Kelvin "discussing a problem with his sister, Elizabeth." [Reproduced in *Energy and Empire* from A. G. King, *Kelvin the Man* (London, 1925)]

cance to us, not only because of their significance to their own time. (Thus American and British historians publish more books about 19th-century British physicists than about 6th-century Chinese emperors.)

In our century Lord Kelvin has come to represent a certain kind of thinking about science summed up in his two famous statements: (i) I can't really understand something unless I can make a mechanical model of it; (ii) if you can't measure something in numbers, your knowledge of it is not really scientific. Smith and Wise discuss the contexts of these statements but leave it to the reader to supply their consequences.

More recently Kelvin has been dragged into the creation-evolution controversy as an example of a great scientist who was also a creationist. (The creationists have difficulty finding any respectable living scientists who support their views.) When history is abused in this way it is up to the historian to point out that, while Kelvin thought natural selection was inadequate to explain evolution, he also rejected creationism, "never aligning himself with biblical literalists and anti-evolutionists" (Smith and Wise, p. 634). In fact Kelvin's cosmology was evolutionary in the broad sense, while allowing a place for divine guidance.

I am grateful for the intellectual feast provided by *Energy and Empire*; and I am hungry for more.

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Persuasion at a Distance

Shaping Written Knowledge. The Genre and Activity of the Experimental Article in Science. CHARLES BAZERMAN. University of Wisconsin Press, Madison, 1988. xii, 356 pp. $40; paper, $17.50. Rhetoric of the Human Sciences.

This is an old-fashioned book best described using compliments that have been devalued. It is about rhetoric in a positive sense of the word: about eloquent and persuasive writing in the experimental sciences. Eloquence doesn't refer to flowery embroidery but to effective composition. Scientific rhetoric has become a trendy topic, replete with well-funded conferences. Much of that activity is skeptically anti-scientistic, intended to reveal and undermine the sources of scientific authority. Charles Bazerman is well informed about current "social construction of scientific facts" schools of philosophical sociology of science, but he is himself an English teacher—in the best sense of that label, for he tries to teach people how to write well and has published manuals and studies of reading and writing. In fact, he concludes his present book with a chapter called "Writing well, scientifically and rhetorically," but this is not a manual. It is a study of how the criteria for good writing of experimental science came into being. It includes for analysis samples of fine writing, Compton on his effect, for example. But they are not used as models, but to discover how the writing persuades. What, in a field, at a time, enables the writer to succeed, especially when readers are asked to believe new facts, even those contrary to expectations?

Eloquence is not a timeless relation between reader, writer, and content. The scientific magazine came into being at a definite moment—most of us think of the *Philosophical Transactions of the Royal Society of London*, 1665, although there are rivals. The same is true of specialist journals, closely associated with professional societies or subgroups and hence part of the history of professionalization. In each type of publication styles of writing have evolved. That means that standards of excellence have changed.

How did styles and standards evolve, why, and in response to what interests? Bazerman keeps a good balance between two violently opposed pictures. One presents the writing up of an experimental result as a final, necessary, and perhaps tedious job for the record or for professional advancement. The other locates all the real work of experimental science in the transformation of inscriptions from the initial scribbles in a notebook, tracings of a marker on graph paper, or the first printouts, through the transparencies at the talk, via preprint, to published paper, the author all the while embracing allies and overwhelming any opposition; scientific writing should be seen as a political act. Bazerman is well informed about the second picture, which goes along with ideas of "social construction of scientific facts," but he is addressing readers who incline to the first picture without realizing the extent to which scientific writing is a collection of specific styles, with an instructive history, whose forms are essential to the growth of knowledge.

Bazerman proceeds in two ways, case studies and literature surveys. The surveys are happily free of phony methodology. He reads every fifth volume of *Phil. Trans.* up to 1800. He gets a sense of the publication practices of memorable scientists (book or periodical?) by skimming the A's and B's in the *Dictionary of Scientific Biography*. In modern times, 1893–1980, a subject is chosen, spectroscopy, a premier journal, *Physical Review*, and articles and even sentences are selected in the same unpretentious way. These surveys will, I think, confirm the subjective opinions of people familiar with the field, although as rhetorician Bazerman focuses on unexpected or seemingly trifling aspects of articles. It is the case studies that motivate a study of those aspects, and for many readers they will carry the book.

Why should anyone believe what the experimenter reports? The truth must be transparent, beyond question. A kind of writing empowered with authority had to be created. In the beginning experiments were demonstrated at a society meeting. The very rank of the witnesses was important to credibility: it helped to have a king in the company. This model entered crisis with what Bazerman regards as the first truly important experimental report in *Phil. Trans.* (1672), Newton's demonstration of "the phenomena of the colours." These are ill suited to public demonstration, requiring a large pitch-dark room and a point source of light. Newton casually talks of letting in a ray of light from the sun through his shades, but a successful result is (to almost everyone's surprise) powerfully difficult to achieve. Notebooks and lecture notes confirm that Newton had deep theoretical concerns, but he insisted he was only reporting what he saw. He wanted us to be "as it were" in the rooms of the Royal Society seeing it all—but we weren't. His critics, especially the tenacious Hooke, distressed him. He angrily replied, but never again published in a journal (aside from a squib on temperature), reserving himself for the *Optiks* (1704). Bazerman gives a new direction to this well-known story. The experimenter must forge new ways of being convincing, given that

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.