Science Books Since World War II

Bruce V. Lewenstein
Departments of Communication and
Science & Technology Studies
321 Kennedy Hall
Cornell University
Ithaca, NY 14853 USA
b.lewenstein@cornell.edu

In press for volume 5
in the *History of the Book in America* project funded by the National Endowment for the Humanities and administered by the American Antiquarian Society (http://www.americanantiquarian.org/hob.htm). Cite as: Lewenstein, B. V. (2009, in press). Science Books Since World War II. In D. P. Nord, M. Schudson & J. Rubin (Eds.), *The Enduring Book: Publishing in Post-War America*. Chapel Hill: University of North Carolina Press.

In early 1988, an editor at Bantam Books in New York faced a challenge: he had just been handed the portfolio for a "popular" science book that drew on both quantum mechanics (the science of the very small) and general relativity (the science of the very big). Scheduled for publication within the month, the 200-page book filled with dense and difficult science and philosophy had suddenly become an orphan when the editor who had shepherded it for nearly four years left for another company. Although Bantam had paid more than $200,000 in advance for the volume, the text was challenging, and it was not clear that anyone other than a specialized audience would be interested. Worried, the editor cut the press run "drastically," to 40,000.[1]

That book was Stephen Hawking's A Brief History of Time, written by a Cambridge University astronomer who held the same endowed chair once occupied by Isaac Newton.[2] Within weeks, the book entered the bestseller lists; within two years, it had sold one million copies worldwide. By the beginning of the twenty-first century, A Brief History of Time had sold more than nine million copies. Some of the book's sales were driven by curiosity, for the author suffered from amyotrophic lateral sclerosis and by the publication date could communicate only through a computer and a voice synthesizer. But sales also resulted from widespread interest in Hawking's subject. In that respect, the volume's success signaled the centrality of scientific ideas in intellectual life.[3]

This essay will explore the role of books in the years after World War II in scientific culture, in broader public culture, and in the coalescence of those cultures into a single "culture scientifique" (a French term with no English equivalent, expressing the absolute integration of science into the cultural matrix).[4] While the focus is on America, science by its nature crosses many boundaries and thus so will this story. Many scientists believed that science itself no longer needed books, for they had become accustomed to reading about most new findings in journals (or, by the end of the century, in electronically-circulated preprints. Yet books continued, in a variety of ways, to construct the community of science, both among scientists themselves and among wider publics. Indeed, the history of science books in America shows that public interest in and support for science grew throughout the post-war years, especially after the "baby boom" demographic bubble reached maturity in the late 1970s. The popularity of science books in the last twenty years of the twentieth century may also have reflected one branch of a cultural tension between Romantic or "anti-science" beliefs (supported by fundamentalist approaches to religion) and an Enlightenment vision of reason and evidence as the base for social progress.

Science Communication as a Community Activity

Although scientists and the public often perceive science as a collection of facts and ideas about the natural world, sociologists have long understood that it is also a social activity, dependent on the collective actions of individuals and institutions organized in both formal and informal ways.[5] Communication, according the psychologist and sociologist William Garvey, is the "essence" of science.[6] Yet both observers and practitioners of science have traditionally regarded the history of science communication as a progression towards modern peer-reviewed journal literature.[7] At the turn of the twenty-first century, a young scientist being trained in how to report results is likely to be given a copy of the most recent edition of Robert Day's How to Write and Publish a Scientific Paper.[8] Similarly, the Council of Biology Editors' Style Manual (frequently updated since 1968) contains sections on research articles, review articles, multi-authored books, abstracts, posters, theses, book reviews, and grant proposals, among others; the main instructions are labeled "Writing the article."[9] The 1968 combined Publications Handbook and Style Manual of the American Society of Agronomy, the Crop Science Society of America, and the Soil Science Society of America begins with "journal management and procedures," while the American Chemical Society's 1992 Style Guide launches immediately into "the scientific paper."[10] There is good reason for this emphasis: the number of journals grew from between 5,000 and 10,000 in 1945 to as many as 100,000 in the 1990s.[11]

Yet the almost complete absence of reference to books in those manuals and handbooks is striking. To a historian steeped in the traditions of Isaac Newton's Principia (1687), Antoine Lavoisier's Treatise on the Elements of Chemistry (1789), and Charles Darwin's Origin of Species (1859), the question becomes: what happened to books? The answer lies in recognizing what research on science communication in the last twenty years has demonstrated: that robust knowledge about the natural world emerges not fully-formed in a single article, but becomes "science" only after passage through a matrix of multiple forums and audiences that collectively produces a successful description of what Nature is (Fig. 1).[12] Books clearly appear in such a complex system. They serve as locations for the development of ideas and as repositories for stable knowledge. They are markers of community activity and forums for establishing community values—both for those communities existing within scientific practice and for those extending beyond the professional scientific world to encompass various publics. Books, for this purpose, can be understood as shared social experiences, ones that create a common bond that may or may not be based on the substantive content of the text. In some cases, books may serve multiple communities, crossing boundaries in complex ways. Books likewise serve as social memories, providing cultural touch points that give communities their common understandings.

Although these functions of books remained constant throughout the post-war period, the changing form, content, and availability of books of various types helps identify changes in the communities of science. These changes become clear in examining several categories: books within science itself; textbooks; and books with clear influence on intellectual culture and on broader public culture, on "culture scientifique." In each of these contexts, information and ideas are presented, conveyed, and used to create intellectual regimes, shaping discourses that contribute simultaneously to scientific knowledge and to science's social authority, with ideas shifting meanings as they are employed in different contexts.

Daily life in science

At the beginning of the post-war period, books continued as they had for generations to play a role in routine scientific work, creating communities of practice that shaped daily life. Reference books like the CRC Handbooks (of math, chemistry, and so on) appeared on many scientific desks, and teachers encouraged students to buy them early in their careers for easy access to formulas, standardized data, and common calculations or tables.[13] Librarians bound database serials such as Chemical Abstracts (begun early in the century) or Science Citation Index (published in its earliest form in the mid-1950s) as books; scientists routinely visited the library to check for new publications or references to older material.[14] Beginning in the 1960s, publishers compiled these databases on computers, and the books consisted essentially of computer printouts. Scientific societies such as the American Chemical Society (publishers of Chemical Abstracts) and government agencies like the U.S. National Library of Medicine (publisher of the Index Medicus) expanded their units preparing bibliographic material. New businesses emerged: Eugene Garfield, a chemist and librarian, in the late 1950s created the Institute for Scientific Information (ISI) to publish the Science Citation Index that he had invented; by the 1990s ISI had become a part of the worldwide Thomson Publishing empire.[15]

The shift to computer production had profound implications for the behavior of scientists. By the end of the 1970s, distributed computing networks allowed libraries and some scientists direct access to the electronic databases, a development that dramatically accelerated with the advent of personal computers and the Internet in the 1980s and 1990s. By the turn of the century, few young scientists made a weekly library visit to scan new journals; they expected to have information delivered directly to their office computers. Even the handbooks and reference books of the past were replaced by online tables and reference sites. Thus the shift in production and eventually distribution of scientific information led to a declining commitment of scientists to traditional books and libraries. It also isolated them in their labs and offices, leading to less of the informal exchange of information common in libraries and hallways, which compounded the increasing specialization of scientists and their increasing inability to share information and ideas across disciplinary boundaries. (In the 1980s, designers of scientific laboratories began deliberately creating "conversation spaces" in their buildings, to attempt to overcome increasing isolation.[16])

The Internet also affected the dissemination of conference proceedings. Many scientific societies had issued proceedings of their meetings or special symposia. The American Association for the Advancement of Science, for example, began formally publishing symposia in the 1930s and continued into the 1970s.[17] Especially during the 1960s and 1970s, some scientific societies with smaller budgets distributed proceedings less elegantly (for instance, by photo-offset from typewriter manuscripts) or less systematically. Despite these limitations, conference proceedings often provided the first notice of new findings. They were also literally documentation of communal efforts, of occasions when scientists came together to work through their ideas. With the spread of the Internet in the 1990s, however, scientists found new ways to distribute their ideas in progress. Because meeting abstracts and papers were published online, they became available to much wider audiences than the few hard copies that might sit only on the shelves of meeting participants. New systems of online preprints (draft papers circulated before the formal version was published in a journal) became common in some fields, again obviating the need for the collections of preliminary ideas and initial experimental reports that conference proceedings had provided.[18] While no statistics are yet available, the value of formally published conference proceedings available in paper formats appears to be decreasing as the new century begins.

Nevertheless another type of communal book affecting daily life in science, the festschrift, is surviving those developments. The festschrift is a celebratory volume intended to document a senior researcher's career and interests. Production of a festschrift is a statement about shared values and personal bonds, a commitment to science as a community as well as a body of knowledge. Although festschrifts are usually collections of reviews or summary papers, they have sometimes allowed a researcher to publish ideas that have had trouble passing through the peer review system, such as geologist Harry Hess's first systematic presentation of the ideas that became plate tectonics, an essay that he labeled as "geopoetry."[19]

Textbooks

But while the books of daily practice and the festschrift document science as a community, textbooks show how books can create and shape a community. By the mid-1980s, for example, three-quarters of a million students took introductory biology each year; about 20 texts vied for that market, with an average wholesale cost of $30 per book. The number of new titles to serve the biology market grew from about five each year in the early 1950s to fifteen each year by the mid-1980s.[20] Several factors contributed to rapid growth in the science textbook market. The GI Bill after World War II sent a new generation of students to college, and the palpable value of science and technology in "the good war" led many students to those fields. In 1958, after America was shocked by the success of the Soviet Union's Sputnik satellite, new money flowed into primary and secondary science education as well.[21]

The intellectual effect of the new textbooks was most apparent at the college level. There, scientists were eager to shape the minds of the new generations of students streaming into universities. Linus Pauling's General Chemistry (1947), one of the first great post-war textbooks, illustrates the importance of such works. Pauling (who won Nobel prizes both in Chemistry and in Peace) used his textbook explicitly to reformulate how to teach chemistry, introducing visual imagery and insisting on organizing the material around the new knowledge of atomic structures that had emerged earlier in the century, rather than continuing to invoke older "laws" of chemical behavior. By introducing a conceptually different way of thinking about the natural world, Pauling's book went beyond a simple "discovery" about Nature. It was more important: it was the means by which thousands of students came to understand chemistry as a theoretical structure for comprehending the arrangement and behavior of atoms and molecules.[22]

By contrast, two leading physics texts, Francis Sears and Mark Zamansky's College Physics (1947) and David Halliday and Robert Resnick's Physics for Students of Science and Engineering (1960) made their mark by sustaining older views of the physical world. Both focused on the needs of engineering students, being fundamentally designed to teach the Newtonian mechanics that most physics students would have to face in their careers. As the physicist and historian Charles Holbrow has shown, quantum mechanics and other issues of twentieth-century physics were almost literally an appendage, appearing in separate chapters near the ends of these texts.[23] For many work-a-day physicists, not the elite researchers but the ones keeping government laboratories and experimental facilities running, the ones doing routine calculations and operations, the engineers who make up the vast bulk of the physically-oriented scientifically-trained workforce, esoteric cutting-edge science was just one part of what they learned. The world-view, the intellectual matrix into which they placed the individual facts, theories, formulas, and behaviors that to them defined science, was essentially a product of the nineteenth century.

Even so, textbooks, especially at the advanced level, were more likely to be places for creating and consolidating new fields. James Watson's Molecular Biology of the Gene (1965) was one such work. Watson, co-discoverer of the structure of DNA, was a wunderkind whose more famous book, The Double Helix (1968), has been interpreted as a polemic arguing for a new, competitive, high-stakes approach to biological research.[24] Less recognized has been the role of the earlier text in creating a new discipline. Watson brought together the range of research that had previously been scattered in crystallography, biochemistry, genetics, and other fields to show that it could be taught together fruitfully – and that, by so doing, teachers could train a new generation of scientists ready to move into this coherent area rather than merely reaching into it from their own home disciplines. Other books synthesized new knowledge, providing the theoretical base for whole new areas of research. Historians have called Ledyard Stebbins's Variation and Evolution in Plants (1950), for example, the founding document of evolutionary botany, one which "provided a detailed argument that plants were subject to the same processes of evolution as animals." After a larger debate about the nature of biological progress – a debate that took place largely in books, such as magnum opuses published by Ernst Mayr and Stephen Jay Gould at century's end – biologists could not imagine a world in which plants were not subject to evolutionary forces.[25] The power of such textbooks lay in their ability to create communities of people with similar training, similar perspectives, and similar tools. Sustained by those communities, texts often acquired additional authors in their revised versions and grew dramatically in size.

The increasing length of texts, however, reflected a tension between the intellectual goal of organizing information and the economic goal of ensuring that no teacher or textbook adoption committee could reject a text because it did not contain a particular favorite topic. In 1988, an exasperated chemistry professor plotted the growth of organic chemistry textbooks from the 1950s onward and discovered a growth rate of 16 pages per year – which, he predicted, would lead within 15 years to average textbooks of more than 1500 pages and "a body-building prerequisite to the organic chemistry course." More seriously, he worried that while new, exciting, challenging material was added, older material was not being deleted.[26] A survey of biology teachers in the late 1980s showed that more than half believed that textbooks had too much information and too many facts.[27]

To address these concerns, textbook publishers used new production techniques in the 1980s and 1990s to offer "custom" texts, packaging individual chapters to meet a particular teacher's course design. Supplementary material was provided on CD-ROMs or websites, rather than added as appendices or sidebars within the texts. The texts also changed in their intellectual substance, capturing new interdisciplinary linkages among the sciences and adopting more theoretical approaches to such reconceived subjects as earth science. But not all scientists applauded the shift to theory. "Some people say the study of descriptive chemistry is dull and boring," wrote prominent chemist John C. Bailar, Jr., near the end of his life. Recalling the evocative power of the books he'd used in his own studies, Bailar called them "extremely interesting…. I frequently wonder if we wouldn't attract more students into the chemical fold by giving them this sort of [detailed, specific] introduction to the subject. At least it would give them the feeling that chemistry is useful. I wonder whether they get that feeling from a long discussion of theory."[28]

The tension between theory and fact – a tension between different visions of what science is and what knowledge a community of students needs – occurred at the elementary and secondary school level as well. New school curricula launched during the Cold War crisis of confidence after the 1958 Sputnik launch were designed to attract the very best students into the sciences, and curriculum designers drawn from the top ranks of research scientists often drew on the latest theories for their projects.[29] The theoretically-oriented curricula were particularly difficult for students unlikely to become cutting edge scientists. By the 1990s, 30 years of research into student learning and dissatisfaction with the various approaches tried since the 1950s led to reform efforts. New national "standards" for mathematics and science education were developed. Although the standards were voluntary, most states by the turn of the century had adopted some version of them, leading texts to carry tables showing teachers how particular units addressed particular standards.[30]

In one field, evolution, conflict over fact and theory in school textbooks reflected a wider, recurring struggle between America's commitment to science and widespread fundamentalist religious values. In several states, most notably Texas, citizens committed to Biblical interpretations of Creation successfully lobbied state textbook adoption committees to reject any text that described evolution as a scientific "fact." At best, the creationists argued, evolution was a "theory," and should be taught only in the context of competing theories. Because the Texas market for high school biology texts was very large, and because the state had a statewide textbook approval system, many publishers chose to avoid discussion of evolution in their texts, to protect the sales of their texts in a key market.[31] The struggles over creationism in schools showed the power of textbooks to create common cultural meanings for students—sometimes at the expense of what scientists believed.

Culture scientifique

As the cultural resonance of textbooks suggests, even books intended for use within the scientific community (or the proto-scientific community, in the case of students) were shaped by and had influence on wider communities. A famous example was The Structure of Scientific Revolutions (1962), a scholarly treatise by the physicist and historian of science Thomas Kuhn.[32] Kuhn offered a dramatic restating of how to imagine scientific change. He argued that the sciences did not proceed incrementally, but periodically underwent "paradigm shifts" in which scientific communities had to develop entirely new conceptual frameworks to reconcile new findings with "incommensurable" long-established explanations. In the tumultuous 1960s, many scholars and social commentators appropriated the term “paradigm shift” to question the traditional, positivist belief that progress necessarily followed from the continuing development of science and technology – an appropriation that deeply bothered Kuhn himself.[33]

Although Kuhn’s influence was mainly confined to the intellectual community, throughout the post-war period other science-related books appeared frequently on bestseller lists, earning Pulitzer prizes and similar tokens of cultural importance, thus illustrating the growth of a "culture scientifique" in America. Some books, such as Rachel Carson's Silent Spring (1962), credited as the founding document of the environmental movement, became revered objects for those sounding warnings about perils to the public interest; praised by some scientists, vilified by others, Carson's book illustrated how scientific controversies could not be separated from public controversies. [34] Indeed, although scientists frequently complain that science is not respected in American culture and that nonscientists need more "science literacy," the history of science books in public discourse suggests that science grew in popularity during the second half of the twentieth century – especially after the well-educated baby-boom generation began to reach adulthood in the1970s. By the end of the century, that popularity may have been a factor in the simultaneous growth of a religious, fundamentalist culture – a culture war between science and religion, between Romantic and Enlightenment outlooks that played out both on college campuses and in politics and other forums.[35]

From the end of World War II until 1977, only two science-related books won Pulitzer Prizes (Table 2). But from 1978 to 1984, five science books won, all in the "general nonfiction" category (which had been introduced in the early 1960s). In the late 1970s, science was also succeeding in other areas of public culture, with a "science boom" in magazines and television shows.[36] Even after the boom in magazines and television waned, science books remained strong, winning Pulitzers on average every other year from 1985 to 2000. Although the trend was not as clear for National Book Award winners (Table 3), science books were recognized by the arbiters of quality publishing (Fig. 2). These books became part of public culture through cocktail party discussions, references in editorials and magazine articles, and as college readings.

The 1970s also marked an inflection point for best-sellers. In the early post-war period, science books had appeared regularly on various best-seller lists, mixed in with other general reading books. Those lists became increasingly dominated, however, by cookbooks, self-help and fitness books, and various "packaged" books designed to be consumed as products rather than read as literature.[37] But a significant increase in best-selling titles that scientists could recognize as popularizations of current research occurred in the 1970s (Fig. 3). From the end of World War II until 1975, almost never did more than 10 new science books a year reach the New York Times weekly bestseller lists. After 1975, virtually never did fewer than 10 new science books each year reach the bestseller list.[38]

In 1974, Little, Brown released as a book the scripts of Jacob Bronowski's Ascent of Man, a BBC-produced television series. The book spent more than 40 weeks on the New York Times list, and the series became "required" viewing for many scientists and intellectuals. Bronowski's personal vision was crucial: the scripts contained an extended argument for the dominance of science over other approaches to understanding the world.[39] The success of Ascent of Man led to the U.S. Public Broadcasting System's decision to commission an even broader exploration of the universe from the astronomer Carl Sagan, who had already won a Pulitzer Prize for his best-selling Dragons of Eden (1977). Moreover, Ascent of Man producer Adrian Malone deliberately set out to create a star out of the astronomer.[40] He succeeded, perhaps too well: much of the criticism of the resulting show, Cosmos, focused on Sagan's immense ego. Sagan's insistence that the book version be a separate text, though it caused tension with Malone, nonetheless gave the book (published in 1980) an extra intellectual boost and many reviewers preferred it to the television show. The book was on the Times best-seller list for more than 70 weeks.

With Cosmos, science books became dramatically more visible in the publishing world. Until then, most science-oriented volumes had sales in the region of 100,000--200,000 hardcover copies, with a few reaching sales of 500,000. Cosmos sold 900,000 copies while on the bestseller list, and continued to sell well for years. As a result, in 1982 Sagan received a $2 million advance for his novel, Contact (1985), which at the time was the largest advance ever given for a fiction book that was not even in manuscript.[41] A few years later, Richard Feynman's Surely You're Joking, Mr. Feynman (1985) spent 15 weeks on the New York Times bestseller list. Three years later Hawking's book started its remarkable career. The numbers affected even books from less well-known authors: in 1995, Daniel Goleman's Emotional Intelligence sold 400,000 copies when it was fourteenth on the annual best-seller tally, and then sold more than 300,000 copies the following year even though it failed to break into the top-30 list.[42]

Still, Sagan and Hawking demonstrated an increasingly important phenomenon for book sales: the photogenic, media savvy scientist as object of public worship. As early as the 1950s, Jacques Cousteau's The Silent World (on the New York Times bestseller list for 33 weeks in 1953) was followed by a film of the same name, with stunning views of the undersea world. Joy Adamson's Born Free (1960), describing her life with a lion cub, spent 34 weeks on the New York Times best-seller list before becoming a 1966 feature film that directly contributed to the wildlife conservation movement. But these authors also show the complex relationship between the content of their books and their celebrity. Cousteau was as admired for his physique as his science; Adamson's maternal reflections on life in the jungle were as important as her ethological observations. Even Sagan himself was probably famous as much for his appearances on the Tonight Show with Johnny Carson as he was for his printed words. Like Hawking, Adamson, and others he was a celebrity within a general culture that increasingly valued celebrity for its own sake.[43]

Not all contributions to "culture scientifique" required such dramatic authorial presence, of course. The increasing attention to science made it easier for "explanatory" books to gain influence—volumes that served primarily to present the current status of areas of scientific work. Sometimes, these books addressed multiple audiences, serving as community-builders not just with the general public, but also within the scientific community. James Gleick's Chaos (1987), for example, was primarily a broad description of current developments in a fascinating area of science, and thus fit securely in the "popular science" genre. Yet at the same time, like Watson's Molecular Biology of the Gene, Gleick's book brought together for the first time a set of disparate work that had never previously – even among the intellectual community – been clearly seen as a single coherent field. Thus it was, in some ways, a founding document for a field of science that is today characterized by its own institutes, meetings, journals, and so on.

Coming shortly after Sagan's Contact novel and at about the same time as Hawking's Brief History of Time, Gleick's book also helped demonstrate the changing nature of the relationship between the scientific community and books. Beginning in the late 1970s with a series of autobiographies subvented by the Sloan Foundation, senior scientists had begun to see books as a way to address the public directly without violating the norms of peer-reviewed journals that held together their community of professional colleagues.[44] This new generation of "great men" of science discovered that books allowed them to make broad philosophical statements. They were aided in many cases by the literary agent John Brockman, who perceived his role to be the intellectual agent provocateur, that is, not simply a financial or sales agent, but one who shaped publishing to ensure that it affected cultural debate.[45] In the 1990s, he could achieve his goal of being a cultural avatar by focusing on science, demonstrating the crucial role that science had acquired in American culture.

The popularity of books by Alfred Kinsey, William Masters, and Virginia Johnson (Table 4) suggests the place of sex in contemporary culture as well. Based on scientific studies of human behavior, these authors' volumes were deliberately written in dry, technical language. Although the authors had political agendas, their authority depended on maintaining their scientific status, and so their rhetoric had to meet scientific expectations.[46] They skillfully plied the boundaries of science, sex, and culture. Many purchasers probably bought the books expecting something more titillating and never finished the detailed research reports. Nonetheless, the books created a common bond in conversations, set agendas for future debates, and became shared experiences. The language of science provided a cultural touchstone for readers from throughout the culture.

Furthermore, despite the extraneous appeal of celebrity and sex, many science books did have direct impact because of their content. Their arguments became important to policy debates and conversations among what the British call the "chattering classes." They were cited in magazine articles, in newspaper editorials and columns, in policy reports. Books like James Conant's On Understanding Science (1947), E. O. Wilson's Sociobiology (1975), or Richard Herrnstein and Charles Murray's Bell Curve (1994) were widely discussed, their sometimes controversial theses debated in academic conferences and colloquia. The ability of American culture to take up books as diverse as Lewis Thomas's essays on the human spirit or Herrnstein and Murray's polemics on racial politics suggests that the United States was not a science-phobic, anti-science culture (as many scientists feared).[47]

Cultural conflict

Yet it would be wrong to suggest that the growth of "culture scientifique" was universal, or even that the books of scientists themselves unequivocably contributed to that culture. The increase during the post-war era in religious publishing and the growing political power of religious fundamentalists after the 1960s suggests that a parallel cultural commitment to spirituality was common in the final years of the twentieth century. Indeed, some of the most popular science books carried a spiritual message that almost seemed to counter their more explicit rational, Enlightenment goals. Hawking's book was famous for its final paragraph, suggesting that finding a complete theory of the universe "would be the ultimate triumph of human reason – for then we would know the mind of God." Sagan's work also demonstrates this complexity. Sagan was an adamant believer in the power of science to explain the world, and actively worked with "skeptics" to question spiritual or supernatural explanations of natural events. Yet his biographers and various cultural critics have also noted that some of his books – including the immensely popular Cosmos – have deeply religious and mystical strains to them, commitments to "belief" that seem to contradict his oft-stated norm that "extraordinary claims require extraordinary proof."[48]

Along with challenges from religion, political conflicts also influenced the public life of science books. Silent Spring is the most prominent example of that phenomenon, having sparked or at least fed the growing environmental movement. Many of the key pieces of legislation related to the environment, however, came only after publication of other science-based polemics in 1968, including Garrett Hardin's "Tragedy of the Commons" and Paul Ehrlich's Population Bomb. On the opposite political side, Julian Simon and Herman Kahn published their The Resourceful Earth in 1984, countering the argument that Earth's ability to sustain human population growth and technological development was necessarily limited. And, carrying the debate into the twenty-first century, Danish social scientist Bjørn Lomborg published The Skeptical Environmentalist (2001), arguing that data compiled over the years since the beginning of the environmental movement showed that concerns about environmental degradation were unwarranted. The book was widely attacked within the scientific community, with major critical reviews in the journals Science, Nature, and Scientific American, but the book received substantial support from the business community, including the Wall Street Journal and The Economist.[49]

Books provided the forum in which religious, spiritual, and political exchanges involving science could take place. Those forums provided a place, a discourse space, for communities of interest to explore crucial issues in American society in the postwar years.

Conclusion

Although scientists consider the post-war period to be a time when "science" appeared solely in journals, the evidence suggests that books continued to play a critical role in the practice of scientific work, the development of scientific knowledge, and the integration of science into the matrix of social and intellectual culture in post-war America.

Some of the vibrant life of science took place in the books "within" science, such as reference books and textbooks. The rapid growth of science and technology during the post-war era led to equally rapid growth in the numbers of these books, and the tremendous changes in scientific knowledge during that period led to new forms of reference material on the World Wide Web and in massive textbooks in constant need of revision. But ultimately more important for the life of science was the growing role of science in "culture scientifique."

To speak of science as something separate from culture is, of course, nonsense. Science is a fundamental part of the modern world, a way of understanding Nature that provides tremendous resources and potential for affecting the human place in the world. Society is, in very real ways, constituted by scientific knowledge and the products of thinking about practical problems in scientific ways. At the same time, science itself is shaped by the social networks in which it exists—including the networks governing book production. In the post-war era, science books kept science alive. They kept knowledge growing through reference books and textbooks; they ensured that the intellectual elites had access to scientific ideas and incorporated them into broader intellectual life; and they provided a means for the American public, in its many forms, to engage with scientific knowledge and agree to the powerful social consensus that provides life to science through public funding and other resources. Scientific knowledge may be produced at the micro-level through journals and other types of communication. But science itself lives through books.

# # #

Bibliographic Note

The recent history of science communication has focused on peer-reviewed journals, with little attention to books. Key works include William D. Garvey, Communication: The Essence of Science (Oxford/New York: Pergamon Press, 1979) and David A. Kronick, A History of Scientific and Technical Periodicals: The Origins and Development of the Scientific and Technological Press, 1665-1970, 2nd ed. (New York: Scarecrow Press, 1976). More general discussions of the role of communication in science appear in Diana Crane, Invisible Colleges: Diffusion of Knowledge in Scientific Communities (Chicago: Chicago Press, 1972), Warren Hagstrom, The Scientific Community (New York: Basic Books, 1965), Robert K. Merton, The Sociology of Science: Theoretical and Empirical Investigations, ed. Norman W. Storer (Chicago: University of Chicago Press, 1973), Derek J. de Solla Price, Little Science, Big Science (New York: Columbia University Press, 1963), and John M. Ziman, Public Knowledge: An Essay Concerning the Social Dimension of Science (Cambridge: Cambridge University Press, 1968).

Since the 1970s, the sociology of science has highlighted the ways in which rhetoric shapes the creation of scientific knowledge, with changes in rhetoric tied to different audiences. Though the cases explored in this literature range from the Scientific Revolution to the contemporary, the ideas are key to understanding the current state of science books and the idea that science and culture are deeply intertwined. Several key works include Terry Shinn and Richard Whitley, eds. Expository Science: Forms and Functions of Popularisation (Dordrecht/Boston/Lancaster: D. Reidel, 1985), Charles Bazerman, Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science (Madison: University of Wisconsin Press, 1988), and Greg Myers, Writing Biology: Texts in the Social Construction of Scientific Knowledge (Madison: University of Wisconsin Press, 1990).

Records of recent science publishing are still scattered in individual collections, or often still in the possession of particular publishers or companies. In addition to statistics drawn from best-seller lists in Publishers Weekly and The New York Times, for much of the period of this chapter, the Journal of Chemical Education carried a regular column commenting on textbooks and other science-related publications, providing pointers to important books of the time.

Acknowledgements

I thank Cornell undergraduate Diane Renbarger for compiling bestseller and prize statistics; the Chemical Heritage Foundation for its generous support through a Eugene Garfield Fellowship in the History of Science Information; and David Paul Nord, Joan Shelley Rubin, and Michael Schudson for their interest, support, and forbearance.

ENDNOTES

1. Michael White and John R. Gribbin, Stephen Hawking: A Life In Science, new updated ed. (Washington, DC: Joseph Henry Press, 2002).
2. Stephen W. Hawking, A Brief History of Time: From The Big Bang To Black Holes (New York: Bantam Books, 1988).
3. John Maddox, "The Big Big Bang Book," Nature 336 (1988): 267; Michael Rodgers, "The Hawking Phenomenon," Public Understanding of Science 1, no. 2 (1992): 231-234.
4. Pierre Fayard, La communication scientifique publique: De la vulgarisation a la mediatisation (Lyon: Chronique Sociale, 1988); Bernard Schiele, ed., When Science Becomes Culture: World Survey of Scientific Culture (Proceedings I) (Boucherville, Quebec: University of Ottawa Press, 1994); Bernard Schiele and Réal Jantzen, eds., Les territoires de la culture scientifique (Lyon/Montréal: Press Universitaires de Lyon/Les Presses de l'Université de Montréal, 2003).
5. Diana Crane, Invisible Colleges: Diffusion of Knowledge in Scientific Communities (Chicago, Illinois: Chicago Press, 1972); Warren Hagstrom, The Scientific Community (New York: Basic Books, 1965); Robert K. Merton, The Sociology of Science: Theoretical and Empirical Investigations, ed. Norman W. Storer (Chicago: University of Chicago Press, 1973).
6. William D. Garvey, Communication: The Essence of Science--Facilitating Information Exchange among Librarians, Scientists, Engineers and Students (Oxford/New York: Pergamon Press, 1979).
7. David A. Kronick, A History of Scientific and Technical Periodicals: The Origins and Development of the Scientific and Technological Press, 1665-1970, 2nd ed. (New York: Scarecrow Press, 1976); Charles Bazerman, Shaping Written Knowledge: The Genre and Activity of The Experimental Article in Science (Madison: University of Wisconsin Press, 1988); Alan G. Gross, The Rhetoric of Science (Cambridge: Harvard University Press, 1990); Greg Myers, Writing Biology: Texts in the Social Construction of Scientific Knowledge (Madison: University of Wisconsin Press, 1990); Antoinette Miele Wilkinson, The Scientist's Handbook for Writing Papers and Dissertations (Englewood Cliffs, N.J.: Prentice Hall, 1991).
8. Robert Day, How to Write & Publish a Scientific Paper, 5th ed. (Phoenix: Oryx, 1998).
9. CBE Style Manual Committee, CBE Style Manual: A Guide for Authors, Editors, and Publishers in the Biological Sciences, 5th rev. and expanded ed. (Bethesda, Md.: Council of Biology Editors, 1983).
10. American Society for Agronomy, Crop Science Society of America, and Soil Science Society of America, Author's Guide and Style Manual for ASA, CSSA and SSSA Publications (Madison, WI: American Society for Agronomy, Crop Science Society of America, Soil Science Society of America, 1968); Janet Dodd, ed., The ACS Style Guide (Washington, D.C.: American Chemical Society, 1992).
11. Committee on Scientific and Technical Communication of the National Academy of Sciences-National Academy of Engineering, Scientific and Technical Communication (Washington, DC: National Academy of Sciences, 1969); National Academy of Sciences, Proceedings of the International Conference on Scientific Information (Washington, DC: National Academy of Sciences, 1959); Royal Society, The Royal Society Scientific Information Conference, 21 June--2 July 1948: Report and Papers Submitted (London: Royal Society, 1948); Marcel C. LaFollette, "Scientific and Technical Publishing in the United States, 1880-1950," in A History of the Book in America (1880-1950) (New York: Cambridge University Press, in press); Eugene Garfield, "In Truth, The `Flood' of Scientific Literature Is Only A Myth," The Scientist 5, no. 17 (1991). Derek J. de Solla Price first explored the

exponential growth of science in Derek J. de Solla Price, Science Since Babylon (New Haven: Yale University Press, 1961).
12. Stephen Hilgartner, "The Dominant View of Popularization: Conceptual Problems, Political Uses," Social Studies of Science 20, no. 3 (1990): 519-539, Bruce V. Lewenstein, "From Fax to Facts: Communication in the Cold Fusion Saga," Social Studies of Science 25, no. 3 (1995): 403-436; Terry Shinn and Richard Whitley, eds., Expository Science: Forms and Functions of Popularisation (Dordrecht/Boston/Lancaster: D. Reidel, 1985).
13. The original Handbook of Chemistry and Physics, published in 1913 by the Chemical Rubber Company, had grown by 1973 to become the base of a publishing program so full that the Chemical Rubber Company sold its manufacturing activities to concentrate on publishing; in 2003, the CRC Press became part of the Taylor & Francis group of scientific journals and book publishing companies (www.crcpress.com/corphistory.asp, accessed 10 July 2003).
14. Mary Ellen Bowden, Trudi Bellardo Hahn, and Robert V. Williams, eds., History and Heritage of Science Information Systems (Proceedings of a Conference) (Medford, NJ: Information Today, 1999); W. Boyd Rayward and Mary Ellen Bowden, eds., The History and Heritage of Scientific and Technological Information Systems: Proceedings of the 2002 Conference (Medford, NJ: Information Today, 2004).
15. Eugene Garfield, Arnold Thackray, and Jeffrey L. Sturchio, "Oral History of Eugene Garfield" (Philadelphia: Chemical Heritage Foundation/Beckman Center for History of Chemistry, 1987), 40 pp., available at http://www.isinet.com/aboutus/, accessed 8 January 2004.
16. Thomas F. Gieryn, "What Buildings Do," Theory and Society 31, no. 1 (2002): 35-74.
17. Sally Gregory Kohlstedt, Michael Sokal, and Bruce V. Lewenstein, The Establishment of Science in America: 150 Years of the American Association for the Advancement of Science (New Brunswick, N.J.: Rutgers University Press, 1999).
18. The field of physics and its subdisciplines had the most well-developed system, originally housed at Los Alamos National Laboratory, now based at Cornell University and available at www.arxiv.org.
19. H. H. Hess, "History of Ocean Basins," in Petrologic Studies: A Volume in Honor of A. F. Buddington, ed. A. E. J. Engel, H. L. James, and B. L. Leonard (Boulder, Colo.: Geological Society of America, 1962), 599-620.
20. Robert V. Blystone and Kimberly Barnard, "The Future Direction of College Biology Textbooks," BioScience 38, no. 1 (1988): 48-52.
21. The growth of the U.S. scientific and technical community is documented in the Science and Engineering Indicators series of reports issued biennially by the U.S. National Science Board, the governing body for the U.S. National Science Foundation.
22. Mary Jo Nye, "From Student to Teacher: Linus Pauling and the Reformulation of the Principles of Chemistry in the 1930s," in Communicating Chemistry: Textbooks and Their Authors, ed. Anders Lundgren and Bernadette Bensaude-Vincent (Canton, Mass.: Neale Watson Publications, 1999).
23. Charles Holbrow, “Archaeology of a Bookstack: Some Major Introductory Physics Texts of the Last 150 Years,” *Physics Today* (March 1999): 50-56.

24. Edward Yoxen, "Speaking Out About Competition: An Essay on The Double Helix as Popularisation," in Shinn and Whitley, Expository Science, pp. 163-181.
25. Carol Kaesuk Yoon, "Ledyard Stebbins, 94, Dies: Applied Evolution to Plants," New York Times, 21 January 2000, B9; Vassiliki Betty Smocovitis, Unifying Biology: The Evolutional Synthesis and Evolutionary Biology (Princeton: Princeton University Press, 1996); Stephen Jay Gould, The Structure of Evolutionary Theory

(Cambridge: Belknap Press of Harvard University Press, 2002); Ernst Mayr, What Evolution Is (New York: Basic Books, 2001).
26. Robert C. Kerber, "Elephantiasis of the Textbook," Journal of Chemical Education 65, no. 8 (1988): 719-720, on p. 719.
27. Robert V. Blystone, Kimberly Barnard, and Sarah Golimowski, "Development of Biology Textbooks," BioScience 40, no. 3 (1990): 300-303.
28. John C. Bailar, Jr., "First Year College Chemistry Textbooks," Journal of Chemical Education 70, no. 9 (1993): 695-698.
29. Kohlstedt, Sokal, and Lewenstein, The Establishment of Science in America; Jack S. Goldstein, A Different Sort of Time: The Life of Jerrold R. Zacharias, Scientist, Engineer, Educator (Cambridge, MA: MIT Press, 1992).
30. American Association for the Advancement of Science, Benchmarks for Science Literacy (New York: Oxford University Press, 1993); National Council of Teachers of Mathematics, Curriculum and Evaluation Standards for School Mathematics (Reston, Va.: National Council of Teachers of Mathematics, 1989); National Research Council, National Science Education Standards (Washington: National Academy Press, 1996).
31. The Texas controversy and related efforts to teach creationism and "intelligent design" elsewhere in America waxed and waned over the last four decades of the twentieth century. They continue as this essay is completed: see the National Center for Science Education's website (www.ncseweb.org) for current information.
32. Thomas S. Kuhn, The Structure of Scientific Revolutions (Chicago: University of Chicago Press, 1962).
33. Thomas S. Kuhn, Black Body Theory and the Quantum Discontinuity, 1884-1912 (Chicago: University of Chicago Press, 1978). See also Steve Fuller, Thomas Kuhn: A Philosophical History For Our Times (Chicago: University of Chicago Press, 2000). A new biography of Kuhn which will include more discussion of the cultural response to his work is in preparation as this chapter goes to press: Keay Davidson, The Death of Truth: Thomas S. Kuhn and the Evolution of Ideas (New York: Oxford University Press, in press). For just one example of the commentary on Kuhn, see Steven Best and Douglas Kellner, The Postmodern Turn: Paradigms Shifts in Art, Theory, and Science (New York: Guilford Press, 1997).
34. For reactions to Carson, see for example Lawrence Lessing, "The Three Ages of Science Writing." Chemical and Engineering News, 6 May 1963, 88-92; Linda Lear, Rachel Carson: Witness for Nature (New York: Henry Holt, 1997); and Julian Simon, The Economics of Population Growth (Princeton: Princeton University Press, 1977).
35. Gerald Holton, Science and Anti-Science (Cambridge: Harvard University Press, 1993).
36. Bruce V. Lewenstein, "Was There Really a Popular Science 'Boom'?," Science, Technology & Human Values 12, no. 2 (Spring 1987): 29-41.
37. Michael Korda, Making the List: A Cultural History of the American Bestseller, 1900-1999 (New York: Barnes & Noble Books, 2001).
38. Data compiled by research assistant Diane Renbarger, "New York Times bestsellers, 1945-2000" (Ithaca, NY: 2002), and maintained in a database by the author.
39. Thomas M. Lessl, "Naturalizing Science: Two Episodes in the Evolution of a Rhetoric of Scientism," Western Journal of Communication 60, no. 4 (1996): 379-396.
40. Keay Davidson, Carl Sagan: A Life (New York: J.Wiley, 1999), p. 321.
41. Davidson, Carl Sagan; William Poundstone, Carl Sagan: A Life in the Cosmos (New York: Henry Holt, 1999).
42. All sales figures drawn from the annual compilations from Publishers Weekly.
43. Maddox, "The big Big Bang book"; Rodgers, "The Hawking Phenomenon."

44. The first book in the series was Freeman J. Dyson, Disturbing the Universe (New York: Harper & Row, 1979).
45. Felicity Barringer, "Cancer-Drug News Puts a Focus on Reporters and Book Deals," New York Times, 8 May 1998, A11;Carlin Romano, "Agent of Eggheads," Philadelphia Inquirer, 5 September 1995, D1; and John Brockman, The Third Culture (New York: Simon & Schuster, 1995).
46. Jonathan Gathorne-Hardy, Sex -- The Measure of All Things: A Life of Alfred C. Kinsey (Bloomington: University of Indiana Press, 2000).
47. Fears about an "anti-science" culture were widely circulated in the mid-1990s; see, for example, Holton, Science and Anti-Science and Paul R. Gross and Norman Levitt, Higher Superstition: The Academic Left and Its Quarrels With Science (Baltimore: Johns Hopkins University Press, 1994).
48. Davidson, Carl Sagan; Poundstone, Carl Sagan.
49. Jim Giles, "The Man They Love To Hate," Nature 423 (2003): 216-218, Bjorn Lomborg, The Skeptical Environmentalist (New York/London: Cambridge University Press, 2001).