BOOK REVIEWS

Success Stories

Making PCR. A Story of Biotechnology. PAUL RABINOW. University of Chicago Press, Chicago, 1996. viii, 190 pp. $22.50 or £17.95. ISBN 0-226-70146-8.

Exquisite Specificity. The Monoclonal Antibody Revolution. ALBERT CAMBROSIO and PETER KEATING. Oxford University Press, New York, 1995. xii, 243 pp., illus. $59.95 or £39.50. ISBN 0-19-509741-6.

Monoclonal antibodies and the polymerase chain reaction (PCR) are widely regarded as among the most important biomolecular technologies developed during the past two decades. Not only did each technique rapidly grow indispensable in research and medicine, each was recognized with a Nobel Prize and became a major commercial success. Monoclonal antibodies enjoy a vast market, and the patent rights to PCR sold in 1989 for a reported $300 million. But how were these techniques invented? From what organizational and cultural settings did they emerge? How did they take shape, gain acceptance, and become consequential in science, commerce, and medicine? Such questions are central issues in the field of science and technology studies, and *Making PCR* and *Exquisite Specificity* are both welcome contributions to the literature.

The problem of explaining how technologies move from the laboratory to become ubiquitous features of our world has sparked lively scholarly debate. The familiar story of the heroic inventor (an extraordinary individual famous for light-bulb flashes of insight or lean years of stubborn persistence) has rarely survived intensive scrutiny. Instead, recent work has generally framed innovation as a collective process, distributed among many actors and organizations. In a parallel development, much current scholarship has explored how technological change involves not only modifying technical artifacts but also integrating them into "sociotechnical" networks that weave together a wide variety of artifacts, practices, and institutions.

In *Making PCR*, Paul Rabinow provides a succinct account of the development of PCR—a powerful means for making copies of specific DNA sequences in vitro. Drawing on documentary evidence and interviews with former personnel of the Cetus Corporation, which developed PCR, he explores the highly nonlinear path to its invention. Rabinow, an anthropologist from the University of California at Berkeley, also offers a description of the milieu in which PCR emerged. His ethnographic approach nicely portrays some of the excitement and intensity of doing science in the fast-paced world of biotechnology start-ups in the 1980s. The book is aimed at a broad audience, and Rabinow alludes to major scholarly debates in science studies more often than he presents extended arguments about them. Nevertheless, even specialists in the field will find this book a provocative and useful addition to the literature on contemporary biotechnology.

One item on Rabinow's diverse agenda is to examine the question of who invented PCR. This matter was disputed not only in the famous courtroom battle between Cetus and DuPont, which unsuccessfuly contested Cetus's PCR patents, but in a less celebrated conflict among Cetus personnel. Rabinow addresses only the latter controversy. On one side stands the flamboyant Kary Mullis, who was recognized with the Nobel Prize in 1993 for his work on PCR. In public comments, Mullis has depicted the discovery of PCR as a conceptual achievement. In this view PCR came into existence the moment that Mullis, inspired by what he himself refers to as "the genius thing," envisioned using polymerases to replicate DNA molecules in a cyclic chain reaction.

In contrast, other Cetus researchers who worked on PCR contend that the journey from concept to practice was long and difficult. Although no one denies that Mullis thought of the concept, these scientists and technicians argue that Mullis alone failed to produce experimental data capable of convincing even mildly skeptical critics that PCR worked. In short, the concept could do nothing until it was successfully adjusted, reconceptualized, and fitted into a functioning experimental system. The initial idea of "PCR" was significantly transformed as it was made into a practicable technique.

Another of Rabinow's interests is the "new field of institutional arrangements and cultural practices" that was emerging in the biosciences in the 1980s, especially in Cetus and other biotechnology start-ups. He portrays Cetus as an "improvisational space" where experiments were performed not just on biotechnology but also on new ways of doing science. Thus, in Rabinow's hands, infighting within Cetus about corporate strategy and arguments about who invented PCR become vehicles for exploring how researchers at biotechnology start-ups understood science as a practice and vocation.

In keeping with the relentless self-reflection of much contemporary ethnography, Rabinow also questions his own practices. Who has the authority to represent the experience of the people being studied? To what extent should an account of a group's culture be filtered through the analytic categories of the social scientist? Rabinow experiments with these issues by splicing long fragments from interviews with Cetus researchers into his own narrative. These excerpts—which arrive without warning as abrupt interruptions—are often interesting, but they raise more questions than they answer. Readers with conventional tastes will find this mode of presentation a poor substitute for argument.

Exquisite Specificity provides a detailed account of how hybridoma technology—a tool for making precisely targeted monoclonal antibodies—became such a remarkable success story. Alberto Cambrosio and Peter Keating, specialists in science studies from McGill University and the University of Quebec at Montreal respectively, base their analysis on a wealth of interviews, observations of laboratories, and written material. The book sports a foreword by César Milstein, who shared the 1984 Nobel Prize with Georges Köhler for hybridoma technology. Cambrosio and Keating argue that the development of hybridoma technology cannot be understood as a process of diffusion: far from being a static object, invented in one location and later spread, hybridoma technology was repeatedly redefined—both conceptually and materially— as it was woven into the world.

That technologies are remade as they spread has become a familiar theme in science and technology studies. The distinctiveness of the authors' argument stems from their attention to how scientists fitted hybridoma technology into a "practical cosmology"— a set of important categories, such as the distinction between scientific facts and laboratory techniques, that scientists use in their day-to-day reasoning. By rigorously avoiding the blinders of hindsight, Cambrosio and Keating are able to show how hybridoma technology's place in scientists' practical cosmology changed over time and how these changes were fundamental to its evolution.

The authors begin their story at a time when hybridomas occupied an ambiguous position on the border between facts and techniques. Today, scientists regard a 1975

Vignette: Atrocities of the Book World

Two pressing ethical issues need to be addressed by the publishing industry. First is the solicitation of advance blurbs for new books, a corrupt practice that chiefly afflicts the United States and that has grown wildly out of control over the past twenty years. . . .

Pre-publication endorsements have long outlived their usefulness. No informed person takes them seriously because of their tainted history of shameless cronyism and grotesque hyperbole. A string of breathless blurbs on a book is ultimately counterproductive, since it betrays the publisher's lack of confidence in the project, as well as the tin ear and general ineptitude of the publicity department. And the luminaries who turn out inflated blurb after blurb are hacks who give prostitution a bad name. . . .

The unbridled lust for provocative advance blurbs has led to a second horror—the dunning of potential endorsers with an avalanche of promotional mailings. . . . I have had to fight back mountains of sometimes tediously inappropriate material, which has overwhelmed the limited facilities of my small university and generally made life hell.

—*Camille Paglia*, in *Publishers Weekly*, 3 June 1996

paper from Milstein's laboratory as representing the foundation underlying hybridoma technology. But as Cambrosio and Keating point out, the 1975 paper did not mention hybridoma technology and the research was not aimed at developing such a technology. Indeed, at the time, the paper was seen as just another study using cell fusion techniques to examine the control of antibody diversity. Not until 1978 were hybridomas understood as revolutionary.

This revolutionary status, the authors contend, was achieved as hybridomas were gradually redefined as the basis for a new technology. This reclassification entailed more than simply changing the label applied to a static entity: changing the label also transformed hybridomas by altering their place in scientific culture and practice. Thinking of something as a "tool," for example, positions it in competition with extant tools. Thus, as hybridomas came to be understood as tools, scientific activities were reoriented toward establishing the advantages of monoclonal antibodies (such as purity and specificity) over conventional immunoassays. These activities included creating institutions that distributed hybridomas, controlled their quality, regulated nomenclature, and otherwise standardized the technology.

In a chapter on intellectual property, Cambrosio and Keating analyze the process that transformed monoclonal antibodies into patentable inventions. Briefly put, the authors treat patent litigation as a site for an ethnographic investigation of what counts as novelty. The result is a nuanced picture of how the disputing parties seamlessly integrated technical, legal, historical, and philosophical considerations into arguments about whether (and in what sense) monoclonal antibodies represented a significant departure from what had come before. This chapter, like the entire book, is extremely well documented. The authors' meticulous scholarship may deter some readers, but *Exquisite Specificity* offers rewarding insights not only about contemporary biotechnology but also about scientific practice and innovation more generally.

Stephen Hilgartner
Department of Science and Technology Studies, Cornell University, Ithaca, NY 14853, USA

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Fiery Drops

Chondrules and the Protoplanetary Disk. R. H. HEWINS, R. H. JONES, and E. R. D. SCOTT, Eds. Cambridge University Press, New York, 1996. xiv, 346 pp., illus. $120 or £90. ISBN 0-521-55288-5. Based on a conference, Albuquerque, NM, Oct. 1995.

Chondrules are tiny spherules of crystals and glass that occur commonly in primitive meteorites (chondrites). When Henry Sorby, inventor of the petrographic microscope, focused his attention on chondrites in 1877, he reasoned that chondrules were once-molten droplets that solidified in free fall, "like drops of a fiery rain." He suggested that they might have been ejected from the sun in solar prominences or formed when the sun's surface extended farther out into the solar system. More than a century later, scientists are still puzzling over the origin of these enigmatic objects.

In October 1995, a NASA-sponsored conference considered what clues chondrules might hold about nebular processes and whether current astrophysical models can explain their formation. This collection of 34 short papers by 50 authors summarizes the proceedings. The book's organization roughly mimics that of the conference: Part 1 is an overview by one of the organizers. Reviews of protoplanetary disks and disk process constitute part 2. Part 3 describes the precursor materials that melted to form chondrules. Constraints on the thermal histories of chondrules are explored in part 4. Part 5 concludes with an imaginative variety of chondrule-formation models.

A few conclusions run like threads through many papers in this collection: Chondrules were partly or completely melted, sometimes repeatedly, at temperatures as high as 2100 kelvin. The heating phase was short-lived (seconds or minutes), and cooling rates were also rapid (10 to 1000 kelvin per hour). Compared to time scales for global nebula processes, the duration of chondrule heating and cooling is so short as to require localized thermal events. However, there is little agreement on other aspects of chondrule origin or on the nebula processes that could have led to their formation.

Despite the lack of consensus, this book clearly demonstrates the synergy derived from bringing together scientists from different disciplines. I will only mention a few of my favorite contributions. Astronomical observations of protostellar disks are described by L. Hartmann, and the possible role of nebula turbulence in sequestering chondrules is explained by J. Cuzzi *et al.* J. Wood presents 15 debating points crucial for the understanding of chondrule formation, and A. Boss offers a concise guide to chondrule formation models. Additionally, there are papers dealing with the timing of chondrule formation, the chemical components of chondrules and relict grains, the agglomeration of chondrule percursors and chondrule rims, and constraints on chondrule heating and cooling from melting experiments and from the retention of volatile elements. The book ends with an assortment of chondrule formation models, which include lightning, shock waves, protostellar jets, and collisional melting.

This book is intellectually stimulating, but I found its production somewhat disappointing. Chondrules and chondrites are ar-