

Understanding Scientific Communication

A Collaboration with Alan G. Gross

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In contemporary science outside purely theoretical physics collaboration is a way of life. An article with a dozen authors is the rule, not the exception. In scholarship within the humanities, by contrast, seldom does one encounter journal articles or research monographs with more than one author. My scholarly collaboration with Alan Gross is thus somewhat unusual. It is even more unusual in that within the span of two decades, it has yielded four books published by university presses, with a fifth nearing completion and a sixth in the planning stages. The books we have written together differ significantly, for the better, from what either of us could have produced alone.

Past Is Prologue

My own scholarly interest in scientific communication started in the mid-1980s, when I happened upon a little known but impressively researched book by David A. Kronick, *A History of Scientific & Technical Periodicals: The Origins and Development of the Scientific Press, 1665-1790* (1976). Based on Kronick's PhD thesis in library science at the University of Chicago, it is a comprehensive guide to the scientific journals and society proceedings founded in the seventeenth and eighteenth centuries. Kronick's history begins in the year 1665 because that year marks the beginning of the scientific literature with the founding of *Philosophical Transactions* in London and *Journal des Sçavans* (Journal of the Learned) in Paris. A similarly impressive but equally obscure book is Robert Mortimer Gascoigne's *A Historical Catalogue of Scientific Periodicals, 1665-1900* (1985). That book identified the most significant scientific periodicals from their origin in 1665 through 1900. These two books gave me a strong sense of the history of scientific journals and proceedings, but did

not offer much of a sense of what the articles in them were like. Also, neither book ventured into the scientific literature of the twentieth century.

The above books aside, in the mid 1980s, I did not find much scholarly literature on scientific communication in general, and nothing to speak of on the narrower topic of the origin and development of the scientific article. Nevertheless, in my visits to the University of Chicago's library, I did find complete runs of *Philosophical Transactions*, *Mémoires de l'Académie Royale des Sciences*, *Annalen der Physik*, and a building full of other scientific journals spanning the 17th century to the present. Many a glorious vacation day away from work I spent paging through dusty journals and reading articles by the famous (Newton, Boyle, Hooke, Huygens, Lavoisier, Darwin, Einstein, Wegener, Feynman, Watson, Crick, Weinberg, and so on) along with the largely forgotten. Wouldn't Martin Lister (1639-1712), I wondered, have been thrilled to know that someone in the distant future was reading his marvelous article on English plants in *Philosophical Transactions*? Here's a short extract from that early scientific article (1697), with the original spelling and punctuation intact:

The 21st of April, 1665, about eight in the morning, I bored a hole in the body of a fair and large Birch, and put in a Cork with a Quill in the middle; after a Moment or two it [a sap] began to drop, but yet very softly: Some three Hours after I returned, and it had filled a Pint Glass, and then it dropped exceeding fast, *viz.* every Pulse a Drop: This Liquor is not unpleasant to the Taste, and not thick or troubled; yet it looks as though some few drops of Milk were split in a Bason of Fountain Water (Lister, 1697).

How, I also wondered, did we get from Lister to the typical prose of contemporary science, a complex web of long noun phrases, quantifications, abbreviations, and specialized technical terminology? This passage from Goodman and Rich is fairly typical:

A plateau appears as a mass ratio of sRNA to DNA of 0.025 per cent. Thus, only a very small portion of the DNA is able to accept an sRNA molecule in hybrid formation. Furthermore, these results show that the preparation does not contain ribosomal RNA, since DNA-ribosomal RNA hybrids contain six times more RNA. If cold ribosomal RNA is added to the annealing mixture, it does not compete with the bonding of sRNA, thereby suggesting that the ribosomal RNA sites are

different from the sRNA sites. The genome in *E. coli* contains a DNA molecular weight equivalent of 4×10^9 (Goodman and Rich, 1962).

I initially planned to write a book on the topic, but made no real progress.

Other scholars at that time must have also realized that scientific communication was fertile ground, largely untilled, because everything changed in the late 1980s. From my point of view, a turning point was the publication in 1988 of Charles Bazerman's *Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science*. Bazerman wrote about the composition of the experimental article from its beginning in the 17th century through the 20th. Especially noteworthy was his brilliant analysis of Newton's 1672 *Philosophical Transactions* article on optics. He showed how the controversy it raised among the Fellows of the Royal Society of London resulted in Newton strengthening the arguments and counterarguments that eventually appeared in his major book *Opticks*, published more than three decades later. Bazerman performed a similarly astute literary analysis of Arthur Holly Compton's drafts and notes for his 1925 experimental article related to quantum theory, published in *Physical Review*. These examples showed beyond a shadow of a doubt to me that rhetoric matters in science.

Rhetoric has several dimensions. While Bazerman's emphasis was on argumentation and persuasion, he mostly relied on traditional literary techniques for his analysis of scientific texts. Aristotle is barely mentioned. The year after Bazerman's book came one by Lawrence Prelli, *A Rhetoric of Science: Inventing Scientific Discourse* (1989). Drawing heavily on Aristotle and Kenneth Burke, Prelli rigorously applied classical rhetorical theory to case studies—most notably the controversy over whether the great ape can communicate with humans through language.

The year after Prelli's book, 1990, came two more classics. One was Greg Myers's *Writing Biology: Texts in the Social Construction of Knowledge*. As the title suggests, Myers focus was the social aspects of constructing texts in the biological sciences. One chapter, for example, follows the changes in two biological papers as the authors respond to criticisms from peer reviewers and adjust their prose to the different audiences for different scientific journals. Myers highlighted the consensus-building aspect behind the process of writing and revision.

The other important book of 1990 was, of course, Alan Gross's *The Rhetoric of Science*. Alan's title notwithstanding, and in

contrast to Prelli's similarly but not identically titled book, he varies widely in his analytical tools, drawing on the works of not only rhetoricians Aristotle, Chaïm Perelman, and Lucie Olbrechts-Tyteca, but also on literary theorist Roland Barthes, sociologist and philosopher Jürgen Habermas, sociologist of science Robert Merton, historian of science Thomas Kuhn, social anthropologist Claude Lévi-Strauss, and cultural anthropologist Victor Turner. And unlike the other books on scientific communication at the time, Alan took a radical position that drew much critical fire: in particular, "the sense that a molecule of this structure [DNA] exists at all, the sense of its reality, is an effect *only* of words, numbers, and pictures judiciously used with persuasive intent" (Gross, 1990, 54; my emphasis). Alan has been wrestling with the epistemological implications of the "only" in that sentence ever since (see, for example, Gross, 2013). Those implications aside, Alan's provocative sentence also conveys a weaker claim, but no less important: We can understand science fully only if we understand how its "words, numbers, and pictures [are being] judiciously used with persuasive intent." And that has been one of the main concerns in all our subsequent collaborations.

I hope the above remarks convey that the late 1980s and early 1990s were heady times for those with a strong scholarly interest in the rhetoric and communication of science. Indeed, there are many other superb books and articles from that period that I did not mention, ones by Herb Simons, Carolyn Miller, Jeanne Fahnestock, John Angus Campbell, Marcello Pera, Randy Allen Harris, Leah Ceccarelli, and others too numerous to list here.

The Collaboration Lifts Off

In the spring of 1993, Alan and I met for the first time. I invited him to give a talk before the Chemical Technology Division at Argonne National Laboratory. He read a paper about rhetoric and the 1986 *Challenger* accident, when its seven crew members died after the space shuttle exploded shortly after takeoff. A much-publicized investigation revealed that, as a result of the low temperature at launch, the shuttle's O-rings did not seal adequately. Alan's talk centered on the pre-launch debate between NASA management and engineers over whether it was too cold to launch.

I had warned him beforehand that it would be best to give a "talk," not read a paper before a group of scientists because they, in general, take a dim view of those who must rely upon the crutch of a prepared text to speak on something about which they supposedly have some expertise. Alan ignored me because at that time (long before PowerPoint presentations had penetrated all disciplines) he

was not comfortable without a paper to read for that sort of oral communication.

As you might expect, the paper he read was highly critical of NASA management and its “cognitive and ethical failures.” I knew that it might not sit well with some scientist-manager types in the audience. As it turned out, the talk went over better than I had anticipated, but one scientist-friend accosted me in the hallway afterwards as I was returning to my office. Himself a manager and notoriously demanding with his staff, he was furious about Alan’s criticism of NASA management.

“Where in the world did you find this guy?” he challenged me. “What does he know about management? He could not even speak on the topic without reading verbatim his prepared text. (I knew that one was coming.) What’s his background anyway?” I gave a brief synopsis, mentioning the *Rhetoric of Science*. “Oh yeah, who published it?” (I think he expected some obscure academic press.) When I answered “Harvard” he was momentarily taken aback. (The name does bring with it some authority, even among scientists who did not attend there). Then, he asked, “On yeah, how many copies did it sell?” I responded, “I don’t know, probably a couple thousand.” To which he scoffed, “Figures!” and stomped off. The lesson here is that factors beyond just argumentative rigor do matter when it comes to persuasion.

At lunch with Alan afterwards, I did not mention that minor encounter with my irate friend, but Alan and I did have a long conversation about our mutual interest in scientific communication, in the course of which I mentioned my vague idea for a book on the history of the scientific article from its origin to the present time. I was not really interested in pursuing that book by myself because I had already done some preliminary work and got nowhere other than rehashing material of others. I was floored how quickly Alan came up with an ambitious strategy that I could immediately see, if executed properly, would result in a publishable manuscript of original research. Alan explained that we would need a reasonable strategy for assembling a representative sample of scientific articles, a uniform method for analyzing the selected articles, and a theory with which to explain changes in them over time. At that same lunch, we also hashed out our basic approach to solving those methodological problems and agreed to mull over, in the coming month or two, whether such a book project would be worth our time and effort. Little did we know what we were getting ourselves into when, shortly thereafter, Alan wrote me to say, “‘In dreams begin responsibility’ (W. B. Yeats). Let’s follow this dream.” We estimated such a book should take us two years, three

max...Part rhetoric of science, part genre study, part history of scientific communication, part quantitative linguistic analysis of a corpus, *Communicating Science: The Scientific Article from the 17th Century to the Present* (2002) appeared in print nine years later.

In those years with the partial assistance of Michael Reidy, then a graduate student in the history of science, we analyzed thousands of randomly selected texts from hundreds of scientific journals in French, English, and German published between 1665 and 2000. What emerged from our study was the first ever quantitatively based picture of the changes that have occurred in the writing style, presentational features (such as section headings and method of integrating illustrations into the text), and the argumentative structure of scientific articles over four centuries in the three main languages of Western science. We also explained those changes by drawing on a selection theory for conceptual evolution developed separately by philosophers Stephen Toulmin, David Hull, and others. In a review article on the rhetoric of science literature, Cezar Ornatowski captured the main conclusion from our research in a long, winding, but accurate sentence:

Gross et al. show that the stylistic, presentational, and argumentative apparatus of modern science evolved largely in response to the changing contexts of doing science, the changing tools of science, the increasing volume of knowledge, the need to adjudicate increasingly conflicting accounts of phenomena, the growing professionalization of science (from science as something performed and read by enthusiasts to something increasingly done by specialized professionals), and the need to navigate the increasingly complex nature of scientific information, as well as to larger socio-political changes in Western society (Ornatowski, 2007).

Looking back on this ambitious book project now, I wonder how we managed to do as much as we did in only nine years. Had we not reached a point of exhaustion, we could probably have continued gathering and analyzing data for another nine years.



Alan Gross (left) and Joseph Harmon (right) in 1999. Photo by Dr. Ralph Leonard.

The Collaboration Continues: One Book Leads to Another

About a year after the publication of *Communicating Science*, in November 2002, Alan and I attended a History of Science Society Meeting in Milwaukee, where we met one evening for dinner and planned our next two books, both drawing heavily upon the extensive research we had done for our first book.

While consuming our main course, we decided our next book would be an anthology-like collection of short extracts from the scientific literature. For understandable reasons, very few outside of scientists or science studies scholars ever read the scientific literature. And even scientists or scholars are typically familiar only with a narrow segment of this literature. Our aim was to give anyone interested a guided tour of this genre over more than three centuries. While the articles from which we extracted passages all first appeared in scientific publications, we assiduously searched for short passages within them that could be understood by a general learned audience without major struggle. To further assist our readers, for each excerpt, we appended a commentary that explains its scientific and historical context and analyzes its communicative strategy. For this book the time between conception and its realization was comparatively short. *The Scientific Literature: A Guided Tour* appeared in 2007, five years after our Milwaukee brainstorming session.

Over dessert at the same dinner, we also decided to write a how-to-write book for scientific researchers. While there was really no similar book to *The Scientific Literature*, the market was already flooded with style manuals and writing guides, several of them

quite good. So we needed an angle to distinguish our planned book from the horde. We eventually decided that our unique approach would be to focus on how good scientists actually write, rather than how we thought they ought to write. In *The Craft of Scientific Communication* (2010), we did that by basing our writing principles on the previous research that we and others had done and drawing our examples from actual articles and books by successful scientists of the past and present. We thought that most other similar writing books suffered from too heavy reliance on manufactured and sometimes misleading examples to illustrate a point, lack of a historical context, and a focus on minor stylistic details that have little to do with making complex prose understandable by the intended audience.

For our next book project together, we needed no meeting or meal to decide upon its course. Through email and phone conversations, we decided to leave pedagogical and anthology writing behind and return to original scholarship, in particular, a study of visual scientific communication. From our previous books, we had become acutely aware of the historic pervasiveness and importance of images in scientific texts. Still, the emphasis in scholarly inquiry into scientific communication had been firmly on the verbal, including our own past publications. *Science from Sight to Insight: How Scientists Illustrate Meaning* (2013) was intended to bring the study of scientific images and visualization into the mainstream of the scholarship on the communication of science.

In trying to decipher the meaning behind the many figures reproduced in *Science from Sight to Insight* (more than a hundred), we consulted many science studies books and articles in which the authors had discussed a given figure. Much to our dismay and frustration, we too often found the text provided a very thin exegesis of the figure. Indeed, in some cases, we had to question whether the scholar had fully understood the given figure in the first place. Our hope is that this our latest published book will provide science studies scholars with an approach for better understanding and explicating scientific images.

Science from Sight to Insight ends with a chapter on scientific communication and the Internet. So, it seemed only logical that our subsequent book should treat that important topic in greater depth. At a meeting with our editor, Christie Henry, and two associates in the summer of 2012, over a light lunch (yes, food again) in a stately wood-paneled conference room at the University of Chicago Press in Hyde Park, she suggested we expand the scope of this book project to cover the humanities. Thus was born *The Internet Revolution in Science and Scholarship*, which is under peer review

as I write. It opens with a new look at C. P. Snow's distinction between the two cultures, the sciences and humanities, a distinction that provides the impetus for a book that contends that the Internet revolution has sown the seeds of transformative changes in both cultures. It is because of this common situation that each culture can learn from the other in matters key to both: generating, evaluating, and communicating new knowledge on the Internet. By closely examining what's happening at the forefront of Internet science and humanistic scholarship in these three areas, we hope to provide readers with a glimpse into the future. We also hope this book will inspire scientists and scholars, at whatever stage in their careers, to experiment more with and participate in Internet-based projects.

As we were closing in on a complete manuscript for *The Internet Revolution in Science and Scholarship* early in 2013, we naturally began thinking about what to do next. Examining our body of work, Alan decided that one potential topic we had given short shrift is the communication of science to the public. In this latest book, which is very much in the early stages and tentatively titled *Popular Science and Popular Scientists*, we will seek to come to grips with the popularization of science by contemporary or near-contemporary scientists and science writers: writers such as Steven Weinberg, Richard Feynman, Stephen Hawking, Richard Dawkins, Steven Pinker, Stephen Jay Gould, Brian Green, Rachel Carson, and Lisa Randall. We will emphasize their ability to employ argumentative and narrative skills to persuade the general public of the value of science for answering fundamental questions such as, What is the origin of the universe? What makes us tick? How did we get here?

Over the years Alan and I have occasionally discussed what makes our collaboration click. There are many factors, none of them too surprising. Perhaps most important is our complementary skills and experience: Alan having spent most of his career as an academic with a specialty in the rhetoric of science, I serving on the communications staff of a scientific research laboratory. But there are other factors such as willingness to accept criticism from each other without taking offense (much), drive to succeed, compatible writing styles, and enjoyment of each other's company. Because of the synergistic power of collaboration, the books we have written together differ significantly, for the better, from what either of us could have produced going solo, as I said at the beginning.

To write a publishable scholarly book—as we have done together five times now—one must not only do research on a topic nearly

every day over many years, but start with a dream that has a reasonable chance of becoming a reality. After two decades, we have not stopped dreaming.

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