office in Bern as a technical expert third class (as of 1906, second class). In 1905, for a dissertation on a new determination of molecular dimensions, he was awarded a Ph.D. in physics from the University of Zurich. In 1909 he left the Patent Office to become an associate professor at the University of Zurich, a position he renounced in 1912 in order to become full professor at the Karl-Ferdinand University in Prague. Barely a year later, at age 34, he returned to Switzerland to become professor of physics at the ETH. Besides these professional advances Einstein formed during these Swiss years deep personal and intellectual friendships (with Marcel Grossmann and Michele Besso, for example) and a relationship with Mileva Marič, a fellow ETH student, who would become his first wife and mother of his three children. With his appointment in 1914 as a research professor in Berlin, Einstein's Swiss years came to an end; his marriage soon found a similar fate.

The foundation of Einstein's professional progress was, of course, his stunning achievements in physics. His first publications concerned the nature of molecular forces (1901–1902) and the foundations of statistical physics (1902–1904). In 1905, his *annus mirabilis*, Einstein published three bold, pathbreaking studies: a completely new, and highly controversial, interpretation of light as being composed of energy quanta; an explanation of Brownian motion that provided convincing proof of the atomic nature of matter; and an equally powerful analysis of the electrodynamics of moving bodies (special relativity), a study that led the way into our modern understanding of the physical nature of space and time. During the remainder of his Swiss years, Einstein continued to publish on these topics as well as on the electrodynamics of moving media and on general relativity. After 1905 he moved naturally from the periphery to the center of professional physics: many of Germany's leading physicists (such as Max Planck and Wilhelm Wien) initiated correspondence with him; and in September 1909 he made his debut at a professional meeting when he was invited, as an honorary guest, to speak before the Physics Section of the Gesellschaft Deutscher Naturforscher und Ärzte in Salzburg. Einstein's "arrival" in the world of professional physics is all the more striking given that as an employee of the Patent Office between 1902 and 1909 (perhaps the most intellectually creative period of his life) he could conduct research in physics only in the evenings and on weekends and holidays and that he had the support of neither laboratory nor university colleagues (though he did have scientifically trained and philosophically minded friends in Besso, Grossmann, Conrad Habicht, and Maurice Solovine).

Scholars of the history of physics, indeed of modern culture in general, are naturally interested in having an authentic, documentary account of Einstein's intellectual development and rise to scientific prominence. In volume 1 of Einstein's *Collected Papers* John Stachel and his associates elegantly documented Einstein's early years. There they presented all known primary source materials giving essential information about Einstein's person and scientific training from his birth in 1879 to his appointment at the Patent Office in 1902. Their chief discovery was a revealing, previously unavailable set of letters between Einstein and Marič. With the publication of volume 2, the editors commence the division of their series into two: One series, "Writings," chronologically presents Einstein's published articles along with such items as unpublished papers, research and lecture notes, reviews, and patent applications. The other series, "Correspondence," presents all available letters written by Einstein along with all significant letters sent to him and many important third-party letters written about him.

In volume 2, here under review, the editors furnish 62 documents that constitute Einstein's published writings from 1900 to 1909. They provide facsimile republications (in German) not only of all of Einstein's full-length articles but also of all his reviews, published lectures, and published discussion remarks during these years. Scholars who have previously sought (often in vain) to obtain the relevant volumes of the *Annalen der Physik*—the journal in which Einstein published more than three-quarters of the documents here presented—now have easy access to Einstein's writings. Apart from the reviews, the writings from this period divide, in effect, into seven thematic categories: molecular forces, the foundations of statistical physics, the quantum hypothesis, determining molecular dimensions (Einstein's Zurich dissertation), Brownian motion, the theory of relativity, and the electrodynamics of moving media.

Volume 2 provides far more than merely facsimile reproductions. The editors have rendered at least three further services to its users. First, they have included a substantial introduction and a set of eight "editorial notes" that place Einstein's writings within their immediate scientific context, relating them both to Einstein's own developing work and to the work of his contemporaries. The introduction and the accompanying "editorial notes" are virtually independent historical articles and serve as useful guides both to the secondary literature on Einstein and to the scientific literature of Einstein's day.

Second, the editors have provided footnotes to Einstein's texts designed to illuminate the sources of the scientific problems that Einstein confronted and the ideas and techniques with which he addressed them and to point out occasional errors. Third and finally, they provide a comprehensive index to Einstein's early writings. The reader who wants to know where Einstein used or referred to a certain problem, theory, concept, or instrument—the second law of thermodynamics, electrons, fluctuation phenomena, molecules, quanta of action and of energy, time dilation, the ultramicroscope—now need only consult the excellent indexes, which also provide references to all institutions and individuals cited by Einstein or the editors.

Volume 2, along with the already published and equally handsome volume 1 and the forthcoming volume 5 (the "Correspondence" for 1902 to 1914), constitutes an essential scholarly tool for the continuing study of the intellectual and social context of the young Einstein and his work.

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New Examinations

Einstein and the History of General Relativity. DON HOWARD and JOHN STACHEL, Eds. Birkhäuser Boston, Cambridge, MA, 1989. xii, 445 pp. $69. Einstein Studies, vol. 1. From a conference, North Andover, MA, May 1986.

As recently as 15 years ago there was very little serious historical study of Einstein's work after 1905, or of the development of field theory and cosmology by Einstein and his contemporaries. Before 1975, historical studies were usually confined to argument over the sources of Einstein's ideas in physics and philosophy; the details of paths to discovery were left mysterious. A more ambitious historical enterprise has been under way for the last decade or so. It undertakes to reconstruct the details of the work that led Einstein and his contemporaries to their views, to reconstruct in modern mathematical form the arguments and exchanges that were of historical importance but appear in retrospect to be opaque or confused, and to give scientific readers a real sense of the intellectual struggles of historical figures. The change in historical writing is due in part to John Stachel, a physicist turned historian and the original editor of the Einstein papers. In 1975 Einstein's papers were available only on microfilm at Princeton University; scholars were forbidden to make photographic copies of any of the film, and no transcriptions were available. Today, thanks to Stachel there are readable photocopies available at Princeton, Boston, and Jerusalem, as well as the two volumes of Einstein's papers that have been published. This collection of essays on a variety of aspects of the historical development of the general theory of relativity attests that physicists, historians, and philosophers from around the world are making good use of these sources.

Einstein and the History of General Relativity is not an easy book. It is a book about work and scientific opinion, not about character or personal relations. Almost the only indication of an assessment of Einstein as a person occurs in an essay contributed by Peter Havas, who gives a not altogether flattering picture of aspects of Einstein's character in his mature years. Readers without a good knowledge of differential geometry and the elements of the general theory of relativity will find none of the essays rewarding. Those with an adequate background should find the collection very valuable. The essays are not uniform in quality, but all of them are worth reading and several of them are extraordinary pieces of scholarship and writing.

The first four essays, two by Stachel and two by John Norton, explore Einstein's passage from the special theory through a sequence of gravitational theories to the discovery of the field equations of the general theory in November of 1915. Norton's second essay is concerned with the sequence of gravitational theories Einstein offered between 1912 and 1915 and the reasons for the succession of conjectures. Stachel's second essay covers the same period, paying special attention to Einstein's shifting views about the possibility of a generally covariant theory. These pieces are among the best "internal" intellectual history to be found anywhere.

Two essays by Carlo Cattani and Michelangelo De Maria discuss Einstein's public and private exchanges with Max Abraham and Tullio Levi-Civita in 1913 and 1914. The authors' discussion of Levi-Civita's correspondence with Einstein and his criticism of Einstein's attempts at proofs using the calculus of variations is detailed and interesting. Their discussion of Abraham is less satisfying: Abraham's own work is scarcely described, and he is discussed chiefly as an example of Italian hostility to the theories of relativity. He deserves better and deeper study. A. J. Kox offers a sympathetic picture of H. A. Lorentz's reaction to the general theory of relativity and of his attachment to the aether. Jean Eisenstadt has contributed a careful and insightful essay on the early understanding of the Schwarzschild-Droste solution to the field equations of general relativity. Eisenstadt has also contributed a paper on the state of the enterprise of general relativity between 1925 and 1955, and Peter Bergmann has written a short essay on the history of steps toward quantum gravitation through canonical quantization.

The relationship between the field equations and the equations of motion is part of the special explanatory unity of the general theory, and, I suspect, one of the fundamental reasons Eddington and Weyl found the theory attractive. The essay by Havas is a refreshingly blunt account of the history of derivations of the geodesic equation of motion from the field equations and conservation laws of the general theory, focusing on issues of priority. Einstein, Leopold Infeld, and H. P. Robertson do not fare well.

Vladimir Vizgin contributes an extremely interesting essay on the early history of geometrical unified field theories, beginning with David Hilbert's work. The essay is regrettably brief, and reminds me of how much we need a thorough study of the idea of unifying physics through geometrical field theory, beginning no later than with the work of Gustav Mie. The volume also includes an essay by Michel Biezunski on an exchange between Eli Cartan and Einstein in the 1930s and two essays on relativistic cosmology. One, by Pierre Kerszberg, focuses on Einstein and De Sitter; the other, by George Ellis, is an astonishingly compact overview of cosmological theory and evidence between 1917 and 1960.

The book is handsomely bound and printed. The absence of figures (save in Eisenstadt's essays) is regrettable, especially in Norton's essay on the equivalence principle, as is the failure to give addresses and affiliations of the contributors.

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