# Science and the Media


Edited by Donald Kennedy
and Geneva Overholser

AMERICAN ACADEMY OF ARTS & SCIENCES

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# Contents

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Leslie Berlowitz
*Chief Executive Officer and*
*William T. Golden Chair*
*American Academy of Arts and Sciences*

# Preface

How do we enrich Americans' engagement with science and technology? That is the quest that brought scientists, journalists, and leaders of science institutions together at a series of workshops organized by the American Academy of Arts and Sciences and supported by the Annenberg Foundation Trust at Sunnylands.

Why did the participants find this topic so compelling? Discomfort with or disinterest in science is widespread enough to seem "normal" in the United States. Since *somebody* must understand science and technology well enough, why worry that others don't?

In fact, scientific illiteracy has deep and wide implications for public policy in the United States and around the world. Having a minority in a democracy conversant with science and technology produces a low level of public discussion and makes for impoverished policy-making. On issues of great public import, from energy policy to climate change, from how to teach evolution to how to fight disease, a lack of scientific knowledge undermines progress. When a nation invades another with little clarity about the science and technology underlying the war's proximate cause, when a population is seized by fears that science has shown to be unreasonable, when children may not learn basic building blocks of knowledge because scientific understanding and moral judgments are conflated—then a widespread understanding of science seems a compelling need. And this is true not just for Americans. With the rest of the world feeling the results of our policy decisions, the responsibilities of this nation's citizens are ever greater.

So what accounts for the sorry state of Americans' civic scientific literacy? The educational system, of course. But many other factors contribute. Journalists and their conventions play a powerful role, one made more complex today with growing resource pressures on the media. Scientists and *their* traditions are also part of the problem—and solution—along with public information officers and public officials. The Academy's working group on Science, Technology, and the Media wrangled with all these questions, trying to determine which issues seemed most critical—and what eventually might be done to address them.

How science and technology are covered by the media is a central factor in scientific illiteracy. Journalists value timeliness, speed, simplicity, and clarity. Yet stories about science and technology may be long-building, complex, and without dramatic, time-pegged events. The need to grab and hold attention, to write tight stories or produce short segments, can come at the cost of context and nuance. One observer, noting journalism's preference for attention-grab-bing, conflict-driven events, has joked that reporters two thousand years ago would have covered the heck out of the crucifixion—and missed Christianity.

To make science and technology coverage still more challenging, the journalistic tradition of objectivity has often been distorted into a kind of false balance, giving equal weight to opposing views, no matter how much or little credibility or value they possess. Scientific issues may be closely interwoven with moral or ethical controversy—consider stem-cell research, evolution, even climate change. Yet journalism's conventions make it ill-suited to aiding the public in disentangling the underlying science from the controversy, sometimes creating in the observer the notion that scientific thinking is divided even when it is not. And it is not always easy for journalists—or the public—to accept the tenet that all scientific knowledge is provisional. As one of the journalists put it: should we have covered Newton or should we have waited for Einstein?

Meanwhile, many in the scientific community are reluctant to speak to the press or to engage with the public. One bad experience with an interviewer may turn a scientist off to journalists for a lifetime. And "popularization" of one's work in mainstream media, far from winning acclaim for a scientist, is often viewed instead with disdain by colleagues. Our group also noted the glaring lack of training opportunities for scientists and engineers to acquire the skills to make them strong communicators. In fact, courses that might prepare future scientists to present their work to lay audiences are completely absent from most graduate training programs.

On the other side of the spectrum, some scientists who *have* become adept at dealing with the press and the public either hype or over-simplify their work for an all-too-credulous interviewer. Little wonder, then, that science and medical stories—as one of our participants noted—seem always to fall into one of two categories: either no hope or new hope.

While the group focused much of its attention on science journalists, it recognized that many—perhaps the majority of—big science and technology news stories are covered by reporters who do not specialize in these areas. In fact, coverage of stories that have important science components appears every day, written or produced by journalists who lack any particular training or experience in science. The fact is there are fewer and fewer reporters on the science beat and ever smaller science news holes at the nation's daily newspapers and broadcast and cable outlets.

Into this mix, add public-relations people with varying degrees of training and government officials with varying degrees of scientific understanding themselves—not to mention the pull of institutional loyalties and varying attitudes toward openness. Meanwhile, traditional news media resources dwindle, and competition for limited government money for scientific research increases, while those determined to "spin" scientific stories grow ever more adept at doing so.

And what of the public? How well prepared are American citizens to engage in science and technology issues? The single largest determinant of a person's scientific literacy, one of the workshop participants noted, is whether he or she has taken a science course in college. Surveys indicate that Americans have a healthy respect for science. And they evince considerable interest in it. It's the *understanding* of science and technology that's lacking.

A piece of emerging good news is that enormous possibilities are opening now, with new media, for citizens to inform themselves. And the evidence suggests that there is a healthy appetite among news consumers for information about science and technology (and health); these topics are among the ones that people search for most frequently online. But what about their vulnerability to the pressures of narrow interests in the Wild West atmosphere of the Web? And, if understanding and communicating complex science stories is sometimes challenging even for veteran science reporters, what happens in an environment in which the user is king and the audience drives the discussion?

The participants in the workshops resolved to address this complex set of issues in a number of ways. The essays in this volume discuss the roles of scientists, journalists, and public information officers in communicating about science and technology. The authors look at the role the media play in boosting Americans' scientific literacy and at how the new digital media are changing the coverage (and consumption) of science news. They discuss how inadequate press coverage combined with poor communication by scientists can lead to disastrous public policy decisions.

* * *

The relationship between scientists and science journalists is the subject of the introductory essay by project cochair **Donald Kennedy**, former Editor-in-Chief of *Science* and President Emeritus of Stanford University. Starting with the assumption that citizens' broad understanding of science and technology is "a public good," Kennedy explores the complaints on both sides of the relationship and discusses ways to improve the clarity of communication.

Actor, writer, and director **Alan Alda**, who has interviewed dozens of scientists as the host of science-themed programs on public television, admonishes scientists to share their passion for their work with the public. Noting that good communication is fundamental to successful science at multiple levels, he suggests that some of the actor's techniques are well suited to enhancing scientists' ability to convey their work to the public.

According to **Cristine Russell**, Senior Fellow in the Environment and Natural Resources Program at the Harvard Kennedy School's Belfer Center for Science and International Affairs and President of the Council for the Advancement of Science Writing, the greatest challenge for the news media is to enhance public understanding of policy options. Russell provides a wide-ranging look at the state of science writing and explores opportunities for the media to provide more balanced coverage to benefit a wider audience.

Most Americans receive foundational instruction about science in school. But if science literacy is crucial to an informed citizenry, then adults need to continue learning about science long after their formal schooling, argues **Jon D. Miller**, the John A. Hannah Professor of Integrative Studies at Michigan State University. Miller, who has developed a scorecard for measuring a nation's "civic scientific literacy," examines the impact of the media on adult scientific literacy in the United States.

An essay coauthored by **Rick E. Borchelt**, Director of Communications for the U.S. Department of Agriculture's research, education, and economics mission area, **Lynne T. Friedmann**, freelance science writer, and **Earle Holland**, Assistant Vice President for Research Communications at Ohio State University, addresses a "trust gap" in science as an enterprise, and holds public relations practitioners responsible for a lack of dialogue and transparency. To cultivate trust, the authors argue for a fundamental change in the way information flows—from the current model of "one-way" communication to "two-way symmetric communication" between scientific organizations and their stakeholders.

**Robert Bazell**, Chief Science and Health Correspondent for NBC News, has spent his journalistic career interacting with public information officers like Borchelt and his coauthors. While agreeing with many of their conclusions, Bazell questions the basic assertion that Americans no longer trust science or the scientific enterprise. He also offers his own pragmatic assessment of the role that institutions play in disseminating science news.

**Cornelia Dean**, science writer and former Science Editor at *The New York Times*, discusses the "collective unwillingness and/or inability of scientists" to talk to the public. Dean recalls a time when the disconnect between scientists and the public was not very important. Today, however, it has big implications for the nation's public life. She offers practical suggestions for bridging the gap between scientists and the public.

In assessing the prospects for science journalism in a digital age, **Alfred Hermida**, a veteran BBC correspondent and now Assistant Professor at the University of British Columbia Graduate School of Journalism, explores the changing nature of science news. Hermida welcomes the participatory potential of the Internet for science stories but warns that the nonlinear nature of the Web can make it a challenging medium, in which readers may "jump straight into a deep end."

Although journalists need not be scientists or engineers, they do need to have enough technical understanding to communicate effectively the scientific or technological dimensions of public policy issues that dominate the news. In his essay, **William A. Wulf**, University Professor and AT&T Professor of Engineering and Applied Sciences at the University of Virginia, cites six "poor, and perhaps even dangerous" examples of media coverage. His intention is not to condemn the media, but rather to invite journalists and the technical community to share a responsibility to inform the public.

* * *

As the world grows more complex, there is an increasing need for citizens to understand the scientific and technological dimensions of daily news events. Journalists play a critical role in helping readers, listeners, and viewers appreciate the science underlying major policy choices. And scientists, in turn, must effectively communicate to the public, especially through the media. We hope that the essays gathered in this volume will generate a broader understanding of the intertwined roles of the media and the scientific and technical community in helping to ensure a well-informed public.

Donald Kennedy and Geneva Overholser, *Cochairs*
*American Academy working group on Science, Technology, and the Media*

# CHAPTER 1

# Science and the Media

Donald Kennedy

Geneva Overholser, Director of the School of Journalism at the USC Annenberg School for Communication, and I have been engaged with a fine group of colleagues in thinking about an old and sometimes difficult topic: the relationship between journalists who report science and scientists who do the science on which they report. We are not the first group to have tackled this problem, nor do we seriously expect to have the last word on it. We have had wonderfully thoughtful written analyses by some of those involved in the transaction—not only science journalists like Corey Dean, Boyce Rensberger, and Bob Bazell; but scientists like Tom Lovejoy and Dan Schrag; and public information officers like Earl Holland and Rick Borchelt, who are often found near the center of such exchanges. Our committee has proceeded with some enthusiasm because we think scientific understanding is a precious resource for society and because we believe the interface for scientific communication can be improved.

## RATIONALE

Why is this issue worth so much attention? A broadly spread citizen understanding of science and technology is a public good, one the United States cannot have too much of. Several arguments support this proposition. First, Americans are a curious people, equipped with a lively sense of wonder. Knowledge about the natural world is a mainstream of the culture—absolutely on a par with the arts and humanities, though unaccountably often given second place on the liberal arts menu. Second, American democracy has to decide, in any given year, on a host of issues that have important scientific and technological content: what to do about climate change, how to organize human or robotic exploration of space, how to develop a sustainable national energy policy, how to treat the health potential offered by embryonic stem cells, and the like. To vote intelligently, citizens will increasingly require a level of scientific literacy. Finally, the United States needs to develop a layer of committed scientists who will lead the march of discovery, providing the basic research findings that will be the seed corn for the next generation of new developments. In making that kind of commitment, young people are often inspired by dramatic research accomplishments—ones that are being made by scientists and interpreted by those who write about the work.

## CONCERNS

Those are the three legs that support science in our culture, and they all depend on this singularly important relationship between scientists and science journalists. In a number of respects that relationship is in good health: the best reporters have learned a lot of science, and the best scientists have forged productive relationships with journalists. Nevertheless, complaints are heard from both sides—enough to encourage a kind of caricature of misunderstanding. Scientist A complains that the reporter has not taken the trouble to get some background on climate change science and has to be educated from scratch. After a certain amount of that, the reporter writes a story in which A's view is paired with criticism from a person who denies global warming. "The trouble with these guys," Scientist A says, "is that they each have a two-card Rolodex with an IPCC [Intergovernmental Panel on Climate Change] name on one and Fred Singer's on the other." The journalist might point out that had scientists in this area been both more careful and more understandable in describing the underlying issues to journalists, Scientist A would not have had to deliver a cram course to a reporter with a short deadline. As for the two contending views, to ask that journalists count the ayes and nays for every issue may be asking too much—although in the climate change case the scientists' complaint has some grounding.

A second concern revolves around a disturbing question: is science writing a disappearing culture? Cristine Russell contributed a poignant piece to the journal of the National Association of Science Writers in which she describes the demise of the science page—in its time a very good one—at *The Baltimore Sun*. The number of sections or departments dedicated to science in major American metropolitan dailies is estimated to have fallen by half over the past ten years as declining newspaper economics have tightened their grip. Even at *The New York Times*, with its splendid staff of science writers, fans have watched its excellent Tuesday Science section gradually morph from mostly science to mostly health.

At *Science* we faced some interesting choices because we had some well-trained and careful science writers in our news department, which has sent several of its alumni to *The New York Times* and National Public Radio, as well as two dozen or so science editors who are all well post-Ph.D. in their disciplinary specialties. Every week the two groups met to decide which among the papers we planned to publish would be covered by the news section and which would instead be covered in a "perspectives" written by a scientist recruited by the editorial staff. Blood was never shed on these occasions, but sometimes problems followed. The purpose of the perspective was to look at the broader field to which the paper contributes; it was written by a scientist who knew the field well and could establish a context for the new findings. If the news section covered the paper, the writer could ask questions that challenged the judgment of an editor. Although this occasionally happened, a clear separation was maintained: editors did not tell writers who the peer reviewers of a paper were, and writers did not ask editors who ought to be contacted or avoided.

## A HYPOTHETICAL PROBLEM

In pondering the understandings and failures of understanding that occur when a scientist from, say, the University of the Midwest is talking to journalists from, say, the *Capitol Star*, our committee has tried to identify some common themes. The scientist thinks that her discovery is important, and with great enthusiasm she describes the problem and her experimental solution of it. The journalist, for whom the science beat constitutes only a small part of his portfolio, has little knowledge of the context for his interviewee's work and cannot judge its significance. To check things out, he calls the public information officer (PIO) at the scientist's university to get some background. This particular PIO had prepared a press release based on discussing the work with the investigator and her colleagues and is able to supply the journalist with what he needs. Part of the release does seem clearer to the reporter than the investigator had been. Being on short deadline, he makes use of a paragraph from the release as the lead for his story, but he adds additional material he had absorbed from the researcher's account. The story appears the next morning with the headline "University of the Midwest Researcher Finds Gene for Muscular Dystrophy." This story initiates a brisk conversation between the researcher and the journalist. The former points out that the gene relates to a mouse model of muscular dystrophy and that what she had actually found was a site on one chromosome that probably contains the gene. The journalist blames the headline writer, pointing out that the text of the story is far more realistic—save perhaps for some modest overreaching in the part of the press release he had quoted—which naturally he blames on the PIO. No one is left entirely happy with the outcome.

This scenario is not only hypothetical; it is a caricature. But it is a not unrealistic scenario for understanding the roles played by different actors in this complex and challenging relationship.

## TRANSLATION: WHEN CULTURES MIX

Public understanding of science is a major social good. Understandable and inspiring writing about science changes lives: consider the number of young men and women whose passion for nature was stirred by Rachel Carson's *Under the Sea Wind* or, more recently, by David Quammen's *The Song of the Dodo*; or consider the Los Angeles children who started thinking about the cosmos because K. C. Cole's books based on her *Los Angeles Times* pieces roused their curiosity. Beyond the value inherent in the creation of an inquiring citizenry, another case is to be made for public understanding of science. Important social decisions have to be made wherever science and technology have a powerful impact on prospective public policies. Support for those policies is dependent on voters who can sort out that relationship and evaluate the science. That, in turn, depends heavily on what the scientists say and how carefully they say it and on the journalists who record and interpret the outcome for the public. The relationship between scientists and journalists must be improved—not because it is in trouble but because it is important.

Various forces—some natural, some human—make the junction of science and policy a perilous place in which to move from the one to the other in a seamless, untroubled way. The case of climate change and what to do about it is perhaps the clearest venue where science is interacting with policy formation. The IPCC, a project begun in 1988 as a collaboration between the World Meteorological Organization and the United Nations Environment Programme, has assembled a large body of the best climate scientists from around the world. Their reports include not only briefings on the status of the science—drawing on atmospheric physics, oceanography, paleoclimatology, and other disciplines—but also sections on adaptation and mitigation strategies from groups including economists and other social scientists. Each IPCC assessment report includes a summary for policy-makers. The summary represents a consensus view of the climate science as developed by government officials and others. As such, the views expressed in the summary are sometimes marginally more cautious than the views of the scientists. The nuances of this process, well understood in the climate-change science community, may be lost in published accounts of IPCC findings.

For example, the general conclusions relate the increase in average global temperature already experienced—about 0.7 degrees Celsius—to the increase in greenhouse gases (especially $CO_2$, which has risen from a preindustrial level of 280 ppm/v to the present 388 ppm/v) that has resulted from human activity. The conclusions are also firm in supporting the use, for projection, of general circulation models that predict a gradual increase in average global temperature of between 2.5 and 7.0 degrees Celsius by the end of the century, as well as a sea-level rise of 20 to 82 cm and an increase in the frequency of extreme weather events. A small number of scientists in the field still disagree with the IPCC consensus. Some of these scientists believe that the consensus understates sea-level rise. Others deny its more general conclusions and are joined and sometimes supported by interests that do not wish to see a strong regulatory policy outcome that will have significant economic consequences.

A journalist following this story has to deal with the following circumstances: first, this is a big story—a majority of the American public now overwhelmingly believes that climate change is a major problem and poses a serious threat. Thus, the question of who is right about the science is a big, important question. Second, the journalist will encounter well-credentialed scientists who have deeply held, even passionate views on the subject. Most will be strong advocates for the IPCC consensus and will wonder why a journalist would consider another view. Others, fewer in number, will cite histories of natural fluctuations in world climate or will challenge the utility of the models or point to other work that, in their view, makes the scientific position on global warming "controversial."

Under those circumstances, many good reporters will consider it fair and reasonable to discuss the matter with several people on each side. In and of itself, this is not a problem. But the IPCC consensus involves hundreds of scientists, and its conclusions all rest on research published in peer-reviewed journals. The historian of science Naomi Oreskes, at the University of California, San Diego, analyzed the consensus on climate change four years ago (the 2008 consensus is far stronger):

> In its most recent assessment, IPCC states unequivocally that the consensus of scientific opinion is that Earth's climate is being affected by human activities: "Human activities . . . are modifying the concentration of atmospheric constituents . . . that absorb or scatter radiant energy. . . . [M]ost of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations."[1]
>
> IPCC is not alone in its conclusions. In recent years, all major scientific bodies in the United States whose members' expertise bears directly on the matter have issued similar statements. For example the National Academy of Sciences report, *Climate Change Science: An Analysis of Some Key Questions*, begins: "Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise." The report explicitly asks whether the IPCC assessment is a fair summary of professional scientific thinking, and answers yes: "The IPCC's conclusion that most of the observed warming of the last 50 years is likely to have been due to the increase in greenhouse gas concentrations accurately reflects the current thinking of the scientific community on this issue."

1. Naomi Oreskes, "The Scientific Consensus on Climate Change," *Science* 306 (2004): 1686. See also her outstanding book with Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (New York: Bloomsbury, 2010).

> The drafting of such reports and statements involves many opportunities for comment, criticism, and revision, and it is not likely that they would diverge greatly from the opinions of the societies' members. Nevertheless, they might downplay legitimate dissenting opinions. That hypothesis was tested by analyzing 98 abstracts, published in refereed scientific journals between 1993 and 2003, and listed in the ISI database with the keywords "climate change."
>
> The 928 papers were divided into six categories: explicit endorsement of the consensus position, evaluation of impacts, mitigation proposals, methods, paleoclimate analysis, and rejection of the consensus position. Of all the papers, 75% fell into the first three categories, either explicitly or implicitly accepting the consensus view; 25% dealt with methods of paleoclimate, taking no position on current anthropogenic climate change. Remarkably, none of the papers disagreed with the consensus position.

In fact, today only six or so scientists regularly appear in opposition to the consensus, and most of them do not publish original research. If the reporter has a short deadline, she may resort to one or two scientists on each side of an issue. When this happens in the climate change arena, most people in the research community are horrified.

What should the poor reporter do? She should be concerned about two important attributes. The first is the scientists' qualifications: the kinds of journals they have published in and other credentials, such as invited articles, membership in scientific societies and academies, support from agencies that award grants on the basis of peer review—indeed, information of the kind she might get by taking advantage of the type of sources Oreskes mentions. The second concerns possible financial conflicts of interest. The journalist should ask hard questions about whether the scientist is getting financial support and from whom. In the case of climate science, certain energy companies and foundations, the Competitive Enterprise Institute, the Heritage Foundation, and the George C. Marshall Institute have all supported scientists who actively publish critiques of the IPCC consensus. Support from those sources might raise questions that would not arise from a National Science Foundation grant.

Journalists should also be attuned to evidence of a more organized agenda. Oreskes and Robert Porter have studied the development of a particular strategy on the part of those who dispute the evidence for global warming. Early contacts were made between these individuals and others, including scientists who had challenged the epidemiological consensus on the relationship between smoking and lung cancer. The common theme of both campaigns, which the climate group learned from the tobacco scientists, is that one should "teach the controversy"—that is, present the underlying science as unclear because some scientists have expressed disagreements with the consensus. When the "controversy" is abetted by support from particular industries or foundations, money again enters the picture.

Journalists should not, however, assume guilt by association. A conflict of interest or the prospect of financial gain is a matter quite different from that of scientific competence. *Science* requires authors to declare all their support, and publishes any information that might suggest to the reader the existence of a potential conflict. But determination of the paper's scientific merit is conducted independently of the assessment of potential conflicts of interest, and the two should not be confused. Some reporters are apt to make conflict of interest or financial stakes a proxy for serious judgments about competence, and that may mislead the reader. Neil Munro, a Washington investigative reporter who contributes to *National Journal*, warns reporters to include outside financial sources when writing about academic researchers. For example, in a piece called "Doctor Who?" in *Washington Monthly*, he compares two biologists who work on stem cells. Dr. David Prentice of Indiana State University believes that all the medical promise of stem cell research can be met with adult stem cells; Dr. Irving Weissman of Stanford University is a partisan for the use of embryonic stem cells. "Part of the explanation, of course, is simply an honest difference of opinion among scientists," Munro says. But he then goes on to elaborate the financial advantages Prentice might gain from a biotech company he hopes to found, and the fact that Weissman has "made millions" in companies using stem cell technology. Munro points out that neither man has kept his affiliations a secret. Munro's objection is to the press, which invariably refers to Weissman as "a biologist from Stanford." (I should disclose here that I am one of those, too.)

Munro's objection is interesting given that he himself is a reporter. He takes care of a significant difference of opinion by explaining it in terms of financial interest and ignores evidence of a stark difference in competence. Weissman has published numerous articles in top-tier peer-reviewed journals and is widely regarded as an innovative leader in cell biology. He is a member of the National Academy of Science (not merely a chair of one panel, the distinction Munro allows him) and is a recipient of a number of prizes and awards. David Prentice has no peer-reviewed publications. His website refers to a letter in *Science* that was unreviewed and soon followed by a letter from three distinguished scientists contesting nearly every claim he had made. All of this information was readily available to Munro.

The advice to reporters to disclose financial relationships is good advice. But Munro would have made it better had he included an admonition to follow the credentials as well as the money.

## THE LESS-COVERED ISSUES

Climate change and the stem cell debate are the current poster children for scientific issues that converge with public policy, which means that they cannot help but be political. In each case, federal action has failed to follow public preference. The result has been a down-migration of jurisdiction—with states passing referenda to support stem cell research, California pushed its own emissions standards by passing AB 32, and mayors are organizing to reduce the carbon footprints of their cities. This is an interesting development that probably ought to get more press than it does.

So should another problem: a growing scientific suspicion about the number of "fixes" now making their appearance in the climate/energy space. Most scientists do not regard biofuels, especially corn-derived ethanol, as workable—either economically or as a means of reducing carbon emissions once all costs are accounted for. An equal skepticism attends the number of "carbon offsets" available to households, industries, or even individuals who have taken on a sense of obligation to reduce their carbon footprints. Some offsets doubtless do achieve a carbon-neutralization effect—but these are rare and do not include random acts of tree planting or the fertilization of bits of ocean with nutrients that might produce blooms of phytoplankton.

Journalists can do much to help create a more balanced and knowledgeable account of science for the public. But to leave the burden on the press would be foolish as well as unfair. Scientists need to do much more of the work themselves: by learning to speak more clearly about what they are doing, by getting out into the real world to talk more directly to the public, and by taking care to be scientifically sound and rigorous as they connect their own work to public policy.

A number of incentives make this difficult to achieve. Scientists training in the iconic Ph.D.-granting departments seldom are urged to work on their communication skills. Too many of their mentors are exclusively interested in their students' progress toward completion of a dissertation. A joke current in molecular biology is that the professors are determined to create clonal offspring. Graduate students are commonly instructed that instead of undertaking a course involving some kind of outreach they should focus on their theses. I once asked Bob Berdahl, the thoughtful president of the Association of American Universities (AAU), if it might be possible to find out how many science departments in AAU member institutions offered seminars or courses on how to discuss science with the media or the public. He said he would try, but then predicted that the answer would be few or none.

The actual picture is now not quite that bleak. The Pew Foundation has sponsored some efforts of that kind, and the highly successful Aldo Leopold program has been coaching and teaching young scientists at media relations for some years. The best institutional PIOs help their science faculties make press contacts and often work to improve the clarity of communication between scientist and reporter. But discouragingly little is happening at the great research universities, as Berdahl warned. Even worse than for a graduate student to be told “that’s a waste of your time; stick to your thesis” is for his colleagues to warn him about the dangers of being “Saganized”—that is, of becoming popular enough as an explainer of science to risk the contempt of more “serious” researchers, a contempt that owes more than a little to envy.

A final problem that must be addressed is that of resource concentration. The influential national media—heavily concentrated in the Boston-New York-Washington area—pay much more attention to science than do daily newspapers elsewhere, let alone cable television and talk radio. Areas of higher media concentration are, not surprisingly, areas that produce mergers of science and media. For example, that Corey Dean—then of *The New York Times*—and Dan Schrag of Harvard University were involved in a seminar that accomplished just such a merger is hardly an accident. Nor is it surprising that Andy Revkin, also formerly of the *Times*, consults regularly at Harvard and Stanford about climate change science. In the long run, the business of relationship-making must be extended to more disparate, less comfortable situations in which we reach the majority of Americans with institutions, people, and technologies we haven’t yet connected. I wish I were a better example of what can be done, but I’m as limited as many of the rest of you. I hope the young scientist in the Leopold program and the young science writer from the *San Jose Mercury News* will be able to show us the way.

CHAPTER 2

# In Your Own Voice

Alan Alda

About seventeen years ago, I was asked to host a series on public television called *Scientific American Frontiers*. I was excited by the prospect because I had been reading for almost three decades every article in every issue of *Scientific American*. This is not to say I understood everything I read. I had no formal training in science and sometimes I couldn't even understand the magazine's *pictures*. But I loved science and I would spend hours puzzling out articles written in what at first had seemed like a foreign language, but with practice eventually became more familiar.

Now, on the television show, I would spend whole days talking with scientists about their work. For the eleven years the show ran, I had a chance to exercise my curiosity, and along the way we developed an unusual kind of science show. I wouldn't ask formal questions set out in a didactic way; instead the scientists and I would have an impromptu conversation—a spontaneous attempt on my part to truly understand their work. If I didn't get it, I would keep after them until I did. Sometimes there was an amusing sense of frustration expressed on both sides. But their genuine effort to help me understand brought out the scientists' human side. They were relaxed, they spoke simply, and they were often funny. They weren't lecturing me; instead, we were having a conversation.

I began to realize how important this distinction was one day when a scientist was explaining her work to me on camera. She was engaging and clear. But a few minutes into our talk she realized, I suppose, that what she was saying was very much like a lecture she was used to giving. She turned slowly away from me and started speaking directly to the camera. Our conversation came to a halt. Now, she was in lecture mode. Her tone of voice lost its simple, natural quality, and her words became more formal and laced with jargon. Within a minute, I found her hard to understand and I knew she had probably left the audience behind, too. This was unsettling because I wanted very much to understand her work. I coaxed her back with naive questions and her tone became warm again. Looking into the face of another human, eager to understand, her language once more became comprehensible. After a couple of minutes, though, she drifted off into lecture mode again and I had to draw her back. This happened three or four times, and it made a profound impression on me. There seemed to be a tremendous difference between talking in general, to no one in particular, and speaking to an actual person. It was the difference between speaking in her own natural voice and becoming almost an automaton. It reminded me of my days as a young actor when I had studied the rigorous art of improvisation. I, too, went from mechanically *seeming* to relate to actual contact.

It made me wonder: if scientists could communicate more in their own voices—in a familiar tone, with a less specialized vocabulary—would a wide range of people understand them better? Would their work be better understood by the general public, policy-makers, funders, and, even in some cases, other scientists?

As a young actor, I was transformed by learning to improvise. Almost everyone I knew who had studied it was changed for the better by it—because the heart of improvisation, far less than the ability to make things up, is relating and communicating with others.

I wondered if being exposed to the techniques of improvisation could help scientists improve their oral presentations. I asked a friend at USC if she could arrange for me to work for an afternoon with twenty engineering students. I began the session by having the students talk for a couple of minutes about their work. Then we improvised for three hours, and after that the students spoke again. There was a noticeable improvement in their ability to communicate and to speak with an animation and presence that encouraged listeners to stay with them. They had begun to relate better.

Oral presentation is, of course, only one small part of the communication of science. But I was curious to see if this unconventional approach might have a place in building a bridge between the rigor of science and the curiosity of non-scientists.

A couple of years later, we tried the experiment again at Stony Brook University and Brookhaven National Laboratory, and we seemed to get similar, positive results. (A short video of what we did is available at www.stonybrook.edu/journalism/science.) The next step will be to test the results more rigorously—for instance, we might poll audiences on the clarity of scientists' presentations before the scientists learn to use these techniques and then again after they've studied them to see if their second presentations actually rate higher.

It's clear that improvisation is not the only way to improve oral presentations, and neither is oral presentation the only kind of communication that's keeping non-scientists away from the pleasures of science. Stronger writing skills need to be developed as well. To address the full range, Stony Brook has founded a Center for Communicating Science, which will offer courses in all forms of communication. In Spring 2010, the center began a series of conferences in partnership with Brookhaven National Laboratory and Cold Spring Harbor Laboratory that included workshops on distilling the message, writing for the public, interacting with the media, using newer media, and improvisation. An early review of questionnaires completed by scientists who participated showed a strong interest in these workshops.

The effort is not to oversimplify science. We need clarity and vividness, but not—please, not—dumbing down. Some of our great science communicators have shown that there are deeply engaging stories in science (science itself is the greatest detective story ever told) and that it's possible to be personal and passionate about the study of nature without losing respect for the precision and accuracy at the heart of that study. Richard Feynman was both fun to listen to *and* precise. Even when he explained something in simple terms, he usually let you know that it was often more complicated than that. And when you were ready, he let you in on a little more of the complexity.

Feynman was one of those extraordinary communicators that nature produces from time to time. But they occur by chance. Why should effective, inspiring communication of science be left to chance? Science is rigorous; can't we be just as rigorous about teaching its communication?

Is it too much to hope that there will be a time when the skills of communicating science will be taught as a regular part of the science curriculum, and not as something added on for a few hours at the end? Isn't good communication fundamental to science? How else can it be successfully replicated, funded, and taught?

But don't let my high-flown arguments fool you. This is really a selfish plea. I'm too old to learn all the math and chemistry I need to understand the subtleties of the Higgs particle or the intricacies of reverse transcriptase. Even if I did, I'd only have access to one small part of the whole. I want to stand next to you scientists and gaze out at the entire horizon, while you point out what to look for.

Every scientist reading this has a deep passion for science. I implore you: let your passion out. Share it with us. Warmly, with stories, imagination, even with humor. But most of all, in your own voice.

# CHAPTER 3

# Covering Controversial Science: Improving Reporting on Science and Public Policy

Cristine Russell

On a daily basis, news headlines blast warnings and trumpet battles over controversial scientific research and public-policy issues that confront the United States and the rest of the world in the early twenty-first century.[1] Global climate change, influenza pandemics, embryonic stem cell research, genetic engineering, diet and obesity, teaching evolution in schools, space exploration, renewable energy technologies, and bioterrorism are just a few of the media subjects that have significant implications for both public policy and personal decision-making.

There is a greater need than ever before for journalists who are skilled in reporting both the underlying complexity of science and technology as well as the legal, ethical, and political ramifications. Unfortunately, jobs for full-time science writers at major print and electronic outlets are declining, while the number of important science and science-policy developments to cover is increasing. The news hole is shrinking, and the stories that do appear may be confusing, misleading, or downright wrong. Many important topics are left unreported in favor of soft "news you can use" consumer health and medical features on everything from fad diets to the latest exercise machines. The Internet offers an unlimited source of real-time information, but, unsorted and unevaluated, it can be bewildering and inaccurate for the unsophisticated user. The rise of partisan blogs on controversial science-policy topics, such as climate change, may mislead or further polarize the American public.

1. This paper was originally prepared during a Spring 2006 fellowship at the Harvard Kennedy School (HKS) Joan Shorenstein Center on the Press, Politics and Public Policy. Additional work has been conducted by the author as a Senior Fellow at the Environment and Natural Resources Program of HKS's Belfer Center for Science and International Affairs. This updated version was prepared in Spring 2010, with the help of HKS research assistant Matt Homer. Please see http://www.hks.harvard.edu/presspol/publications/papers/working_papers/2006_04_russell.pdf for the full 2006 paper on the Shorenstein website.

Surveys show that many Americans are "scientifically illiterate" and woefully unprepared to understand basic scientific concepts or the applications of science and technology. Since the general public gets most of its scientific, environmental, and health information from the news media, journalists have an opportunity to help fill the information gap. But leaders in both the scientific and journalistic communities feel that too often reporters and scientists are themselves ill-prepared for communicating about science and public policy in a manner that helps the public better understand pressing issues, from climate change to the pandemic spread of the novel H1N1 influenza virus.

As a result, science and policy issues are frequently presented as a battle between dueling experts at two extremes, an approach that gives a false sense of balance and often overemphasizes minority views. Complicated issues become oversimplified; uncertainty is underemphasized; controversy trumps consensus. "Yo-yo" reporting swings from breakthroughs that over-promise to disasters that disproportionately emphasize the negative. Coverage, particularly by inexperienced reporters, may fall short on science and long on political reporting, promoting conflict and personality over substance. This type of coverage trumpets who is winning or losing the race in an effort to capture public and political support.

The challenge ahead is to boost both spot news and analytical coverage—in old and new media—of the important issues in science and technology, providing insight and context for understanding the status of important debates involving scientific research. In doing so, the news media must help sort out the potential public and personal choices facing both decision-makers and individual citizens.

This paper will examine some of the following questions:

- What is the supply and demand for specialized science reporters, and what is the pipeline?
- Is the amount of science coverage declining in the major news media?
- What types of science and policy stories receive the most coverage?
- Who is best equipped to cover science and public policy?
- How responsive is the scientific community to participating in media coverage of controversial science and policy?
- How does media coverage affect public understanding of current scientific debates?
- What efforts are needed or are under way to improve media coverage of science and policy?

In this paper, *science* will be defined broadly: physical and life sciences; social sciences such as psychology; medicine and health; environment and energy; space; engineering and technology. The common denominator is the use of standard research methodology designed to ask questions and derive answers. Science news ranges from basic research to applications of science and technology, as well as society's responses to scientific developments. Given the breadth of the subject, this paper will focus primarily on the mainstream news media, particularly newspaper coverage of science.

## THE SUPPLY AND DEMAND FOR SCIENCE WRITERS

### *History of Science News Coverage in the United States*

The development of science writing as a journalism specialty mirrors the growth of the scientific research enterprise in the United States. Starting as early as 1934, a dozen science writers from major American newspapers banded together to form the National Association of Science Writers (NASW), an organization dedicated to improving the popular reporting of new scientific developments for the general public.[2] Since then, science writers have covered "some of the most momentous events in human history. Science reporters were the first to tell the public of the splitting of the uranium atom and of the consequent explosion of the first atomic bomb" as well as the discovery of antibiotic "wonder drugs" that could cure deadly diseases.[3]

Following World War II, as the federal government began to invest heavily in scientific and medical research, the pace of new developments required science reporters to be prepared to follow everything from physics to polio vaccine development. Science writing took off as a staple of daily news coverage when a large cadre of general-assignment reporters, many with little or no knowledge of science, were "flung into covering science by editors seeking to sate the reader appetite for science news that exploded in the wake of the Soviet *Sputnik* in the fall of 1957,"[4] noted the late Jerry Bishop, a pioneering science reporter for *The Wall Street Journal*. For much of the 1960s, science reporting was on-the-job training, as the space race received extensive—and usually laudatory—coverage in newspapers and magazines and on television. At the same time, the successful transplant of a heart into a human patient in 1967 and the pioneering use of chemotherapy to treat cancer promoted the ever-growing coverage of medicine.

Early science reporting was often characterized by a "gee whiz" fascination with the new developments in science, medicine, and technology. But in the 1970s, the coverage turned more skeptical as concerns about environmental contamination led to calls for more government regulation, and rapid developments in biomedical research raised new ethical concerns. In the 1980s, new diseases, such as HIV/AIDS, surprised a world that thought deadly infectious diseases were a thing of the past, while the pace of technological developments, such as the computer, quickened.

2. National Association of Science Writers (NASW), http://www.nasw.org.

3. Council for the Advancement of Science Writing (CASW), "Careers in Science Writing," http://www.casw.org/casw/resources-students.

4. The late Jerry Bishop was a former president of CASW, http://www.casw.org/casw/history.

In the 1990s and early twenty-first century, an international effort to determine the structure of the entire human genome, as well as the cloning of animals such as the sheep Dolly, drew attention to the benefits and risks of genetic technology and the global nature of the scientific enterprise. Along the way, some science reporters were required to cover the whole gamut of science, from basic research to the public-policy implications of the use and potential misuse of science. Others specialized further in sub-beats of science writing, from neurobiology to earth sciences. Print journalists at major newspapers, magazines, and wire services provided the most in-depth coverage, with the electronic media (with the exception of public television and radio) often limited in content and dominated by the need for compelling visuals. In recent years, the rapid growth of the Internet has provided a new venue for public access to both scientific developments and writing about science, as well as opportunities for citizen journalism. The 24-hour electronic news cycle has also put more pressure on all journalistic outlets to release information more quickly than ever before, often with little time for in-depth reporting.

Today, those who cover science and technology range from full-time science reporters to general-assignment reporters who literally catch the story on the run. In addition to news and science sections, science and policy stories increasingly appear in less traditional arenas, including business, education, religion, and political coverage. The biotech, pharmaceutical, and energy industries have become a staple of business news. Debates over the teaching of evolution and intelligent design have dominated some local school board and court coverage, while state and local ballot initiatives force legal and political reporters to cover a variety of scientific, medical, and environmental issues, from stem cells to climate change.

Throughout these stories, there has been a growing emphasis on the intersection between science, policy, and politics. As the introduction to a recent science-writing guide notes, science has become "more a part of daily life. Some of the leading issues in today's political marketplace—embryonic stem cell research, global warming, health care reform, space exploration, genetic privacy, germ warfare—are informed by scientific ideas."[5]

### *Number of Staff Science Writers and Newspaper Science Sections Declines*

It is ironic that as science writing has matured as a profession, both in sophistication and numbers, the traditional media outlets for reaching the general public have shrunk. Cutbacks in the news business, particularly newspapers, have brought a severe decline in the number of jobs for full-time staff science writers as well as a drop in the number of weekly science sections. Those that remain have become increasingly consumer-oriented, specializing more on soft health-and-fitness trends than on research information based on scientific

5. Deborah Blum, Mary Knudson, and Robin Marantz Henig, *A Field Guide for Science Writers: The Official Guide of the National Association of Science Writers*, 2nd ed. (New York: Oxford University Press, 2006), vii.

studies. From its humble beginnings seventy-five years ago, the NASW is now the largest membership organization devoted to professional science writers, with about 2,250 members in 2010.[6] But only a small number are employed as full-time news media staff, while the ranks of freelance science writers have greatly expanded. An analysis of NASW membership records from 2005 conducted for this paper found that only about 4 percent of members were staff reporters and editors for newspapers; 2 percent for popular magazines; and 1 percent for radio and television. Nine percent worked for specialty magazines or newsletters. About 40 percent of NASW members were freelance writers for a variety of publications. Another 42 percent wrote or edited science information or worked in public affairs for universities, companies, government, and other institutions, or taught and studied science journalism. By far the most dominant specialty among this science-writing group is medicine and health,[7] although all branches of science writing are represented.

Newer specialty journalism organizations are also encouraging better coverage of crucial issues, such as the environment and health care. However, many of their members focus primarily on policy and politics, with far less emphasis on the underlying science or research. The Society of Environmental Journalists has grown to about 1,500 members since its founding in 1990.[8] The Association of Health Care Journalists, incorporated in 1998, has nearly 1,000 members, about one-third of them from newspapers.[9]

One traditional measure of the interest in science coverage and the willingness of newspapers to showcase it is the decision to run dedicated print science sections—usually produced on a weekly basis with a range of stories, from short takes to in-depth features. *The New York Times*' Tuesday "Science Times" started in 1978; it is still the gold standard of science sections, both in space, content, and the size of its contingent of highly skilled science reporters. Fourteen full-time staff science and medical reporters, seven editors, and a host of outside contributors work on science coverage for the *Times*' news pages and Science section.[10] The weekly section's topics range from the arcane—the latest in dinosaur bones and black holes—to the pressing personal and public policy issues of the day. The space devoted to health and fitness has grown significantly, as have online science and medical blogs.

6. NASW, http://www.nasw.org. Membership numbers accessed April 30, 2010.

7. NASW Membership Directory and Database, July 2005. Membership in NASW is only one measure of the number of full-time science reporters since membership is voluntary and not all staff science reporters choose to join their professional organizations. NASW did not have a breakdown of members' work affiliation, so the 2005 Membership Directory and Database was reviewed for the 2006 Shorenstein paper.

8. Society of Environmental Journalists, http://www.sej.org, and email message to author from Executive Director Beth Parke, April 29, 2010.

9. Association of Health Care Journalists, http://www.healthjournalism.org, and email message to author from AHCJ. As of April 30, 2010, AHCJ membership totaled 974, with about one-third from newspapers and about one-fifth each from broadcasting and magazines.

10. Laura Chang (Science Editor, *The New York Times*), email message to the author, May 4, 2010.

In addition, the paper has other reporters working for the business section on pharmaceuticals, energy and technology, and for a separate cluster created in early 2009 to coordinate environmental coverage across the paper, from local to international stories.[11] (Two of the *Times*' senior environmental reporters chose to leave their newspaper staff positions in late 2009 as part of a newspaper-wide round of staff cutbacks, and the popular DotEarth blog by veteran environmental journalist Andrew Revkin shifted to the paper's opinion section after he left the paper.)

While the *Times*' Science section has largely held its own, other newspaper science sections have not fared as well over time. Popular in newspapers across the United States in the 1980s (corresponding, in part, to computer ads), weekly science sections reached a peak of ninety-five in 1989 but dropped precipitously thereafter. By 1992, only forty-four papers continued to run weekly science sections, according to surveys done by the now-defunct Scientists' Institute for Public Information (SIPI).[12]

Since then, science sections have continued to decline in number and size, particularly among smaller papers. Those that remain have shifted much further toward consumer health and fitness coverage. In 2005, there were at least thirty-four daily newspapers in the United States that ran weekly health and science sections, according to an analysis for this paper using the *Editor & Publisher International Yearbook*.[13] Of them, more than two-thirds focused primarily on health in their titles, up from about 50 percent in 1992. In comparison, the sections that self-identified as "science" dropped from 30 percent in 1992 to 12 percent. The rest—18 percent in 2005 versus 21 percent in 1992—were listed as a combination of "health" and "science."

Of the forty-four papers with science sections in the 1992 survey, only twenty-four remained in 2005. Ten additional sections started between 1992 and 2005 among the nation's top fifty papers in terms of circulation, with eight out of ten of them focused exclusively on health. A preliminary update suggests that since 2005 the number of papers known to have science and

11. Curtis Brainard and Cristine Russell, "The New Energy Beat," *Columbia Journalism Review* (September/October 2009): 44.

12. Scientists' Institute for Public Information, *SIPIScope* 20 (1) (Fall 1992). In 1992, only forty-four newspaper dailies published weekly science sections, but three of these papers published two different weekly science and health sections. There was, therefore, a total of forty-seven different science sections published in forty-four papers.

13. *Editor & Publisher International Yearbook*, 85th ed. (New York: VNU Business Media, Inc., 2005). Editor & Publisher includes information on special sections from 2004 submitted by individual newspapers. Our 2006 project survey examined information from the forty-four papers that had science sections in 1992 and found that twenty-four of them still had science sections. In addition, research assistant Maria Alvarado examined entries from the top fifty newspapers in terms of circulation and found another ten new sections, for a total of thirty-four newspapers with special weekly sections involving science, health, or medicine. There may be additional science and/or health sections that were started by smaller newspapers, as the full directory was not reviewed.

health sections has dropped slightly, down from thirty-four in 2005 to thirty-one papers in early 2009.[14] This includes the loss of the prestigious Health/Science section in *The Boston Globe* in March 2009, after a twenty-five-year run, with science, technology, and environment coverage moved to its Monday Business section and health and medicine shifted to the Lifestyle section.[15] Hit by the sinking newspaper economy, the *Globe* nonetheless kept the bulk of its science, environment, and medical team: six full-time science reporters and an additional part-time medical writer for its "White Coat Notes" medical news blog.[16]

At newspapers around the country, much of the science and health news coverage has also moved into the "lifestyle" sections and out of the news pages. *USA Today*, the United States' largest general circulation national newspaper, puts most of its science, health, and environment coverage at the back of its Life section, although it frequently features medicine and health on its front page. *The Wall Street Journal* regularly puts health, science, and technology coverage in its Personal Journal feature section and has added a regular science column in its news pages that looks broadly at new research and its impact on society.

Some critics, including science reporters, question the need for separate sections, arguing that they have the danger of preaching to the converted by sequestering important science and health coverage in a section that may be read primarily by readers who are already interested in science. Robert Lee Hotz, the *Journal*'s science columnist and a former president of NASW, worries that science sections are "often divorced from the news. They favor lovely but arcane exploration pieces on the wonders of research that may or may not have any connection to the events of the day. . . . We do ourselves a disservice when we set up picket fences that say 'keep out, science writer inside.'" Hotz feels that science coverage needs to be pushed to the front of the paper, competing in the news section with other national and international stories, and that science writers themselves need to be stronger advocates for science and technology coverage. "If we put ourselves in competition with the news of the day, science is extremely successful at elbowing its way onto the front page," he says.[17]

14. The science/health section update was based on the 2009 edition of *Editor & Publisher International Yearbook* (New York: Editor & Publisher, 2009). The yearbook is up-to-date as of September 30, 2008. In addition, in early 2009, the *Rocky Mountain News* ceased publishing and *The Boston Globe* discontinued its health/science section.

15. Cristine Russell, "Globe Kills Health/Science Section, Keeps Staff," *Columbia Journalism Review* (March 4, 2009), http://www.cjr.org/the_observatory/globe_kills_healthscience_sect.php.

16. Interview with Gideon Gil (Health and Science Editor, *The Boston Globe*), April 30, 2010. The *Globe* currently has five health and science reporters, one editor, and a part-time medical blogger.

17. Robert Lee Hotz, telephone interview by the author, April 17, 2006.

However, promoting more science and science-policy coverage in the daily news columns and in weekly science sections is certainly not mutually exclusive. In an ideal world, important science news would be covered as it happens in the daily news pages, and science writers would cover spot news and write in-depth analytical pieces that compete for the front page. But science and health sections provide a reliable opportunity for viewing trends in science and science policy in more depth and with more perspective than may be realistically available in the front-section news hole. By hiring specialty health and science writers, the sections also offer a safety net of trained reporters who are well equipped to cover unpredictable spot news, particularly threats such as the disastrous Gulf of Mexico deepwater oil drilling accident, an outbreak of H1N1 influenza, or a bioterrorism incident, when the need arises. Existing sections need to encourage more substantive and timely science policy and issue stories, rather than settling into covering primarily the more comfortable and timeless "gee whiz" science or consumer health stories.

Newsmagazines, struggling to maintain their audiences, have also shifted their emphasis strongly toward consumer health and medicine and "green" stories, with pure science a casualty here as well. In 2005, ten of the fifty *Newsweek* covers were on health issues, such as lung cancer, autism, and heart disease, according to a *Newsweek* cover story on "Diet Hype," subtitled "How the Media Collides with Science."[18] The story also noted a potential economic connection: pharmaceutical companies spent $1.3 billion in magazine advertising in 2005, with another $2.4 billion on network and cable television.[19]

*Time* has taken a strong pro-environment editorial stance and sounded early alarm bells on climate change, championing these causes on its covers and inside its pages. *U.S. News and World Report* heavily promotes consumer-oriented products, such as its "best hospital" rankings, but has cut back most of its senior science and medical staff, as have its sister magazines.

While print opportunities in both newspapers and newsmagazines are far more limited than in the past, science magazines largely targeted to educated audiences already interested in science still provide high-quality content. The venerable *Science News*, a nonprofit started in 1922 but revamped in 2008, continues to provide biweekly news and analysis of science and society in print and daily updates online.[20] Monthly science magazines like *Discover* and *Scientific American* offer in-depth science features and online coverage that can't be found in mass media publications.

In the electronic media, television network and cable news coverage of science continues to dwindle, with health and environment the mainstays of the limited coverage. CNN caught flak when it fired its entire science, environment, and technology team in late 2008.[21] National Public Radio main-

18. Barbara Kantrowitz and Claudia Kalb, "Food News Blues," *Newsweek*, March 13, 2006.

19. Ibid.

20. *Science News* is published by the Society for Science & the Public, http://www.sciencenews.org.

21. Curtis Brainard, "CNN Cuts Entire Science, Tech Team," December 4, 2008, http://www.cjr.org/the_observatory/cnn_cuts_entire_science_tech_t.php.

tains a strong staff doing science and medical coverage, and Public Broadcasting System's NOVA science series is still going strong.

*The Rise of Online Coverage and the "Blogosphere"*

The biggest growth industry is online, offering the print and electronic news media opportunities to expand their Web coverage of specialized topics in science and technology, health and medicine, and energy and the environment. Online sites, blogs, and social media tools are becoming the twenty-first-century version of the science section, and in many cases have already replaced or augmented the print version of science and medical sections in newspapers as well as in newsmagazines. In theory, they have the potential to update and personalize science stories that appeal to newer, younger audiences and to give the public a chance to participate in the dialogue. Multimedia video, graphics, and other visuals can also bring the stories to life in a way that words alone cannot.

Unfortunately, given the troubling economic status of mainstream news media, online science-related sites often fall short of their potential, even among the most trusted news brands. Catering to popular interests, they overemphasize consumer interests in health and medicine, depend heavily on the latest wire coverage (where newness is the premium) to replace staff-generated content, go for "gee whiz" science visuals, and fall short in terms of serious analysis of science-policy issues.

With science staff cutbacks at most media institutions and a smaller news hole in print editions, those specialty newspaper and magazine reporters and editors that remain find themselves juggling their limited time. At this point, the Web is winning. Updating blogs, feeding online coverage, and promoting visibility through social media sites like Facebook and Twitter often mean that longer, in-depth reporting projects are put aside (or never attempted in the first place). In addition, these online and social media sites tend to appeal to niche audiences, rather than the broader audiences that mainstream media have traditionally attracted.

*The Washington Post*'s science coverage, for example, has suffered with the loss of several senior science writers due to staff reductions and buyouts in recent years. Its twenty-five-year-old Health section now includes some environment and science coverage, but it has limited staff to do so. Online, the *Post*'s current coverage tilts heavily toward health care reform and consumer health, environment, and technology. Of about a hundred blogs listed on the *Post*'s website,[22] two are devoted to health news and health care reform; two to environment, energy, and climate change; and two to consumer technology and policy. None focuses on basic science itself, although there are twenty blogs devoted to sports.

22. *The Washington Post* has a comprehensive list of the paper's blogs posted at http://blog.washingtonpost.com.

However, award-winning sites like MSNBC's Cosmic Log,[23] written by respected science editor Alan Boyle, show the potential for combining serious reporting and commentary on space, astronomy, and science in a popular way that appeals to a broad mainstream audience.

Another trend is media partnerships with other organizations and outside experts who contribute to science, environment, or medical coverage. Many papers and magazines are "outsourcing" their Web content, buying coverage in areas like the environment and energy from specialty news and feature services and utilizing outside experts to blog or conduct online sessions with readers. *The Washington Post*'s blog The Planet Panel brings in outside experts to talk about climate change, while *The New York Times* supplements its staff energy and environment coverage with stories from an independent subscription-based service, Energy and Environment Publishing, LLC.[24]

However, such partnerships can also raise red flags, as lines blur between independent journalism and sponsored content. *U.S. News and World Report*, for example, now features science content sponsored and generated by the federal government's National Science Foundation (NSF)—a decision that calls into question the traditional divide between mainstream journalism outlets and the agencies they cover.[25]

Major specialty monthly magazines such as *Discover*, *Scientific American*, and *Wired* complement their glossy print editions with lively websites that tend to be newsy, fast-paced sources of science and technology content. *Discover* has also cultivated a small set of distinctive blogs by ten scientists and science journalists, with its most popular one, "Bad Astronomy," written by astronomer and author Phil Plait.[26] In contrast, ScienceBlogs,[27] started by Seed Media Group in 2006 with fifteen blogs, has grown to more than eighty blogs from diverse disciplines, providing "a digital science salon" that its founders say is now "the largest online community dedicated to science." The site is a rich source of unedited commentary on all things science (often accompanied by unvarnished language that would never pass mainstream media muster). But there is considerable competition in the wild, woolly world of the Web, as the widespread use of search engines like Google leads the public to a vast array of often unreliable, inaccurate sites run by organizations or individuals with a variety of agendas. Particularly troubling is the growth of a highly polarized blogosphere in the most controversial areas of science: from climate change to evolution. This trend led Harvard Kennedy School professor Sheila Jasanoff to team up with science author and *Discover* blogger Chris Mooney for an April 2010 workshop on "Unruly Democracy: Science Blogs and the Public

23. Cosmic Log, started in 2002 by MSNBC Science Editor Alan Boyle, covers "quantum fluctuations in space, science, exploration, and other cosmic fields"; http://cosmiclog.msnbc.msn.com.

24. Brainard and Russell, "The New Energy Beat," 44.

25. *U.S. News and World Report*, http://www.usnews.com/science.

26. *Discover* blogs, http://blogs.discovermagazine.com.

27. ScienceBlogs in English can be found at http://scienceblogs.com.

Sphere."[28] They explored their concern that the unruly nature of science blogs may have severe negative consequences for scientific communication when distorted information masquerades as scientific truth and uncivil, often ugly, exchanges occur.

Perhaps the most dramatic example has been in the arena of climate change. Partisan blogs fuel anti-science sentiment and further undermine public belief in the scientific consensus that the planet is threatened by global climate change resulting from human-generated greenhouse gas emissions. Public confusion is heightened by misleading sites and blogs labeled as science when they are decidedly not. For example, two of the most popular "science" blogs listed by Wikio,[29] a site that monitors blog traffic, are Watts Up with That? and Climate Audit. Both are anti-climate science, conservative sites that deny that climate change results from human activity. In contrast, two of the other top-ranked science blogs listed by Wikio,[30] Climate Progress and Real-Climate, strongly support both climate change science and a political agenda to curb carbon emissions. Both the pro- and anti-climate science bloggers preach to far different constituencies, but they have something in common: they frequently attack climate coverage by the mainstream media and individual journalists. Once again, it's easy to make the media a scapegoat.

## SCIENTISTS MORE WILLING TO COOPERATE WITH MEDIA

### *History of Scientists' Involvement with News Media*

Traditionally, scientists have viewed the media with suspicion and the prospect of being interviewed by a reporter akin to a visit to the dentist. In fact, such interviews often felt like pulling teeth, as reluctant researchers measured their words and feared being misquoted. Part of the tension stemmed from the scientific tradition of presenting research first to colleagues at scientific meetings and later to the scientific world through peer-reviewed journals. Only then was it considered appropriate to talk to the public through news media translators.

Early scientific popularizers like the late astronomer Carl Sagan, whose riveting books and television documentaries brought the "Cosmos" to the average American, were often viewed critically by their peers for talking directly to the public. However, times changed as the struggle for federal research funds became ever more competitive, and public and political criticism of the products of science and technology—from environmental pollution to nuclear power—put many parts of the scientific enterprise on the defensive. Increasingly, academic institutions and scientific organizations hired communications

28. Held at the HKS by the Program on Science, Technology & Society. A video of the workshop can be found at http://www.hks.harvard.edu/sts/events/workshops/unrulydemocracy.html.

29. Wikio top-ranked science blogs, as of May 2010 based on links from other blogs; http://www.wikio.com/blogs/top/sciences.

30. Ibid.

experts to prepare press releases on their scientific work and publicize the findings to a broader audience. Groups such as the American Association for the Advancement of Science (AAAS), the nation's largest general scientific organization, as well as specialty science organizations, set up elaborate pressrooms and briefings for their annual meetings and publications, with particular attention paid to topical or controversial science that was under public scrutiny.

Through it all, many scientists have felt uncomfortable with press coverage, worrying about being misquoted or having their research taken out of context. Although they place the blame on the media and its shortcomings, a large part of the problem is that many prominent scientists do not see this as part of their job and are not trained to deal with the media. Veteran science reporter Cornelia Dean, a former science editor of *The New York Times*, notes that scientists complain bitterly about the "poor quality of science journalism" and "what I always say to them is, 'You're right. But the only people who can do anything about it are you, the scientists.' As a group, they are not very good at communicating with the lay public or with reporters."[31]

Dean, who designed a Harvard University course for scientists and engineers, feels that scientists' training should include science writing: "I don't think people should get a doctorate in science without some exposure to how to tell an ordinary citizen what they're doing. Scientists have an affirmative obligation to take part in the debate. Their absence is one of the things that has debased the national dialogue."[32]

"There is an uneasy tension between reporters and scientists," admits University of Maryland professor Rita R. Colwell, who headed the NSF for six years. "We have slowly matured from the situation twenty years ago when good scientists simply refused to talk to the press. Frankly, they didn't know how, and they were afraid of being misquoted and ridiculed by their colleagues. . . . Now there is a realization that we need to step into the public fray if the voice of science is to be heard." She benefited from media training in her days at the helm of the NSF, including "learning how to answer questions that don't have answers." Colwell says scientists "need to respect good science writing. It's tough to get it right." She urges her colleagues to "speak as scientists on issues and learn how to work with the press. . . . If we don't put out the information, we have ourselves to blame."[33]

Colwell and other scientists are concerned about declining science coverage for the public. "The quantity of science reporting has decreased alarmingly," says Colwell. Donald Kennedy, a Stanford University biologist who is the former editor of *Science*, agrees: "There are huge gaps. . . . So many met-

31. Cornelia Dean, quoted in Alex Jones, "Covering Science and Technology: An Interview with Cornelia Dean," *The Harvard International Journal of Press/Politics* 8 (2) (Spring 2003): 5.

32. Cornelia Dean, interview by the author, March 21, 2006.

33. Rita R. Colwell (former Director, National Science Foundation, 1998–2004; currently Distinguished University Professor at University of Maryland, College Park, and Johns Hopkins Bloomberg School of Public Health; Chairman, Canon US Life Sciences, Inc.), interview by the author, February 18, 2006.

ropolitan dailies with substantial audiences have lost science pages in the last ten to twenty years." At the same time, says Kennedy, the scientific community has gradually become "more willing and much better at learning how to talk to the press and describe our results in language people understand."[34]

In addition, many scientists are taking their work directly to the public through popular books and blogs that combine their scientific knowledge with engaging writing—the best of both worlds.

*Changing Role of Science in the Political and Financial Landscape*

The scientific community is only one constituency in the science and public-policy world. However, it has traditionally held a privileged place in American discourse, and research funding has enjoyed bipartisan support in the nation's capital. But in recent years, science and science policy, as well as research budgets, have come under greater attack from legal, cultural, and religious organizations with powerful political clout, each of which has claimed its own part of the science-policy turf. Scientists and the organizations that represent them have increasingly found themselves in unfamiliar territory: sometimes treated as if they were just another special-interest group in the messy political food fight.

Under the Bush administration, many scientists and journalists felt that science was politicized to a greater extent than ever before. *The Republican War on Science*, by journalist Chris Mooney, summarized the criticism:

> With the ascent of the modern conservative movement and its political domination of the Republican Party, two powerful forces had fused. . . . On issues ranging from the health risks of smoking to global climate change, the GOP had consistently humored private industry's attempts to undermine science so as to stave off unwelcome government regulation. Meanwhile, on issues ranging from evolution to embryonic stem cell research, the party had also propped up the Christian right's attacks on science in the service of moral and ideological objectives. In short, the GOP had unleashed a perfect storm of science politicization and abuse, in the process precipitating a full-fledged crisis over the role of scientific information in political decision-making.[35]

A *New Yorker* article by science writer Michael Specter reached similar conclusions: "From the start of his first term, George W. Bush seems to have been guided more by faith and ideology than by data in resolving scientific questions,"

34. Donald Kennedy (Senior Fellow, Woods Institute for the Environment, Stanford University; former Editor-in-Chief, *Science*; President Emeritus and Bing Professor of Environmental Science and Policy Emeritus, Stanford University), interview by the author, February 18, 2006.

35. Chris Mooney, *The Republican War on Science* (New York: Basic Books, 2005), introduction, http://www.waronscience.com/introduction.php.

he noted. "On issues ranging from population control to the state of the environment, and from how science is taught in the classroom to whether Iraq's research establishment was capable of producing weapons of mass destruction, the Administration has repeatedly turned away from traditional avenues of scientific advice."[36] Critics, including many in the scientific establishment, felt that the Bush administration's conservative philosophy politicized science to a greater degree than previous administrations: controlling whether research could take place (stopping federal funding of new avenues of embryonic stem cell research), whether scientists could talk about what it means (controlling statements by federal scientists about climate change), and whether regulatory agencies could act (the Food and Drug Administration disregarded scientific advisory committee and staff advice that emergency contraception, "the morning after pill," should be approved for adult over-the-counter sales before finally granting approval in August 2006).[37]

*The New Yorker*'s Specter, author of the 2009 book *Denialism*, acknowledges, however, that the "problems facing American science have not been created by a single politician or party: they reflect a fissure in society which has grown wider as science has edged closer to the roots of life itself."[38] As a result of a virtual stalemate in Washington over the most contentious scientific issues, many of the battles have gone out to the states and localities. In the face of the Bush administration's 2001 mandate that banned federal funding of newer stem cell lines created from human embryos, controversial stem cell research became the subject of ballot initiatives in California and other states that were considering funding it themselves.

The 2008 election of Barack Obama as President of the United States brought a new proponent of science and scientific integrity to the White House as well as a sense of optimism that science would be restored to a place of honor at the highest levels of the federal government. Indeed, President Obama's inaugural promise to "restore science to its rightful place" was followed by the appointment of a number of top scientists to key administration posts and advisory positions—from Harvard Kennedy School's climate expert John P. Holdren as Science Advisor to Nobel Prize-winning physicist Steven Chu as Secretary of Energy. The Obama administration poured economic stimulus money into energy R&D, launched initiatives to protect scientific integrity and openness in government, lifted the Bush administration's ban on federal funding of embryonic-stem-cell research, and gave a boost to science and technology education.

However, the bipartisan improvements that many had hoped for in Congress have not materialized: far from it, the nation's legislators seem to be locked in partisan battles with each other and the Obama White House on

36. Michael Specter, "Political Science: The Bush Administration's War on the Laboratory," *The New Yorker*, March 13, 2006, 62.

37. See, for example, Marc Kaufman, "FDA Official Quits over Delay on Plan B," *The Washington Post*, September 1, 2005.

38. Specter, "Political Science," 68.

issues key to science policy, with energy and climate change legislation foremost among them. Indeed, the fissure in American society over contentious science-related issues continues to widen.

Unfortunately, in many cases, the media have helped light the fire rather than bring light to the controversial science-based issues. National news coverage of congressional and administration actions in the science and technology arena has been conducted by both science and political reporters for the major papers. But in many cases the coverage has fallen once again into predictable political dueling rather than in-depth coverage of the science itself. And as the fights have moved across the country, science-policy coverage has increasingly been carried out by political or general-assignment reporters with little or no knowledge of the underlying science. In the blogosphere, where the gloves are off, opinions too often overpower facts.

## THE PUBLIC ROLE IN SCIENCE AND POLICY DEBATE

The role of the news media in conveying the latest information about science and public policy is crucial, providing Americans with frontline coverage of current controversies facing society. The problem is that the audience is composed of many publics, each bringing a different background and personal agenda that is influenced by cultural and religious beliefs, education, political affiliation, gender, and age, among many factors.

Surveys show that television is still the main source for information about science and technology in its myriad forms. But the use of the Internet is growing rapidly, while print media are losing ground. A 2010 NSF report shows that 40 percent of Americans said they still get their science and technology information from television; 28 percent cited the Internet; newspapers and magazines totaled 22 percent; books 3 percent; and radio 2 percent. The proportion using the Internet has more than tripled since 2001, and the Internet is the main source for learning about specific scientific issues, such as climate change and biotechnology.[39] Use of the Internet is higher among younger Americans and increases with education and income. However, it is not an either-or situation: a 2008 Pew Research Center for the People and the Press report noted that audiences are often getting their information from both traditional print and electronic media and the Internet, "blending these sources together rather than choosing between one or another."[40]

Public understanding of science is another problem. While many people are supportive of science, they still don't know much about the basic tenets of science, says Jon D. Miller, a political scientist who has spent three decades conducting survey research for the NSF and many European governments.

39. The National Science Foundation's *Science and Engineering Indicators* report, chap. 7, "Science and Technology: Public Attitudes and Understanding," includes detailed information on information sources, interest, and involvement, http://www.nsf.gov/statistics/seind10.

40. Ibid.

Miller has found that only about one in five Americans is "scientifically savvy" enough to read the Tuesday *New York Times* Science section, while the rest "just don't know" that much about science.[41]

He considers "civic scientific literacy"—defined as a "level of understanding of scientific terms and constructs sufficient to read a daily newspaper or magazine and to understand the essence of competing arguments on a given dispute or controversy"[42]—as crucial to a citizen's ability to participate in public-policy debates involving science or technology.

In terms of basic scientific knowledge, Miller's surveys suggest that about half of Americans know that Earth orbits the Sun (and not vice versa); about half know that humans and dinosaurs did not live at the same time; less than one-third know that DNA is a basic genetic building block of life (some have guessed it to be the Drug and Narcotics Agency).

Basic knowledge of DNA is important to understanding stories about the human genome, genetic engineering, or the stem cell debate. But Miller's surveys show that, a year before the 2004 election, 40 percent of those surveyed said they had never heard of stem cell research, despite considerable coverage of it from the time President Bush took office in 2001. On the evolution debate, his research shows considerable polarization, with only 14 percent definitely supporting the concept of evolution, one-third saying evolution is false, and the rest holding more tentative positions in between.

An important component of scientific literacy is formal education through science courses. But the media are an ongoing form of informal education, playing "a critical role as an early warning system" for the general public about news and issues of importance in science and technology, says Miller. For example, after the space shuttle *Challenger* exploded in January 1986, within three days 97 percent of Americans had seen pictures of the accident on television.

They followed up for more in-depth information by reading newspaper coverage; "today they would go online," says Miller.[43] Other early-warning systems come through "social and interest groups that are able to activate large groups of people" using email messages, mass mailings, or social media tools. "The public doesn't create issues. Interest groups and political leaders create issues. The public reacts to issues," says Miller. He notes that the United States is unique among Western industrialized countries in that religious groups have such a strong impact on public opinion and policy.[44]

41. Jon D. Miller (John A. Hannah Professor of Integrative Studies, Michigan State University; former Director, Center for Biomedical Communications, Northwestern University Medical School), interview by the author and comments from symposium presentations, American Association for the Advancement of Science meeting, February 17–19, 2006.

42. Jon D. Miller, "The Measurement of Civic Scientific Literacy," *Public Understanding of Science* 7 (1998): 204.

43. Miller, interview by the author.

44. Ibid.

American University communications researcher Matthew C. Nisbet agrees.[45] He says that Americans' views on controversial science and policy are often based on what political or religious leaders believe rather than on their own understanding of the issues. "The dominant assumption in science literacy is if only the public knew more, the debates would go away," says Nisbet. "But most of the public is unlikely to have the motivation or ability to be fully informed about topics like stem cell research, global warming, or intelligent design."

Instead, he says, they tend to use shortcuts, taking their cues from politicians or other opinion leaders they respect. "They take the information and filter it through underlying values like ideology and religion," says Nisbet. Ultimately, how the media cover or frame these debates—the slant of the articles and the sources of scientific and political information—helps shape the way both politicians and other leaders, as well as the public, view scientific and technological issues.

## IMPROVING COVERAGE OF SCIENCE AND PUBLIC POLICY

### *Science Writers versus General-Assignment Coverage*

Are readers and listeners best served by coverage of science and policy topics by specialized science reporters or by reporters with a general assignment or political background?

I would argue that coverage of recent controversies in science and public policy suggests that reporters with a specialty in science journalism are better equipped than general-assignment reporters to provide context and background on the research itself; science reporters can pick up skills needed to write about the legal, political, and ethical debates surrounding the research. This is true of both breaking news, where there is little time to get up to speed on the science, as well as more in-depth features, which require greater understanding of a given science field.

In a 2005 review of coverage of the debate over teaching evolution and intelligent design in schools, authors Mooney and Nisbet agree. They contend that press coverage is often misleading when science moves into political and legal realms, and "it ceases to be covered by context-oriented science reporters and is instead bounced to political pages, opinion pages and television news."[46] In the process, they argue, the science is distorted, as non-science reporters "deemphasize the strong scientific case in favor of evolution and instead lend credence to the notion that a growing 'controversy' exists over evolutionary science."

45. Matthew C. Nisbet (Assistant Professor, School of Communication, American University), telephone interview by the author, May 19, 2006.

46. Chris Mooney and Matthew C. Nisbet, "Undoing Darwin," *Columbia Journalism Review* (September/October 2005).

After reviewing seventeen months of evolution stories in *The New York Times* and *The Washington Post*, as well as television news and local papers, Mooney and Nisbet concluded that science writers generally provide an accurate description of the scientific view of evolution, while political, general assignment, and TV reporters provide little "real context" for the basic science and instead bend over backward to give false "balance" to their stories by lending "undue credibility to theological attacks that masquerade as being 'scientific' in nature." Too often, intelligent design is presented as an alternative scientific explanation, rather than as a sophisticated religious argument that cannot be tested through normal scientific channels.

Mooney and Nisbet say that the news media, and the public, will be better served by assigning coverage of complex scientific and political debates to reporters with training and experience in covering science. "The intelligent-design debate is one among a growing number of controversies in which technical complexity, with disputes over 'facts,' data and expertise, has altered the political battleground. The traditional generalist correspondent will be hard-pressed to cover these topics in any other format . . . balancing arguments while narrowly focusing on the implications for who's ahead and who's behind in the contest to decide policy."[47] Instead, they argue, there should be a "growing demand for journalists with specialized expertise and background."

"Political writers clearly don't have the background. They don't know how to judge the validity" of conflicting scientific and technical information, says author K. C. Cole, a journalism professor at the University of Southern California (USC) and former *Los Angeles Times* science reporter. Science writers, she says, "have a bullshit detector. You know your field and smell stuff that doesn't sound right."[48]

But science writers themselves need to push for a primary role in the science-policy turf. Science writer Hotz criticizes the tendency of some newspaper science writers to "head for the hills" when breaking news or a science-policy story presents itself, preferring instead to hang out in the ivory tower and do more timeless feature science stories.[49]

Others caution that science writers need to be careful not to become cheerleaders for science or appear to get too close to their science sources. Nonetheless, some of the most effective science-policy coverage has come from experienced science reporters who have covered their fields "from soup to nuts" and have developed the ability to analyze both complex science and policy with equal competency.

47. Ibid.

48. K. C. Cole, telephone interview by the author, March 20, 2006.

49. Hotz, interview by the author.

*Better Training for Science Writers*

Despite the current cutbacks in news-reporting jobs, the pipeline for new science writers is bigger than ever before. There are about fifty American universities that offer science writing programs or courses in science writing, with most of the programs at the graduate level, according to a 2007 online Directory of Science Communication Courses and Programs compiled by a team at the University of Wisconsin-Madison School of Journalism and Mass Communication. Some of the oldest programs, at places like Columbia University and Boston University, started in the 1960s, in part because of the boost for science writing as a result of the space program.

A number of new programs started over the past decade. Most are broadly focused on science, while some specialize in environmental or health journalism, says Wisconsin journalism professor Sharon Dunwoody.[50] Many of the newer programs give preference to students with an undergraduate or graduate science background. However, her own research indicates that the primary predictor of effective science reporting is number of years on the job, rather than formal science training.[51]

Improving specialty journalism, including science and medical reporting, was targeted in an Initiative on the Future of Journalism Education, launched in 2005 by Carnegie Corporation of New York and the John S. and James L. Knight Foundation. "Reporters need to know even more about complex beats if they are to deliver stories that are both shorter and more interesting. Whether reporting on the economy, medical advances, or the government, reporters need to provide not just facts but context," said a McKinsey & Company report prepared for the initiative.[52]

In response to a Carnegie-Knight curriculum enrichment grant, the USC Annenberg School for Communication & Journalism launched a new master of arts specialized journalism program to allow journalists to retool their skills and knowledge, with science and technology as one of the core areas.[53] The Graduate School of Journalism at the University of California, Berkeley, expanded the curriculum of its two-year master's degree program to include joint degrees with other disciplines and schools, such as public health. And the

50. Directory of Science Communication Courses and Programs, 2007, http://dsc.journalism.wisc.edu/index.html; and Sharon Dunwoody (Evjue Bascom Professor, School of Journalism and Mass Communication, University of Wisconsin-Madison), email message to and telephone interview by the author, March 17, 2006.

51. Sharon Dunwoody, "How Valuable is Formal Science Training to Science Journalists?" *Comunicacao e Sociedade* 6 (2004): 75–78.

52. McKinsey & Company Report, "Improving the Education of Tomorrow's Journalists," based on individual interviews with forty leaders in the news industry, http://www.carnegie.org/publications.

53. Carnegie-Knight Initiative on the Future of Journalism Education, Curriculum Enrichment, http://newsinitiative.org/initiative/curriculum.html. Also Annenberg Specialized Journalism, http://annenberg.usc.edu/Prospective/Masters/Specialized.aspx.

Graduate School of Journalism at Columbia University, in Fall 2005, launched a new master of arts program for experienced journalists to gain expertise in specific subject areas, including health and science, "so that they may cover complicated issues in a sophisticated, nuanced manner."[54]

### *On-the-Job Training for Journalists*

There is no single route to becoming a science writer. While young science journalists are coming increasingly from specialized science journalism programs (many with formal science training), other science writers have long come from general assignment or other beats. (One trip to an emergency room to cover a local disaster can create an instant medical writer.) In any case, rapid advancements in science require continuous on-the-job training.

NASW, the main professional membership organization, provides a variety of services and publishes a quarterly magazine, *ScienceWriters*.[55] NASW holds its annual journalism workshops in conjunction with the Council for the Advancement of Science Writing (CASW), a fifty-year-old educational organization started by science journalists to improve the quality of science information reaching the public. CASW's New Horizons in Science program showcases cutting-edge science by bringing distinguished scientists from a variety of disciplines to a host university for an intensive journalism seminar.[56] The Society for Environmental Journalists, Association of Health Care Journalists, and American Medical Writers Association also host annual meetings to update their members. International science writers now gather regularly under the auspices of the World Federation of Science Journalists, an association of more than forty science and technology journalism groups from Africa, the Americas, the Asia-Pacific region, Europe, and the Middle East that was founded in 2002.[57] The federation's meetings are creating new global science writing relationships, including an upcoming 2011 international meeting in Cairo hosted by Arab and American science writers. Universities, scientific organizations, government agencies, and other groups also host seminars and backgrounders for journalists.

Increasingly, mid-career fellowships offer opportunities for science journalists to go back to school, allowing them to delve more deeply into scientific disciplines. The Knight Science Journalism Fellowships, started in 1982

54. Ibid. See also http://www.journalism.columbia.edu for information on the master of arts in journalism at the Columbia University Graduate School of Journalism.

55. *ScienceWriters* is published four times a year by NASW. Archives are available to members at http://www.nasw.org.

56. CASW, http://www.casw.org, is an independent nonprofit organization devoted to improving science writing and is run by longtime Executive Director Ben Patrusky and Administrator Diane McGurgan. Paul Raeburn is the Program Director for New Horizons in Science. The author is the current President.

57. Cristine Russell, "Science Journalism Goes Global," *Science* 324 (June 19, 2009): 1491. The World Federation of Science Journalists, http://www.wfsj.org, will hold the 7th World Conference of Science Journalists in Cairo, June 2011.

at the Massachusetts Institute of Technology, give experienced journalists from around the world who cover science, technology, medicine, or the environment a chance to spend an academic year on campus; the MIT program also holds short "boot camps" on topical science issues to help reporters learn about everything from "medical evidence" to nanotechnology.[58] Journalism fellowships offered by the MBL (Marine Biological Laboratory) and Woods Hole Oceanographic Institute in Woods Hole, Massachusetts, allow journalists to experience biomedical and environmental research firsthand by working in the lab and the field, while the Metcalf Institute for Marine and Environmental Reporting in Narragansett, Rhode Island, also sponsors immersion workshops and environmental fellowships. Other programs in biomedicine and health, including at Harvard Medical School and the Centers for Disease Control, provide journalism training as well.

The quality of science journalism for the general public is another issue. While a host of prizes from journalism and scientific organizations have long rewarded the top science writers, there has been less scrutiny of science writing across the spectrum. Now, the Internet has spawned several new sites for evaluating science stories.

In May 2006, the MIT program launched the Knight Science Journalism Tracker, a website for science, medical, and environmental reporters and editors to view major stories from around the world. KSJ Tracker, written primarily by veteran science writer Charles Petit, provides a sampling of recent science news—from research to policy—and, where possible, related press releases and links. Its goal is to improve the quality of science writing by giving science reporters and editors "convenient and timely access to the work of peers across the country" so "they can better evaluate and improve their own performance."[59]

Another ambitious foundation-funded website, Health News Review, has evaluated more than a thousand news stories in major U.S. media about medical treatments, tests, and procedures since it began in 2006. Using a standardized five-star grading scale that focuses on accuracy, balance, and completeness (the ABCs), a team of medical, public health, and journalism professionals provides tough—and sometimes unrealistic—critiques of health coverage in leading circulation newspapers, wire services, newsmagazines, and major online health news sites. (It has stopped daily reviews of health news stories by the major television networks because of the consistently poor ratings.)[60] Health News Review, overseen by University of Minnesota health

58. The Knight Science Journalism Fellowships at MIT, http://web.mit.edu/knight-science, is directed by science journalist and author Phil Hilts.

59. Knight Science Journalism Fellowships at MIT, Knight Science Journalism Tracker, http://ksjtracker.mit.edu. The head tracker is longtime science writer Charles Petit, CASW Vice President and a former NASW president.

60. The publisher of the website Health News Review, http://www.healthnewsreview.org, is Gary Schwitzer, a health journalism professor at the University of Minnesota and former CNN medical editor and reporter. It is funded by the Foundation for Informed Medical Decision Making.

journalism professor Gary Schwitzer, is a valuable resource for journalists, the medical community, and consumers who use the Web for health information.

In January 2008, the *Columbia Journalism Review*, the leading American media monitor, started a new online section, The Observatory, which provides news analysis and commentary on developments and trends in science journalism coverage, from the environment to medicine. "As the twenty-first century unfolds, the need for clear, credible science journalism will only become more crucial. It is among the most important and complicated of all journalistic beats, informing all manner of public, policy, legal doctrine, financial investment, academic research and consumer behavior," wrote founding editor Curtis Brainard.[61]

Sigma Xi, the national scientific research society, also has a daily science news website[62] that provides summaries and links to science stories from a variety of news organizations.

### *Training for Nonscience Writers and Editors*

Many of the journalists who may be called upon to report about science on an occasional or regular basis are not up to the task. General assignment, education, business, investigative, religion, agriculture, political, or foreign correspondents need to be prepared for the inevitable moment when a challenging science, medical, or environmental story lands on their desks. As journalism programs expand specialty training, it is important to expose all journalism students to techniques for writing about science and policy issues, as well as the technical skills to evaluate numbers, public opinion polls, and surveys that are a regular part of all beats.

Similarly, working reporters and editors on a variety of beats need help doing a better job writing about science and technology controversies that regularly crop up in the news. On-the-job training through professional organizations and workshops offers an opportunity for reporters of all stripes to learn how to improve coverage of pressing science and technology topics—from biodiversity to biotechnology. More outreach work can and should be done in this area, finding novel ways to get professional science-writing training to journalists strapped for time and money. Two new Knight Foundation initiatives in online training, for example, could provide a means of improving coverage of science and technology issues. The News University, launched in 2005 by the Poynter Institute for Media Studies, is an innovative way to provide interactive, inexpensive online courses for journalists of all backgrounds and media. For example, a self-directed course on "Covering Climate Change" on the Poynter site is geared toward the non-environment reporter and covers

61. *Columbia Journalism Review*, The Observatory, http://www.cjr.org/the_observatory. The author is a contributing editor.

62. Sigma Xi, Science in the News, is part of the *American Scientist* website, http://www.americanscientist.org/science.

all the basics needed to report on climate change. The Knight Digital Media Center, started in April 2006, provides "training for New Media at all levels—from the traditional journalist making the transition to New Media to the New Media journalist seeking to improve critical thinking and beat reporting skills." A March 2007 Knight seminar looked at best practices for "covering science in cyberspace."[63] Television and radio reporters also need more opportunities for training in specialty beats like science.

Media outlets should explore ways to better utilize science writers in their coverage of local, national, and international policy issues. More team coverage, such as pairing a science writer with a political reporter, could result in a better product for readers (rather than assigning the science or medical reporter to the proverbial sidebar to a story written by a general assignment or political reporter). Also, given the potential for emergency news coverage in a variety of areas, from an outbreak of H1N1 influenza to a massive deepwater drilling oil spill, teams need to be trained for spot coverage that better utilizes the scientific, medical, environmental, and technical capacity of specialty reporters both in print, on the air, and online. Going behind the news, National Public Radio science journalist Richard Harris, for example, was among the first to challenge official estimates of the amount of oil leaking into the Gulf of Mexico from the BP Gulf of Mexico oil spill in Spring 2010. He reported on an exclusive expert analysis suggesting that the amount of oil leaking was far higher than the company originally suggested.

As biotech and pharmaceutical companies fund an increasing array of basic and clinical research and actively court the media, business and technology reporters also need more training. It is now standard to scrutinize potential financial conflicts of interest among university as well as industry researchers, since many academics have become consultants or participants in business-funded research projects. However, business and general-assignment reporters without experience in science coverage are also susceptible to overly promotional coverage of proponents' claims of new product benefits or, alternatively, overly negative coverage of critics' claims of side effects and other risks.

### *Communications Training for Scientists*

Scientists need to become better communicators about science and policy, translating technical studies into plain English that both reporters and the public can understand. Trained science writers in the public information offices of universities, government agencies, and the private sector can be invaluable in guiding this process, as long as their goal is brokering the best

63. The John S. and James L. Knight Foundation, http://www.knightfdn.org, has funded a variety of journalism initiatives. The Knight Digital Media Center, http://www.knightdigitalmediacenter.org, is a partnership between USC Annenberg School for Communication and the Graduate School of Journalism at the University of California, Berkeley. The Poynter Institute News University is at http://www.newsu.org.

information possible for journalists and the public (rather than protective actions to keep scientists at arms length, as was the case with some federal government climate change stories during the Bush administration).[64]

Many of these public information offices, as well as scientific professional organizations, have organized their own training for scientists to better prepare them for the types of questions to expect in press briefings or interviews and have brought in reporters to talk about the process.

In addition, science journalism groups such as the CASW have long offered briefings for scientists at national meetings and at universities about how to improve communication to the public about science. They bring in leading science journalists to explain how the news media does its job and to provide tips for scientists on talking to the press.[65] For thirty years, AAAS has offered "mass media" summer fellowships with media outlets nationwide for graduate and postgraduate science and engineering students who are interested in writing about science. (Some, such as NPR correspondent Harris, become science writers; others go into scientific careers better equipped to communicate about science.) The AAAS also has a variety of science and technology policy fellowships to better acquaint scientists with federal policy-making.[66]

The American Academy of Arts and Sciences, whose membership includes many distinguished scientists and journalists, launched a project in 2006 to look at "The Media in Society: How the Media Cover Science and the Economy."[67]

One of the most intensive efforts to improve scientists' ability to communicate to the media, policy-makers, and the public has been the Aldo Leopold Leadership Program at Stanford University; it offers a model for other disciplines. Aimed at mid-career academic environmental scientists who agree to participate in two weeklong seminars, the Leopold program has trained more than 150 Fellows since 1998. One of its founders, distinguished marine biologist Jane Lubchenco, the National Oceanic and Atmospheric Administration administrator, says the program has empowered previously gun-shy scientists to do a better job communicating with the public. "After training, they have a better understanding of what journalists need, how

64. See coverage by former *New York Times* reporter Andrew Revkin and *Washington Post* reporter Juliet Eilperin for examples of several attempts by Bush administration political appointees to control communications between journalists and scientists in agencies such as the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA).

65. "Why Scientists Should Talk to the Media," a video based on an October 2009 Yale University School of Medicine seminar organized by CASW, http://casw.org/videos-october-2009-brown-bag-event-yale.

66. American Association for the Advancement of Science (AAAS), http://www.aaas.org.

67. American Academy of Arts and Sciences, interviews by the author and information online, http://www.amacad.org/projects/social.aspx.

much journalists know, and how to talk about science in ways that are useful and understandable," she said in an earlier interview.[68]

A more portable version of how and why scientists should talk to the media can be found in recent books from two highly regarded science writers who have operated inside and outside the scientific fence. Veteran science reporter Cornelia Dean makes the case in her compact 2009 book, *Am I Making Myself Clear? A Scientist's Guide to Talking to the Public*. Dennis Meredith, in *Explaining Research: How to Reach Key Audiences to Advance Your Work*, distills decades of work in science communication at the nation's leading universities into a practical guide and website for scientists and engineers. He is fond of a succinct Albert Einstein quote that says it all: "You do not really understand something unless you can explain it to your grandmother."[69]

### *Guidelines for Improving Coverage*

There is no instruction manual for writing about science. Good science writing combines knowledge of the subject, the skill to translate complexity into language understandable to the layman, and the ability to tell a story that will engage the reader, listener, or viewer. Writing about controversies involving science and public policy requires additional juggling skills, assessing the state of science, the stakeholders in the debate, and the means for managing the problem, now or in the future. Although each story is different, journalists and those they cover should keep the following ten guidelines in mind when communicating about controversial science and policy issues.[70]

1. *Put new research in context*. Is it preliminary or definitive? Are findings statistically significant, or could they have occurred by chance? Does the research confirm or conflict with past research? What additional research needs to be done? How important is the new research to advancing the field or to a given public-policy issue? Who conducted the research, and what is the individual or institutional reputation or track record? Who funded the research? Has it been presented at a scientific meeting or published in a reputable scientific journal? How was the

68. Jane Lubchenco (confirmed as Administrator, National Oceanic and Atmospheric Administration, March 2009; former Distinguished Professor of Zoology and Wayne and Gladys Valley Professor of Marine Biology, Oregon State University; former President, AAAS, and Ecological Society of America), interview by the author, February 19, 2006. The Aldo Leopold Leadership Program, http://leopoldleadership.stanford.edu, based at the Woods Institute for the Environment at Stanford University, is funded by the David and Lucile Packard Foundation.

69. Cornelia Dean, *Am I Making Myself Clear? A Scientist's Guide to Talking to the Public* (Cambridge, Mass.: Harvard University Press, 2009); Dennis Meredith, *Explaining Research: How to Reach Key Audiences to Advance Your Work* (New York: Oxford University Press, 2010), http://www.explainingresearch.com.

70. These guidelines were drawn up by the author, based on personal experience as a science writer for more than thirty years, on research for this paper, and on presentations on science writing.

research conducted and over what period of time? Understanding the fine print in terms of who or what was studied and in what manner is crucial in determining the significance and relevance. Laboratory and animal research provides clues for further study but may have limited relevance to humans; smaller studies are less significant than larger ones. Studies that look back in time (retrospective) may be less reliable than prospective studies that follow a population over time. The most valuable medical study is a double-blind, controlled clinical trial in which researchers divide patients into an experimental or treatment group and an untreated control group and compare the outcomes in both groups.

2. *Stop the yo-yo approach to science, environment, medical, and technology coverage (swinging from "breakthrough" to "disaster").* My colleague, the late *Washington Post* medical writer and columnist Victor Cohn, quipped that there are two kinds of front-page newspaper stories: "new hope and no hope." Journalists often emphasize the dramatic over the ordinary; pushing to get on page one or the top of the television news can distort a story. But there is plenty of blame to go around. Scientists and physicians are often overly enthusiastic about their work; business interests can over-promote new products; interest groups often grab attention with dire warnings. Experienced science reporters put in the disclaimers, stay away from the word *breakthrough* (not always easily, since doctors and scientists themselves may throw around the term rather loosely), and let the story sell itself.

3. *Avoid "dueling" experts on science and policy.* Traditional journalistic fairness means giving both sides in a controversy a chance to be heard. But it can be confusing—or even misleading—for the public if each side is given equal weight just to make a story appear "balanced." Too often science-policy stories create drama by citing experts arguing from two extremes without trying to find out whether there is a scientific middle ground. Is there a consensus view among leading researchers or mainstream professional scientific organizations? If not, what is the degree of uncertainty? Try to sort the science from the policy, and find out which hat various experts are wearing. "More than in any other field of reporting, balance in science writing requires something other than just providing an equal number of column inches to quotes from each side. Balance in science writing requires authorial guidance; it requires context, and knowing when certain points of view simply need to be ignored," notes NASW's science-writing guide.[71] This is where experience counts, says former *Washington Post* reporter Rick Weiss, now communications director for the White House Office of Science and Technology Policy. "It's not [a reporter's] job to find equal numbers of voices on both sides of the issue and give them all equal time,"

71. Blum, Knudson, and Henig, *A Field Guide for Science Writers*, ix.

he says. Instead, journalists need "to talk to people on all sides and hear them out and then do some value-added consideration of who has the stronger case for the question at hand. . . . The reader deserves nothing less."[72]

4. *Write about the process of science as well as the end results.* Science evolves; it is incremental; it has false starts; it needs to be replicated by others. Unfortunately, we often focus on artificial end points, when studies are reported at meetings or published in journals (and, of course, negative findings are seldom touted in such proceedings). Getting into the lab or out in the field gives the reporter—and the audience—a better understanding of how science is really done. It results in a better enterprise piece that, unlike the stories from prepackaged journal articles, is not being written by every other reporter. The ability to make science come alive for the reader or viewer only comes with time on the road. But even a basic news story can benefit from some explanation of how the research was done. Reporters should try to add information about how an experiment or study was conducted and not just provide the outcome. "I've become so aware of how little people understand science, how difficult people find it to think scientifically," says Weiss.[73]

5. *Watch out for anecdotes.* Stories involving children or celebrities may dramatize or personalize a particular problem, helping draw in the audience, particularly on local television. But they may overshadow the underlying science (or lack thereof). A story needs to distinguish an individual case or set of cases from what is known or not known about a given problem. Victims of cancer, or a cluster of cancer cases, may prematurely point the blame at certain products or polluters, for example. But science reporters need to explain the uncertainties in proving cause-and-effect without extensive research, and even then it may be extremely hard to determine conclusively for chronic diseases like cancer. In the early 1990s, claims by individuals, citizen groups, and politicians on Long Island, New York, that environmental pollution was responsible for an increased rate of breast cancer among women there drew national attention and a clamor for scientific research. But several studies have since found no evidence to support such claims, including a June 2006 New York State Health Department study that found "no local environmental factors that were likely related to the elevated breast cancer rates."[74]

72. Rick Weiss (former *Washington Post* Science Reporter), telephone interview by the author, March 27, 2006.

73. Ibid.

74. "State Health Department Releases Final Results of Breast Cancer Investigation in Suffolk County," New York State Health Department Press Release, June 23, 2006, http://www.nyhealth.gov/press/releases/2006/2006-06-23_cmp_final_report_release.htm.

6. *Be careful in citing risk statistics.* Distinguish between *relative* risk (a nine times greater risk of stroke) and *absolute* risk (a one in ten thousand risk of stroke per year among women in a given age group). Too often studies in scientific journals, such as *The New England Journal of Medicine*, emphasize relative risk and may not provide any information on the appropriate absolute risk numbers. The resulting stories may incorrectly suggest a major hazard, frightening the audience without giving any perspective as to what the baseline risk was in the first place. For example, British medical journals set off a "pill scare" in England in 1996 with preliminary evidence that low-dose birth control pills doubled the risk of blood clots. A follow-up letter to *The Lancet* pointed out how small the risk was in the first place: it went from a risk of about one case per ten thousand users to two cases per ten thousand users. Going off the pill posed the obvious greater risk of pregnancy.[75] It takes extra time and initiative to push for underlying risk numbers. Look also for comparable risks from other activities that may help put the numbers in perspective for the consumers in a helpful way. Try to include information about potential benefits, if there are any; however, potential beneficiaries and at-risk groups may well be different. (The consumers of a product may benefit, but workers in a plant may be at risk.)

7. *Distinguish between the impact on individuals versus the impact on society.* Public policy is generally geared toward societal impact, not individual problems or risks. Information in the story should give individuals a sense of who is most at risk and what the consequences of that risk may be. A large individual risk may affect only a small group of people. A small risk for any one individual may still pose a larger societal risk if a significant number of individuals are involved in a shared activity. Does the risk involve voluntary or involuntary exposure (through common sources of air, water, or food)? Much of public outrage, as well as government regulation, focuses on involuntary exposure, even though such risks may be far smaller than voluntary everyday risky behaviors, such as driving, eating poorly, or smoking. (Watch out for parties with economic interests that may try to diminish concern about an involuntary risk, like environmental pollution, by comparing it to remote risks, like the chance of being hit by lightning, and then suggesting that nothing really needs to done. It may be apples and oranges for your audience.)

8. *Provide information on what, if anything, can be done about a given problem by individuals, government, or the private sector, as well as the degree to which the available science supports such action.* There is always more research to do; the question for citizens and public policy-makers

75. Cristine Russell, "Risk Reporting," in *A Field Guide for Science Writers*, ed. Blum, Knudson, and Henig, 253.

is when to act on the results of incomplete science, weighing the dangers of premature action and being wrong against the hazards of waiting too long for more answers and causing more harm along the way. It's really a judgment call, with input from scientific (and often legal) experts and decision-making by policy-makers and politicians. "Most people think science is about facts and are quite frustrated when they find that science is in large part about uncertainty," says University of Michigan professor Gilbert S. Omenn,[76] former president of the AAAS and a former federal government official. Prudent public policy, particularly in the health arena, may require action before there is definitive evidence; "more research is needed" may sometimes be an excuse for avoiding tough policy decisions, particularly those with large economic consequences. Complex science-policy stories often require presenting the array of options—including knowns and unknowns—on both sides of the equation. What is the best available scientific advice, and how long will it take to get better answers? What are the economic and human costs of taking action now versus waiting? Who pays? Who may benefit? Is it prevention or treatment/amelioration? What can individuals do on a voluntary basis to help solve a problem? What can businesses do? What are the options for government agencies charged with deciding whether to take action? In terms of climate change, for example, there is a limited amount that individuals can do to make a big dent in the problem; however, public understanding of this polarized issue is crucial to the policy and political debate about what actions to take in the public and private sector, as well as when, or if, to take them.

9. *Avoid becoming an advocate for any side if you are a news reporter or editor.* Leave that to the editorial pages. Present the information fairly, but be skeptical about the sources of information. Look for conflicts; follow the money. And remember, even "good" causes can distort a news or feature story. Advocacy groups push hard for their positions. It is not the traditional journalist's job to side with one group or point of view; rather, he or she should help the audience figure out who is behind what cause and why. A scientist may be wearing both a research and a policy hat; find out which one and what personal or financial incentives may be involved. Transparency is the best approach. The growing number of reporters who also bring a personal voice by blogging and tweeting for their media outlets may create added tensions, and sometimes confusion, as to what hat the journalist is wearing.

76. Gilbert S. Omenn (Professor of Internal Medicine, Human Genetics, and Public Health, University of Michigan; Associate Director, Office of Science and Technology Policy, and Associate Director, Office of Management and Budget, Executive Office of the President, during the Carter administration), interview by the author, February 17, 2006.

10. *Recognize that there is no single "public."* The audience reads, watches, and listens through multiple lenses of age, gender, ethnicity, education, politics, and religion, to name a few. But we often write as if there were a generic "public." In writing about science, environment, medicine, and health, consider the diversity of the audience and its reaction to news, particularly to stories in the "no hope, new hope" categories. It helps to break down stories, with details about who is most affected, how, and why, as well as the potential timeline. Some people personalize every story; others turn off if they don't think it is relevant to them. If science stories are too technical or difficult, those who are less educated may tune out as well. Visualize a grandmother, an eighth-grade son, or a new mother. And, yes, you do need to explain what DNA is.

## CONCLUSION

Media coverage of controversial scientific issues needs to be improved on both the science and policy sides. This paper has provided a wide-ranging look at the state of science writing for the general public, with the following conclusions:

- There are more potential science and science-policy stories than ever before, as new scientific developments push the ethical, political, and legal envelopes of the past.
- The news media are shorthanded, with fewer reporting and editing jobs for reporters trained or experienced in covering specialty beats like science. There is also less space and time to tell the story in traditional media outlets; science sections, particularly in smaller newspapers, have been cut back in numbers and scope.
- The existing coverage is skewed toward one end of the spectrum of science coverage—consumer-driven health and medicine—leaving the audience less informed about many other important developments in science and technology that may affect their lives.
- Reporters with knowledge of how best to communicate about science and technology, as well as the policy issues that these topics generate, are better equipped to tell the story than general-assignment reporters with no science-writing experience.
- New initiatives are needed to help improve coverage by all reporters who might cover science and policy issues. These initiatives must include better training about how to cover technical stories, as well as convenient access to resources that may provide accurate information about science and policy issues. Again, the Internet offers the potential for training journalists and providing better and faster information gathering than in the past.

- Members of the scientific community, particularly those receiving public funding, have an obligation to make communication with the public through the news media a valued part of their jobs. Scientists also need more training about how best to work with the media.
- There is an opportunity for the news media to use new media to provide better information to a diverse public that is generally not well educated about issues involving science and technology. The media can help bridge this gap, using traditional news outlets as well as non-traditional outlets such as the Internet to provide helpful, accurate, thoughtful, and engaging coverage of science and technology that is accessible to a wide audience.

Ultimately, better, more balanced coverage of science and technology policy will help the public, and their representatives, understand the crucial issues that individuals, local communities, the United States, and countries of the world face in the years to come.

CHAPTER 4

# Civic Scientific Literacy: The Role of the Media in the Electronic Era

Jon D. Miller

The health of American democracy in the twenty-first century will depend on the development of a larger number of scientifically literate citizens. Today's political agenda includes a raging debate over the causes and consequences of global climate change, a continuing bitter debate over the use of embryonic stem cells in biomedical research, a spirited set of disagreements over future energy sources, and a lingering concern over the possibility of a viral pandemic. In Europe, the political landscape is still divided over nuclear power and genetically modified foods. No serious student of public policy or science policy thinks that the public-policy agenda will become less populated by scientific issues in the twenty-first century. Yet only one in four Americans has sufficient understanding of basic scientific ideas to be able to read the Science section in the Tuesday *New York Times* (Miller, 1998, 2000, 2001, 2004, 2010). Some research suggests that the proportion may be substantially lower when citizens are faced with strong advocates on both sides, as in the current global warming debate and the embryonic stem cell debate.

At the same time, most adults will learn most of their science information after they leave formal schooling. How many current adults can claim that they studied stem cells or nanotechnology when they were students? In the years and decades ahead, the number and nature of new scientific issues reaching the public-policy agenda will not be limited to subjects that might have been studied in school, but will reflect the dynamic of modern science and technology.

This fact does not mean that formal schooling is irrelevant. When done well, formal science education in high school and especially in college can give individuals a strong foundation of basic scientific constructs for use in making sense of later events. American secondary schools do a poor job in providing this foundation of basic understanding, and the recent PISA (Program for International Student Assessment) report reconfirms our national mediocrity in this area (Baldi et al., 2007). Unbeknownst to most Americans, the United States is the only major country that requires all its college and university students to complete a year of general education, including a full year of science. Recent international comparisons have shown that approximately one in five American adults qualifies as scientifically literate and that exposure to college-level science courses is the primary factor in the performance of American adults in this capacity (Miller, 2000, 2004, 2010).

The need for adults to learn new science after formal schooling is obvious. The overwhelming majority of American adults aged thirty-five or older could not have learned about stem cells, nanotechnology, or global warming in school twenty years ago because it was new information for scientists at that time and was not included in any textbook. Similarly, few current adults could have learned about the human genome project in school. However, the results of that work are often mentioned in public-policy debates, and surveys show that approximately 40 percent of American adults understand the role of DNA in heredity (Miller, 2001, 2004, 2010). Few scientists would assert that they could predict the science issues in the news twenty-five years from now, but the majority of today's adults will have to make sense of those issues at some time in their lives if we hope to preserve more than the rituals of democracy.

For most of the last fifty years, the media—print, broadcast, and other forms of informal learning—have played an important part in sustaining adult science literacy, building on the foundation constructs retained from formal schooling and expanding both the scope and depth of that understanding (Miller & Kimmel, 2001; Miller, Augenbraun, et al., 2006). No one would assert that the job has been done perfectly, but there are numerous indicators of success in this area (Miller, 2004, 2010).

The task of this essay is to use available empirical evidence to describe the recent and current levels of adult understanding of science and technology and to examine the past, present, and future impact of media on adult scientific literacy in the United States. The essay will conclude with a discussion of the merging partnership between science, education, and the media in the development and maintenance of civic scientific literacy throughout the life cycle.

## THE DEFINITION AND MEASUREMENT OF CIVIC SCIENTIFIC LITERACY

To understand the concept of civic scientific literacy, it is necessary to begin with an understanding of the concept of *literacy* itself. The basic idea of literacy is to define a minimum level of reading and writing skills that an individual must have to participate in written communication. Historically, an individual was thought of as literate if he or she could read and write his or her own name. In recent decades, there has been a redefinition of basic literacy skills to include the ability to read a bus schedule, a loan agreement, or the instructions on a bottle of medicine. Adult educators often use the term "functional literacy" to refer to this new definition of the minimal skills needed to function in a contemporary industrial society (Kaestle, 1985; Cook, 1977; Resnick & Resnick, 1977; Harman, 1970). The social science and educational literature indicates that about a quarter of Americans are not "functionally literate," and there is good reason to expect that this proportion roughly applies in most mature industrial nations, with a slightly higher rate in emerging industrial nations (Ahmann, 1975; Cevero, 1985; Guthrie & Kirsch, 1984; Northcutt, 1975).

In this context, civic scientific literacy is conceptualized as the level of understanding of science and technology needed to function as a citizen in a modern industrial society (Shen, 1975; Miller, 1983a, 1983b, 1987, 1995, 1998, 2000, 2001, 2004, 2010; Miller, Pardo & Niwa, 1997; Miller & Pardo, 2000). This conceptualization of scientific literacy does not imply an ideal level of understanding, but rather a threshold level. It is neither a measure of job-related skills nor an index of economic competitiveness in a global economy.

In developing a measure of civic scientific literacy, it is important to construct a measure that will be useful over a period of years and that will be sufficiently sensitive to changes in the structure and composition of public understanding. If a time series indicator is revised too often or without consciously designed linkages, it may be impossible to separate the variation attributable to measurement changes from real change over time. The periodic debates over the composition of consumer price indices in the United States and other major industrial nations are a reminder of the importance of stable indicators over periods of time.

The durability problem can be seen in the early efforts to develop measures of public understanding of science in the United States. In 1957, the National Association of Science Writers (NASW) commissioned a national survey of public understanding of and attitudes toward science and technology (Davis, 1958). Since the interviews for the 1957 study were completed only a few months prior to the launch of *Sputnik I*, it is the only measure of public understanding and attitudes prior to the beginning of the space race. Unfortunately, the four major items of substantive knowledge were (1) radioactive fallout, (2) fluoridation in drinking water, (3) the polio vaccine, and (4) space satellites. Fifty years later, at least three of these terms are no longer central to the measurement of public understanding.

Recognizing this problem, Miller attempted to identify a set of basic constructs, such as atomic structure or DNA, that are the intellectual foundation for reading and understanding contemporary issues, but that will have a longer durability than specific terms, such as the fallout of strontium-90 from atmospheric testing. In the late 1970s and the early 1980s, when the National Science Foundation began to support comprehensive national surveys of public understanding and attitudes in the United States, there was little experience beyond the 1957 NASW study in the measurement of adult understanding of scientific concepts. In a 1988 collaboration between Miller in the United States and Thomas and Durant in the United Kingdom, an expanded set of knowledge items was developed to ask respondents direct questions about scientific concepts. In the 1988 studies, a combination of open-ended and closed-ended items was constructed to provide significantly better estimates of public understanding than had been collected in any prior national study. From this collaboration, a core set of knowledge items emerged; it has been used in studies in Canada, China, Japan, Korea, India, New Zealand, and all twenty-seven members of the European Union.

These core items have provided a durable set of measures of a vocabulary of scientific constructs, but it is important to continually enrich the mix to reflect the growth of science and technology. For example, Miller's recent studies of the American public have included new open-ended measures of stem cell, nanotechnology, neuron, and neuroscience and new closed-ended knowledge items concerning the genetic modification of plants and animals, nanotechnology, ecology, and infectious diseases. It is useful to look briefly at the primary items used in the measurement of civic scientific literacy in the United States in recent years and at the percentage of American adults able to answer each item correctly.

A core set of items focuses on the meaning of studying something scientifically and the nature of an experiment. (See Table 1.) Looking at data collected over the last twenty years, the proportion of American adults who are able to define the meaning of a scientific study has increased from 22 percent to 29 percent. By 2007, half of American adults were able to describe an experiment correctly. Although these percentages are low in terms of our expectations, it is important to remember that each percentage point represents 2.3 million adults; thus we would estimate that 67 million adults understand the meaning of a scientific study, and 115 million adults understand the structure and purpose of an experiment. And we see evidence of growth in the proportion of adults who understand these basic constructs.

Similarly, the proportion of adults able to understand simple probability statements has increased from 56 percent to 73 percent since 1988. Nearly one in five American adults can describe a molecule as a combination of two or more atoms. Many adults know that atoms, molecules, and electrons are very small objects, but are confused about their relationship to each other. Four out of five adults know that light travels faster than sound, but only half know that a laser is not composed of focused sound waves. (See Table 1.)

All these basic physical science constructs are part of middle school and high school science instruction and should have been acquired during formal schooling. If these constructs were understood during the school years, many adults appear not to have retained these basic ideas as adults and are unable to use them in reading a newspaper story or seeking to understand a television show.

Adult understanding of the universe and our solar system is uneven. Four out of five adults know that the center of Earth is very hot, and about 70 percent understand the basic idea of plate tectonics—expressed as continents moving their positions. (See Table 1.) Only 63 percent of adults know that Earth

**Table 1: Percentage Correct on Selected Knowledge Items, 1988, 1997, 2007**

| | Percent Correct | | |
|---|---|---|---|
| | 1988 | 1997 | 2007 |
| Provide a correct open-ended definition of "what it means to study something scientifically." | 22% | 23% | 29% |
| Provide a correct open-ended definition of an "experiment." | – | 39 | 50 |
| Understanding of the meaning of the probability of one in four. | 56 | 54 | 73 |
| Provide a correct open-ended definition of a "molecule." | – | 11 | 18 |
| Indicate that light travels faster than sound. | 78 | 75 | 82 |
| Agree: "Electrons are smaller than atoms." | 46 | 44 | 48 |
| Disagree: "Lasers work by focusing sound waves." | 40 | 39 | 46 |
| Agree: "The universe began with a huge explosion." | 34 | 32 | 30 |
| Agree: "The center of Earth is very hot." | 82 | 82 | 80 |
| Indicate that Earth goes around the Sun once each year. | 50 | 48 | 63 |
| Agree: "The continents on which we live have been moving their location for millions of years and will continue to move in the future." | 81 | 78 | 71 |
| Agree that astrology is not at all scientific. | 62 | 59 | 60 |
| Provide a correct open-ended definition of "DNA." | 27 | 22 | 34 |
| Provide a correct open-ended definition of a "stem cell." | – | – | 15 |
| Agree: "Human beings, as we know them today, developed from earlier species of animals." | 47 | 44 | 40 |
| Disagree: "The earliest humans lived at the same time as the dinosaurs." | 40 | 51 | 50 |
| Agree: "All plants and animals have DNA." | – | – | 77 |
| Agree: "More than half of human genes are identical to those of mice." | – | – | 34 |
| Disagree: "Humans have somewhat less than half of their DNA in common with chimpanzees." | – | – | 40 |
| Disagree: "Ordinary tomatoes . . . do not have genes but genetically modified tomatoes do." | – | – | 49 |
| Disagree: "Antibiotics kill viruses as well as bacteria." | 31 | 43 | 55 |
| Number of cases | 1,600 | 1,484 | 1,407 |

The items listed above were included in the computation of the Index of Civic Scientific Literacy (CSL) but do not constitute the full set of items used. Given the size of the samples, differences from year to year of less than three points may reflect sampling error rather than real differences.

goes around the Sun once each year, and only 30 percent understand or accept the idea of the Big Bang. The slight decline in the acceptance of the Big Bang is undoubtedly the result of increased pressure from religious fundamentalists who reject both biological evolution and the Big Bang. Three in five adults recognize that astrology is "not at all scientific."

The level of public confusion is greatest in the life sciences, undoubtedly reflecting the same fundamentalist pressures noted above. Only 40 percent of American adults accept the concept of biological evolution, and the level of acceptance has declined over the last twenty years. (See Table 1.) One in three American adults can define DNA correctly, but only 15 percent can define the meaning of a stem cell. Only half of adults reject the idea that humans and dinosaurs coexisted. Although three out of four adults recognize that all plants and animals have DNA, a majority of American adults do not think that humans share a substantial majority of our genes with chimpanzees or mice. Misunderstanding is not limited to human genetics: only half of adults reject the statement that "ordinary tomatoes do not have genes but genetically modified tomatoes do."

On a more applied level, the proportion of adults who understand that antibiotics do not kill viruses has increased from 31 percent in 1988 to 55 percent in 2007. (See Table 1.) Other analyses of this result have shown that a large proportion of adults learn about the function of antibiotics during their adult years, largely from encounters with physicians and health personnel for personal and family reasons.

Although these descriptive results are interesting, it is useful to have a good summary measure of the level of adult understanding of these basic constructs. By using Item-Response-Theory (IRT), it is possible to construct a summary Index of Civic Scientific Literacy (CSL) with scores ranging from roughly zero to one hundred. The IRT is a standard testing technology and is widely used in many national tests, including the Graduate Record Examination (GRE) and other tests produced by commercial test publishers (Zimowski et al., 1996). IRT technology also allows the construction of time series measures over a period of years, even when the mix of questions asked in each year varied slightly.

There are two primary ways of looking at the distribution of civic scientific literacy. One approach is to look at the scores of each individual in the study on a full IRT metric, ranging from zero to approximately one hundred. We could look at the mean CSL score for all adults in 2008 (55.9), for example, or we could look at differences in the mean score by gender, education, age, and other factors. This approach provides a reliable measure of central tendency, but it does not tell us how many adults have attained a level of scientific understanding to be able to function effectively as citizens or consumers.

Alternately, we could determine a threshold measure of CSL and examine the proportion of adults who attain that level. For this purpose, a careful analysis of various combinations of potential correct and incorrect responses suggested that individuals with a score of seventy or higher would have a command of a set of basic scientific constructs that would allow them to read moderately sophisticated popular science material such as the writing in the *New York Times* Tuesday Science section and make sense of most of the basic ideas. This level of scientific literacy is still insufficient for head-to-head discourse with a scientist, engineer, or professional in the field, but it represents an ability to read the vocabulary of scientific ideas and to understand at a lay level the nature of scientific inquiry. Using this threshold measure, the percentage of American adults who scored seventy or higher on the CSL increased from 10 percent in 1988 to 29 percent in 2008. (See Figure 1.)

Given this pattern of growth in CSL over the last two decades, it is appropriate to consider how the media influence adult CSL in the United States.

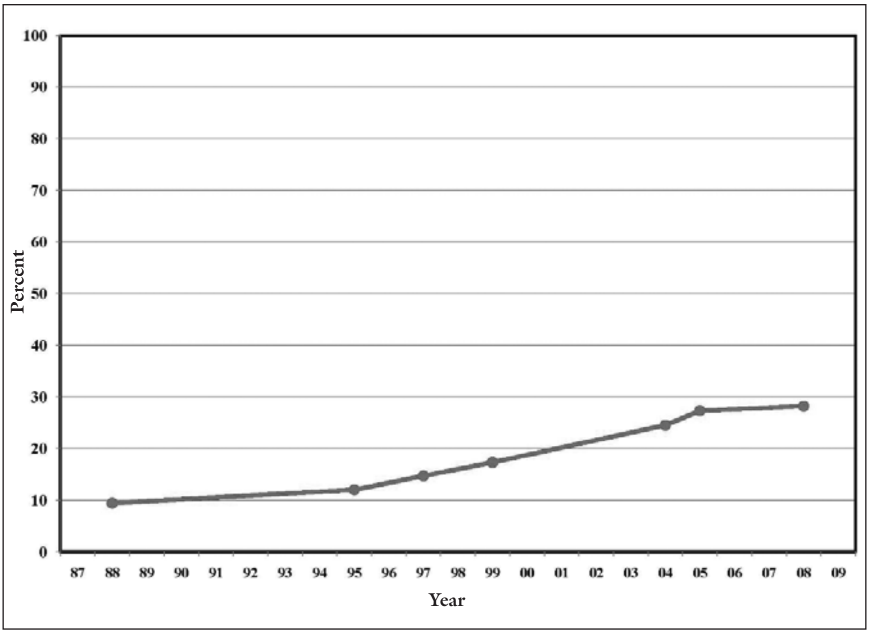
## PATTERNS OF MEDIA CHANGE

We live in the midst of a revolution in communication technologies and media availability and utilization. The sixty years since the end of World War II have witnessed the introduction of television, computers, satellites, transistors, optical fiber, wireless communication, and the Internet. Who would have thought that both our children and our parents would be sending us digital pictures over the Internet?

Citizens of advanced technological societies like the United States have never had access to so much information so inexpensively and have never been able to communicate with so many other individuals over vast distances so quickly. The Internet has become the library for the global village, and evidence suggests that it is being used for a variety of purposes, including the acquisition of scientific and medical information. To understand these broad generalities, it is useful to look at some specific patterns of change over the last twenty years.

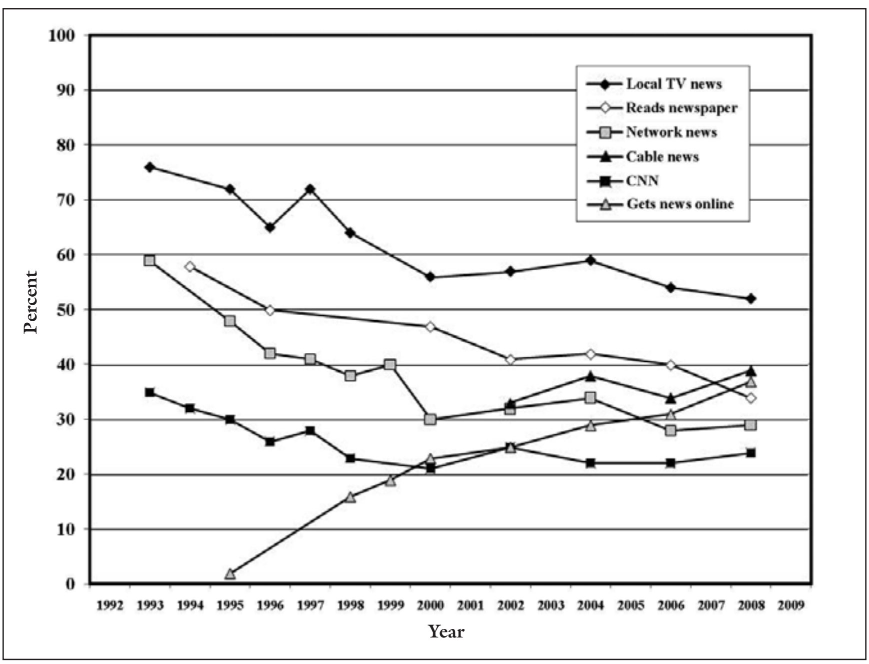
Using data collected by the Pew Research Center since the early 1990s, it is clear that reading newspapers in print has declined from 58 percent in 1994 to 34 percent in 2008. (See Figure 2.) The readership of weekly newsmagazines has declined even more sharply, and these results are often cited to mean that American adults no longer read. But an examination of television viewing patterns shows that adult viewing of network television shows has dropped more drastically than the reading of print newspapers, falling below the market share held by local television newscasts and cable newscasts. The major growth in the last decade has been in the use of online news sources—including online newspapers—and these sources are heavily reading-oriented. The recent National Endowment for the Arts report (2007) on reading points to a troubling decline in the ability of many young adults to read complex material, but a review of the data from Pew and from other national studies suggests that many adults are reading more material online.

**Figure 1: Civic Scientific Literacy in the United States, 1988–2008**




Source: Data for 1988 through 1999 from NSF *Science and Engineering Indicators* surveys. (See Miller, 2004, 2010.) Data for 2004, 2005, and 2008 from *Science News Studies.* (See Miller, Augenbraun, et al., 2006; Miller, 2010.)

**Figure 2: Patterns of Media Use, 1993–2008**




Source: Data from the Pew Research Center for the People and the Press. (See Pew, 2006.)

The 2007–2008 Science News Study[1] included all of the items necessary to measure CSL and an extensive set of items concerning media use and information acquisition. Many of the items replicated questions used earlier by Pew and others, and some new questions were developed to capture adult involvement in reading and posting blogs, seeking and printing digital information, sharing digital pictures and information, and seeking information for specific medical, travel, or other questions. Because the 2007–2008 study included all of the items necessary to measure CSL and media use, it is possible to examine the relationship between media use and CSL empirically.

Before formally analyzing the impact of various media on adult CSL in the United States, it is useful to examine briefly the rates of adult usage of various media reported in 2007. (See Table 2.) Approximately a third of adults reported that they watched a network television newscast three or more days each week. Thirty-six percent indicated that they read a science or health magazine regularly, and 30 percent claimed to have read one or more science or health books in the preceding year. Half of adults claimed to read a print newspaper at least once a week, although only 34 percent reported to Pew in the same year that they read a print newspaper three or more times each week. (See Figure 2.) Only 11 percent of adults reported that they read a newsmagazine regularly, suggesting that the market for week-old news is declining.

At the same time, nearly 70 percent of adults said that they looked for current news information on the Web during the preceding year, and 67 percent said that they looked for specific kinds of non-news information—maps, directions, and weather—on the Web during the preceding year. (See Table 2.) Sixty percent of adults reported that they have access to a computer at home or at work and that they have looked for health information on the Web during the preceding year. Half of American adults indicated that they have printed information from the Internet at home or at work, demonstrating that the Internet is becoming a reference resource for a wide array of purposes. Fifty percent of adults reported that they have a high-speed link from their home computer to the Internet, which undoubtedly facilitates the use of video materials and the downloading of printed materials. Approximately a quarter of American adults reported that they read an online newspaper at least once each week and seek news information from a website three or more days each week. (See Table 2.) Thirteen percent of adults indicated that they sometimes look on the Web for science information.

1. The 2007–2008 Science News Study is a three-wave national probability sample of 960 adults conducted online by Knowledge Networks (KN). The KN national sample is selected on a probability basis and households with a home computer connected to the Internet (now about 65 percent of households) are asked to complete two or three online surveys each month and are compensated with points that translate into the purchase of goods and services similar to frequent-flyer miles. Individuals in households without an online computer are offered an MSN box that allows them to use a television set and a local telephone line as a connection to the Internet. Households that opt for this arrangement are visited by a KN technician who installs the equipment and trains the residents in its use. The net cooperation rate for KN surveys is approximately 60 percent, using the appropriate AAPOR formula.

**Table 2: Use of Traditional and New Media, 2007**

| | Traditional Media | New Media |
|---|---|---|
| Reads a print newspaper more than once/week | 50% | – |
| Watches 1+ science television show/month | 41 | – |
| Reads a science or health magazine regularly | 36 | – |
| Watches network/cable TV news 3+ days/week | 35 | – |
| Read 1+ science/health books in last year | 30 | – |
| Reads a newsmagazine regularly | 11 | – |
| Looked for current news on the Web last year | – | 69% |
| Looked for info (map, weather) on Web last year | – | 67 |
| Searched for health information on Web last year | – | 62 |
| Has computer access at home or work | – | 60 |
| Printed material from the Web at home or work | – | 51 |
| Has high-speed home computer connection | – | 50 |
| Reads an online newspaper more than once/week | – | 28 |
| Looks at online news report 3+ days/week | – | 22 |
| Looked for science information on the Web | – | 13 |

An examination of the data from the Pew studies over the last two decades, together with the more recent 2007–2008 Science News Study, shows a pattern of mixed use, with most adults continuing to use a wide array of traditional media—primarily print and broadcast—while simultaneously beginning to increase their acquisition and use of new electronic communication technologies: computers, mobile phones and handheld email devices, wireless devices, and the Internet (Pew, 2006; Horrigan, 2007). A substantial majority of Americans has at least one foot in the electronic media pool, and large pluralities of adults are beginning to rely on the Internet for current news, weather, and health information. The growth of high-speed links to the Internet, access to better-quality home printers, and an expanding array of useful Web resources have fueled a major transformation in the ways that Americans get information.

To assess the impact of these emerging patterns on CSL and other outcomes of interest, it is necessary to develop a conceptualization or typology to characterize the major clusters of media use and information acquisition. Horrigan (2007) has proposed a ten-category typology that is loosely hierarchical and heavily descriptive. The number of categories and the absence of a clear ordinal logic among them make this typology minimally useful as part of a larger model to understand how media and other factors interact to influence a specific outcome, such as CSL.

A simpler approach is to treat the traditional media and information technologies as a group and to cluster the new electronic technologies as a second group. A confirmatory factor analysis is a method to assess whether a hypothesized clustering of items or behaviors fits the actual data. A set of seventeen items collected in the 2007–2008 study was examined in a confirmatory factor analysis, and a clear two-factor structure emerged. Six traditional media items constituted one factor, and nine new media items loaded on a second dimension. The two factors have a positive correlation of 0.39, indicating that more frequent users of traditional media tend to be more frequent users of new media. But the magnitude of the correlation suggests that only about 15 percent of the variance in either traditional or new media use can be accounted for by the other scale.

Using standard statistical techniques, the scores for each of the two factors were converted into a zero-to-ten scale. The mean score on the Index of Traditional Media Use was 2.1, and the mean score on the Index of New Media Use was 2.7. On balance, these results indicate that American adults use slightly more new media information sources than traditional information sources. The margin of difference is still small, but the trend is clear.

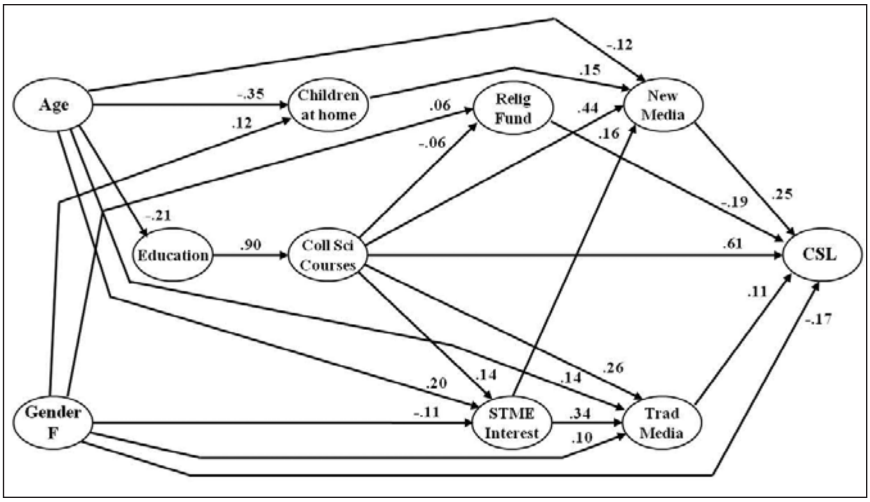
## IMPACT OF MEDIA USE ON CIVIC SCIENTIFIC LITERACY

We now turn to the impact of media on adult understanding of science and technology, as reflected in the Index of Civic Scientific Literacy (CSL). To explore the possible sources of influence on the development of CSL, a structural equation analysis[2] of the 2007–2008 Science News data set was conducted (Jöreskog & Sörbom, 1993). The analytic model included each individual's age; gender; highest level of education; number of college science courses completed; presence or absence of minor children in the household; interest in science, technology, medical, or environmental issues; personal religious beliefs; and level of use of traditional and emerging informal science-learning resources. The dichotomous or threshold measure of CSL was the dependent or outcome variable. (See Figure 3.)

A path model is useful for examining the relative influence of variables that have a known chronological or logical order. Each individual has a gender at birth and an age based on his or her birth date. An individual's gender may influence his or her education, although this influence appears to be diminishing in the United States and several European countries. For most adults, educational attainment and the number of college science courses are determined by the time an individual reaches age thirty-five, although more adults are returning to formal education than ever before. An individual's level of CSL at any specific time may be thought of as the result of the combination of these and other factors. (See Figure 3.) In a path model, chronological or logical causation flows from left to right.

2. In general terms, a structural equation model is a set of regression equations that provides the best estimate for a set of relationships among several independent variables and one or more dependent variables. For the structural analysis presented in this paper, the program LISREL was used, which allows the simultaneous examination of structural relationships and the modeling of measurement errors. For a more comprehensive discussion of structural equation models, see Hayduk (1987) and Jöreskog and Sörbom (1993). For a more detailed example of the use of this technique in the analysis of CSL, see Miller, Pardo, and Niwa (1997).

**Figure 3: A Path Model to Predict Civic Scientific Literacy in the United States, 2007**




The product of the path coefficients is an estimation of the total effect of each variable on the outcome variable—the threshold measure of CSL in this case. It is useful to look first at the total effect of each of the variables in this model, and then return to examine some of the specific path coefficients.

The number of college science courses taken was the strongest predictor of CSL, with a total effect of 0.77. (See Table 3.) It is important to understand this variable and its impact. The variable is a measure of the number of college science courses, including courses in both community colleges and four-year colleges and universities. The number of courses was divided into three levels: (1) no college-level science courses, (2) one to three courses, and (3) four or more courses. Individuals with one to three courses are the students who took college science courses as part of a general education requirement rather than as part of a major or a supplement to a major. The use of an integer measure of college science courses would have given undue weight to majors and minimized the impact of general education science courses in the analysis.

Formal educational attainment[3] was the second best predictor of adult CSL (0.70). This result indicates that students gain some additional value from the full range of university courses, including other general education courses in the humanities and the social sciences. The influence of formal educational attainment may also reflect a greater respect for and acceptance of academic authority as a source of knowledge about the world.

3. Educational attainment was measured with a five-category ordinal variable. The lowest level included all individuals who did not complete secondary school or obtain a GED. The second category included high school graduates and GED holders. The third category included respondents with an associate's degree, and the fourth category included individuals who earned a bachelor's but not a graduate or professional degree. The highest category included all individuals who completed a graduate or professional degree.

The third strongest predictor of adult CSL was the use of new electronic science-learning resources[4] (0.25). A parallel measure of the use of traditional science-learning resources[5] had a total effect of 0.11. (See Table 3.) Although the frequency of use of electronic science-learning resources was only slightly higher than the use of traditional information resources, the impact of the use of electronic learning resources on adult CSL was twice the impact of the use of traditional science-learning resources. In the context of Sternberg's theory of complex cognition, it would appear that these two sources of adult science learning both contribute to an individual's schemas about science and technology and are mutually reinforcing.

The fourth strongest predictor of adult CSL was personal religious beliefs, with adults who hold fundamentalist religious beliefs[6] being significantly less likely to be scientifically literate than other adults (-0.19). In this model, religious beliefs are current religious beliefs, and adults with more college science courses were slightly less likely to hold fundamentalist beliefs than other adults (-0.06). Women were more likely to hold fundamentalist religious beliefs (0.06), holding constant differences in age, education, college science courses, and the presence of children at home. Religious beliefs were not related to the use of traditional or emerging informal science-learning resources.

Gender was the fifth strongest predictor of adult CSL, with a total effect of -0.17. (See Table 3.) The negative coefficient means that men were more likely to be scientifically literate than women among U.S. adults, holding constant differences in age, educational attainment, college science courses, religious beliefs, and the level of use of adult science-learning resources.

4. The Index of Electronic Science Learning (ESL) reflects individual use reports on nine sources of adult science learning: read a newspaper online at least three days a week, searched for science information on the Internet, read online news reports three or more days each week, had access to a computer at home or work, had a high-speed link from a home computer to the Internet, engaged in frequent searches for health information on the Internet, engaged in frequent searches for news on the Internet, printed some material from the Internet at home or work, and sent and received email messages frequently. These nine items loaded on a single dimension in a confirmatory factor analysis and were converted into a zero-to-ten scale for use in this model.

5. The Index of Traditional Science Learning (TSL) reflects individual use reports on eight sources of adult informal science learning: read a printed newspaper three or more days each week, read a newsmagazine most of the time, read a science or health magazine most of the time, bought one or more science or health books in the preceding year, watched a network television news show at least three times each week, watched a cable television news show at least three times each week, watched one or more science television shows most of the time, and visited a science museum or other informal learning facility at least once in the preceding year. All eight of these indicators loaded on a single dimension in a confirmatory factor analysis and were converted into a zero-to-ten scale for use in this model.

6. The index of religious beliefs is a count of the number of times a respondent indicated agreement with (1) "The Bible is the actual word of God and is to be taken literally"; and (2) "There is a personal God who hears the prayers of individual men and women"; and indicated disagreement with (3) "Human beings developed from earlier forms of life." Individuals who scored three on this index were classified as fundamentalist (22 percent); individuals who scored two were classified as conservative (15 percent); individuals who scored one were classified as moderate (25 percent); and individuals who scored zero on the scale were classified as liberal-none (38 percent).

**Table 3: Total Effect of Selected Variables on Civic Scientific Literacy, 2007**

| | Total Effect | |
|---|---|---|
| | Continuous CSL | Threshold 70+ CSL |
| Respondent age | -0.11 | -0.15 |
| Gender (F) | -0.18 | -0.17 |
| Educational attainment | 0.55 | 0.70 |
| College science courses | 0.61 | 0.77 |
| Children at home | 0.03 | 0.04 |
| Religious fundamentalism | -0.08 | -0.19 |
| Interest in science, technology, medical, or environmental issues | 0.07 | 0.08 |
| Use of traditional informal science-learning resources | 0.14 | 0.11 |
| Use of electronic informal science-learning resources | 0.17 | 0.25 |
| | | |
| $R^2$ = | 0.46 | 0.74 |
| Chi-squares | 221.2 | 223.1 |
| Degrees of freedom | 20 | 20 |
| Root mean square error of approximation (RMSEA) | 0.034 | 0.034 |
| Upper confidence limit (90%) of RMSEA | 0.047 | 0.047 |
| N | 1,157 | 1,157 |

Older adults were slightly less likely to be scientifically literate than younger adults (-0.15), holding constant differences in education, gender, college science courses, and other variables. Although older adults display a high level of interest in health and biomedical science issues and are frequently users of the Internet for health information, they are markedly less well informed about the genetic basis of modern medicine. This fact is reflected in this result.

The level of personal interest in scientific, technical, environmental, or medical (STEM) issues had only a small positive effect on CSL (0.08). The model shows that adults with more interest in STEM issues are more likely to be frequent users of traditional adult science-learning resources than other adults (0.34) and that they are more likely to use new electronic adult science-learning resources than adults with less interest in STEM issues (0.16).

The presence of preschool or school-age children in the home had a small positive effect on adult CSL in the United States (0.04). The path model indicated that the presence of minor children at home was related to the use of new electronic science-learning resources (0.15). The influence of children on the use of new electronic science-learning resources suggests a dynamic inside the family in which children may encourage the use of or even introduce new communication technologies into the home.

This model explains 74 percent of the total covariance in CSL among U.S. adults using the dichotomous threshold measure of CSL. A parallel analysis was conducted of the same model using the continuous measure of CSL and the general result was almost identical in terms of the main effects. (See Table 3.)

In the continuous CSL model, college science courses and educational attainment were the strongest predictors of the outcome, and the use of electronic information resources and religious beliefs displayed similar patterns. The continuous CSL model accounted for 46 percent of the total covariance in that model because the dependent variable scores were spread over a much wider range. On balance, a comparison of these two models suggests that both models identify the same primary factors, but that the threshold measure of CSL provided a clearer image of the impact of each of the factors in the model. Both models produced very good fit statistics. (See Table 3.)

## DISCUSSION

What do these results tell us about the impact of media use on adult scientific literacy in the United States?

First, it is clear that education is a foundation for media use. Adults with weak reading and writing skills have significant problems in reading a newspaper, the label on a drugstore medicine bottle, or an insurance policy; they have problems in using the Internet as well. Reading really is fundamental to almost all forms of communication. The recent report of the National Endowment for the Arts (2007) on adult reading in the United States acknowledges the growing volume of reading being done apart from printed books and materials, but its summary of the declining reading skills of adolescents and young adults should be troubling to all Americans. The model constructed in this analysis provides an empirical estimate of the total effect of education (0.70), but a less quantitative reading of these results should remind us that education is the foundation for all communication and for the development of CSL.

Second, these results demonstrate that it is the college and university general education requirement to take at least a year of science that drives American performance on the Index of Civic Scientific Literacy for citizens outside the scientific community. A result of the positive impact of college-level science courses for non-science majors is that a higher proportion of American adults qualify as scientifically literate than do citizens in any other country except Sweden. At the same time, it is ironic that most Americans—including many science, education, and media leaders—do not recognize that this requirement is almost uniquely American. There was no single decision or starting point for this requirement, but a review of the literature on higher education in the United States points to an emerging consensus in favor of "general education" in the first decades of the twentieth century. We are approaching the centennial of this American experiment in higher education, and these results suggest that it has been a worthwhile experiment.

Third, the accelerating pace of scientific development means that most Americans outside the scientific community will learn most of their science after they leave formal schooling. Think about today's scientific and technological issues. Few adults could have learned about stem cells, global climate change, or nanotechnology as students because the relevant science had not been done. The challenge today is to prepare our students to understand science that will not occur for another twenty years. It is not easy, but it is possible. Although we cannot know the precise dimensions of future science, we can be sure that existing constructs such as atom, molecule, DNA, and energy will still be applicable.[7]

Fourth, the model describes the relationship between media use and the development of adult CSL. The model shows that formal education and exposure to college science courses have substantial influence on the level of adult use of both traditional and electronic science-learning resources. The path coefficient from college science courses to traditional adult science learning is 0.26, and the path coefficient to the use of new electronic science-learning resources is 0.44. (See Figure 3.) These paths tell us that college science courses are the gateway to the awareness and utilization of traditional and electronic science-learning resources. This result does not mean that non-college graduates or adults without a college science course cannot use and obtain value from various forms of informal adult science-learning, but it indicates that most of the adults who make extensive use of these adult science-learning resources have had some college science courses.

The path from the use of electronic science-learning resources to CSL has a path coefficient of 0.25, indicating that adults who use electronic science-learning resources extensively are significantly more likely to qualify as scientifically literate than adults who use these resources less often, holding constant the level of educational attainment and the number of college science courses. Comparatively, the path coefficient from the use of traditional science learning to CSL is 0.11, indicating a positive but weaker relationship than the impact of the use of electronic science-learning resources. To understand this relationship, it is essential to note that the path coefficient from college science courses to CSL is 0.61. This path means that there is a substantial value to college science courses above and beyond their function as a gateway to traditional and electronic science-learning resources.

This pattern fits into our general sense of educational impact. A large proportion of individuals who have completed one or more college science courses will have acquired some understanding of a set of basic science constructs. They should know more about the nature and structure of matter, for example, than adults who have never taken a college science course. Similarly, adults who have had one or more college biology courses should know more about the nature and structure of life—cells, DNA, and natural selection—than adults who have never experienced those courses. An understanding of

7. In work reported elsewhere, I have found that adults who understand the concept of a molecule, for example, are more likely to eventually acquire a general understanding of the concept of nanotechnology than adults who do not understand the structure of matter.

these basic constructs might be expected both to encourage the use of informal science-learning resources—books, museums, aquariums, planetariums, and the Internet—and to make that use more effective. When new constructs such as stem cells or nanotechnology enter the popular media and public discourse, adults who have had college science courses will already have a larger array of scientific constructs in their minds than other adults, and they will be able to use those previously acquired constructs to make sense of the new concept more rapidly than adults who lack those constructs.

Finally, science policy has become a part of the political agenda, and it is unlikely to disappear from political agendas in the foreseeable future. In broad terms, it is possible to argue that the twentieth century was the century of physics and that the twenty-first century will be the century of biology. The twentieth century was characterized by enormous advances in transportation, communication, and nuclear science—from the radio to the airplane to the transistor. Although these new developments eventually changed the very character of American society, most of these new technologies successfully avoided direct confrontation with traditional beliefs and values, especially religious values. But as science continues to expand our understanding of the nature and structure of life and develops the technologies to intervene in those processes, the resulting political disputes are becoming more personal and more directly confrontational with fundamentalist religious values.

The current disputes over evolution and stem cell research are only the tip of the iceberg. The problem is exacerbated by the exploitation of anti-evolution attitudes by one political party (Mooney, 2005; Danforth, 2006). More than 60 percent of American adults now believe that human beings were created as whole adults directly by God and are not a part of any evolutionary process (Miller, Scott & Okamoto, 2006). The entire scientific community bears some responsibility for this result. For too many years, too many physical scientists looked the other way while biology teachers were being attacked on the evolution issue. Now, of course, the same fundamentalists are attacking the Big Bang. If the trend toward the politicization of science continues, the scientific community will need to learn to stand together and to argue for the preservation and integrity of science in ways that we have not had to do for centuries.

Looking to the future, it is essential to increase the proportion of scientifically literate adults in our society. As these results demonstrate, formal education and informal science learning are partners in the process of advancing scientific literacy. Without a solid foundation of reading and basic scientific constructs, even the best science journalism and communication will fall on deaf ears. And no amount of formal science education will prepare adults to make sense of new and emerging science throughout their lifetime.

Scientific literacy is not a cure or antidote by itself. It is, however, a prerequisite for preserving a society that values science and that is able to sustain its democratic values and traditions.[8]

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8. The U.S. national data sets for the years 1985 through 2007 were collected with support from the National Science Foundation (awards SRS8105662, SRS8517581, SRS8807409, SRS9002467, SRS9217876, SRS9732170, SRS9906416, ESI0131424, ESI0201155, ESI0515449). The 2008 wave of the Science News Study was funded by Dean Charles Salmon of Michigan State University. The 2008 participation in the American National Election Study was funded by Vice President Ian Gray of Michigan State University. The author gratefully acknowledges this support, but any errors or omissions are the responsibility of the author and not of the sponsors or any of their staff or officers.

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CHAPTER 5

# Managing the Trust Portfolio: Science Public Relations and Social Responsibility

Rick E. Borchelt, Lynne T. Friedmann, and Earle Holland

Science came late to the practice of public relations, owing in large part to a culture of science journalism in the 1950s and 1960s that bordered on cheerleading: who needed PR when you already had many journalists who uncritically reported breakthrough after breakthrough with little of the healthy skepticism we have come to expect from contemporary media?

But times change, and cultures change. The reverent praise-singers who dominated science writing fifty years ago have been replaced by two generations of increasingly wary journalists who substitute news judgment and enterprise reporting for the adulatory stories scientists were accustomed to seeing in print or hearing on radio or television news.

Little wonder then, many scientists believe, that science as an enterprise no longer inspires unalloyed public trust. A survey of U.S. adults in 2004 commissioned by the American Association for the Advancement of Science (AAAS), for example, finds that only 34 percent of respondents trust scientists to put the well-being of society over their personal goals (AAAS, 2004).

This "trust gap" is especially pronounced on issues of great social concern and scientific uncertainty. For example, when respondents in a European poll were asked whom they trusted to tell the truth about genetically modified crops, only 6 percent said they trusted university sources. "National public authorities" garnered the trust of 4 percent, while industry captured a scant 1 percent. By contrast, 26 percent of respondents trusted environmental organizations (Haerlin & Parr, 1999). Kafoglou and colleagues (2004) noted in focus groups on the social implications of scientific advances in reproductive technologies that participants frequently thought scientists would forgo ethical behavior for prestige or money.

## SELLING SCIENCE

Mistrust in scientists and/or the scientific enterprise has been noted elsewhere by many observers (Royal Society, 1985; House of Lords, 2000), leading some communications researchers to postulate that scientists are beginning to develop a culture of "institutional neurosis" (Bauer et al., 2007) about having lost the public's mandate. The response has been the propagation of myriad schemes for harnessing the presumed power of glitzy advertising firms to "sell" science the way they might hawk a political candidate or promote a new clothing line. The buzz at research universities is about "institutional advancement" using "integrated marketing" and "branding." Scientific organizations routinely now turn to industry to fill communications positions in their ranks, assuming perhaps that the person who can instill confidence in consumer goods can do the same for scientists (Nelkin, 1995).

So, for some time now, many scientific institutions have unadvisedly relied on retooled scientists and former reporters to crank out an increasing blizzard of peppy news releases, driven by the axiom—now rejected by communications theorists—that "to know us is to love us" (Bauer et al., 2007). This new Madison Avenue–driven approach has a dim chance of regaining public trust. The scientific community needs to understand what ethical practitioners of public relations have long known: trust is not about information; it's about dialogue and transparency.

As practitioners use the term, *public relations* is the art and science of developing meaningful "relations" (or relationships) with the "public" (or publics) necessary for the continuing work of an organization or the scientific enterprise itself. As the Public Relations Society of America affirms in its statement of principles about professional practice, "Public relations helps an organization and its publics mutually adapt to each other" (http://media.prsa.org/prsa+overview/faq/#a40; accessed June 1, 2009). Public relations helps an organization demonstrate its commitment to and work toward becoming a socially responsible entity. In the context of science, public relations signals the willingness of scientists to come down from the ivory tower and engage the public with language that the public can understand. Practiced this way, public relations on behalf of science or scientists has a different set of ethical constraints and responsibilities than do the practices of marketing and institutional advancement that form today's prevailing model for promoting science and scientific understanding. The best way to understand these differences is by understanding how public relations evolved and what now constitutes best-practice public relations.

## PUBLIC RELATIONS: EVOLUTION OF A DISCIPLINE

The development of effective means of mass communication in the nineteenth century created an entirely new field of play for publicists, and this initial "publicity" phase of public relations continues to this day, benefiting from new technologies to reach mass markets faster with more targeted messages. Historians of public relations refer to this kind of public relations as "press agentry," so named because its practitioners often went by the name "press agents" and were the marketers that hawked press releases and news tips to a willing media enterprise (Grunig & Hunt, 1984).

At its heart, press agentry PR seeks to maximize awareness of a product, an idea, or an institution. "Making the news" or "getting ink" are the primary benchmarks of success for press agentry, and "placement" of stories about one's organization in media outlets still is the primary—albeit shortsighted—goal desired by many scientific organizations. The myth of communication clung to by many scientists holds that sending a message is the same as communicating a message. Dissemination is confused with communication.

What is most significant about press agentry is the *direction* of information flow: it is overwhelmingly *one-way*, from the organization to its public or publics, with few feedback loops from the public to the laboratory bench.

PR practitioners soon learned, however—even if the CEOs of their client organizations did not—that public attention was no guarantee of public support. Being known for the "right" things was as important as simply being known. This required a certain amount of explaining to the public just what you were up to, and a new phase of public relations—the "explanatory" phase—developed early in the twentieth century (Grunig & Hunt, 1984).

In the scientific world, explanation—often under the rubric of "public information"—is the prevailing model of practice.[1] A less flattering term that many people use in referring to explanatory PR of this type is "spin control"—making sure the public knows a lot about the science or the scientists, but only the "right" things the organization or institution thinks the public should know.

Many reporters and citizen watchdog groups are wary of the public information approach to public relations practice. Because little or no attempt is made to interact with interested parties outside the organization except to provide information, these parties often are suspicious of the motives of the organization—too often, rightly so. In many instances, requests for information from the media and public are required to go *through* the institution's public information office, or *only* the public information officer is allowed to talk to members of the public or press on behalf of the institution. For a science reporter bent on interviewing a scientist about a new scientific finding, this

1. Readers should not confuse the public information model with the title "public information officer" (PIO), which is commonly used for communications officers at universities and nonprofit scientific organizations. While most PIOs practice the public information model of communication, many increasingly practice two-way communications models. Unfortunately, many PIOs also still practice simple press agentry.

tactic seems an arbitrary barrier to effective reporting of a story. For members of activist groups who may be critical of the organization (such as an animal rights group flogging a university engaged in animal research), the public relations office is viewed as an obstacle designed to "protect" the university and effectively hide "what's really going on" from public scrutiny.

The public information model of public relations is still basically a one-way street, or at least highly asymmetric. While the organization and its PR practitioners may impart more information than those who practice simple press agentry, little or no feedback is sought from the public. Explanatory public relations may employ focus groups, polls and surveys, and other means of finding out what the public knows or thinks in order to determine the right "spin," but its focus is control. Explanatory public relations does not recognize a legitimate public interest in full disclosure; nor does it engage in two-way dialogue with its publics.

Asymmetric communications practices have cultivated a public wary and mistrustful of the scientific enterprise (Millstone & van Zwanenberg, 2000). Yet asymmetric communications models are far and away the most widely practiced modes of public relations among scientific organizations.

## A NEW FORM OF PUBLIC ENGAGEMENT EMERGES

Many corporations have moved from one-way communications approaches toward more fully symmetric models. By the late 1980s, a comprehensive survey of hundreds of organizations and their approaches to public relations published by the International Association of Business Communicators as the "Excellence" project (Grunig, 1992) found that a significant number of corporations and nonprofit organizations were practicing dialogue-driven stakeholder engagement. Further analysis of these two-way symmetrical communications models (Grunig et al., 2002; Grunig & Hung, 2002) documents that they produce better long-term relationships with the public (or publics) than do asymmetrical approaches to public relations. A case study of pre- and post-transition communications strategies by the Long Island–based Brookhaven National Laboratory (after its original contract was summarily pulled by the U.S. Department of Energy, over displeasure with community relations following an underground tritium leak, and awarded to another contractor) suggests that fully symmetric communication can be highly effective in a scientific setting (Lynch, 2001).

The goal of two-way symmetric communication is the mutual satisfaction of the scientific organization and its publics with the relationships that exist between them. The mutual-satisfaction approach to public relations emphasizes true interaction between organizations and their publics. It requires a commitment to transparency on the part of the organization; negotiation, compromise, and mutual accommodation; and institutionalized mechanisms of hearing from and responding to the public. It places a premium on long-term relationship building with all of the strategic publics: taxpayers, media, shareholders, regulators, community leaders, donors, and others.

A variety of new technologies are available to make symmetric communication possible and even affordable. The Web provides a number of platforms, from online discussion groups to chat forums to Web logs ("blogs"), that allow valuable real-time, person-to-person communication with members of the public.

A profound ethical issue is embedded in the practice of public engagement: one cannot promise engagement and make only a show of listening. The commitment to symmetric communication falls short if the organization hears but does not respond to the concerns or issues of its publics. Mutual satisfaction—and the ethical practice of public relations in science—requires that organizations be open to reasonable changes requested of it, just as effective—and ethical—public engagement programs in science should signal a willingness to incorporate public input in science policy or regulatory programs.

Scientific organizations can productively use all three approaches to public relations. Filling an auditorium for an important lecture by a Nobel laureate is a publicity job. Preparing brochures and articles that clearly and simply articulate the research conducted or promoted by the organization is explanatory public relations. But while many scientific organizations say (and might even believe) they are using the third approach to public relations, few actually encourage or engage in true dialogue with the public or publics. Unfortunately, they treat public engagement or public consultation as a box-checking exercise necessary before they get on with their "real" work. Rarely do scientific organizations devote significant resources to meaningful symmetric communication—to managing the trust portfolio.

## MANAGING THE TRUST PORTFOLIO

"Managing the trust portfolio" refers to the strategies—and, to a lesser extent, the tactics—that scientific organizations use to manage the relationships that exist between the organization and its many stakeholders. Science public relations done effectively and strategically is an important tool in managing this portfolio and helps the other parts of the organization perform their jobs more effectively by cultivating or maintaining trust in the ability of the organization to do science, advocacy, or science policy.

For example, a government-funded research institution may have a number of stakeholders for whom science communication would be helpful in establishing and maintaining trust. First and foremost, the organization is probably concerned about its funding stream, and appropriate kinds of public relations can help it convince legislators or agency heads that money sent to the organization is money well spent, that their research is top-quality and worth supporting. Second, the organization probably needs to make sure that scientists and researchers elsewhere know about the range of research it is conducting, in order to facilitate collaboration, keep abreast of scientific research conducted by other organizations, position the organization as a credible and reliable scientific collaborator, and enhance the organization's attractiveness when recruiting new staff. Third, the organization may need to have a good relationship with the people in the area surrounding the facility; government-run laboratories increasingly are facing the need to maintain the trust and support of their local communities in order to do their research in community settings.

In this context, news coverage becomes one of many means of communication with stakeholders, not an end in and of itself. Media in this context are third-party validators. Bad press can affect the disposition of key stakeholders toward the organization. Conversely, good press can validate the work and integrity of the organization among groups that materially affect the organization's ability to do its research. But good public relations practitioners never mistake the route they use to get to strategic publics with the publics themselves.

Nor do ethical practitioners of science PR trade on their relationships—with reporters, community leaders, funders, or collaborators—in ways that deliberately obscure, alter, or doctor information these stakeholders need to make informed decisions about scientific institutions, research programs, or the scientific enterprise.

## PUBLIC RELATIONS AND SOCIAL RESPONSIBILITY

Most people think of public relations as something that one office in an organization does in relative isolation from the organization's research program. Done well, 90 percent of managing the trust portfolio is management counseling: advising on how to stay out of trouble instead of figuring out how to get out of trouble. Too often public relations is brought in to implement strategic decisions that already are set in stone. Public relations cannot be effective in that situation. Public relations managers need to be involved early, involved often, and have a meaningful say in company or organizational policy development.

Public relations is a function of the entire organization, not just the communications office. The best—and most ethical—public relations practitioners catalyze institutional change rather than simply implementing it. Public relations is most effective at the organizational level when it helps the organization understand what its strategic publics are, how best to interact with them, and what those publics expect in return. This is a management function of public relations and requires that public relations have a place at the table among the organization's senior executives to be truly successful.

At the societal level, public relations professionals can help organizations understand what it means to be socially responsible and can contribute to the ethical behavior and social commitment of the organization. At the societal level, management of the trust portfolio goes beyond the trust engendered between the organization per se and its publics; it helps the organization manage the trust portfolio *for the entire scientific enterprise*. Socially responsible scientific organizations help cultivate public trust in science and technology.

Public relations—if empowered by management—can play a vital role in articulating social responsibility and finding ways for an organization to allay public mistrust and wariness of science and scientists.

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# CHAPTER 6

# Response to Borchelt, Friedmann, and Holland on Managing the Trust Portfolio: Science Public Relations and Social Responsibility

Robert Bazell

Rick Borchelt, Lynne Friedmann, and Earle Holland raise many important and provocative issues about the role public information specialists play in communicating issues concerning science to the public. I agree with many of their conclusions, but I have trouble with some of their initial assumptions.

They posit that science writing and broadcast reporting have changed dramatically. They write, “The reverent praise-singers who dominated science writing fifty years ago have been replaced by two generations of increasingly wary journalists who substitute news judgment and enterprise reporting for . . . adulatory stories.”

If only news judgment and enterprise reporting, two of the sturdiest pillars of good journalism, were more common, science reporting would be far better for it. Instead, even the most cursory look at the coverage today by almost any news organization reveals mostly stories regurgitated from journals or institutional press releases and often hyped as breakthroughs. The biggest chunk of the reporting pie goes to medicine and biomedical stories. But that is hardly surprising. Newspapers, TV news shows, and other outlets want to attract the maximum audience. People care most about what affects them.

The “praise-singers” to whom Borchelt, Friedmann, and Holland refer from the previous generation included large numbers of journalists identified as science specialists who covered the manned space program—big news in those days. NASA’s public relations machine stands as the paragon of the “science” public relations industry that is at the heart of Borchelt, Friedmann, and Holland’s paper. For most space reporters, if NASA did not spoon-feed them the story, there was no story.

Borchelt, Friedmann, and Holland decry, as many do, the alleged and growing "mistrust in scientists and/or the scientific enterprise." In my view, this mistrust does not exist. If Americans do not like science, they certainly support it. Funding, adjusted for inflation, has gone up 1,000 percent since the end of World War II, a time during which the U.S. population doubled. Of course, science faces competing demands on the federal budget—Medicare, Social Security, and the Iraq War are but a few of the current competitors. So we pass through times of relative scarcity of public funding of science research. But the slope of the curve of America's financial support for science has only increased, and I see no reason to think it will not continue to do so.

Borchelt, Friedmann, and Holland cite concern about the profits from technology transfer arrangements as one reason why the public mistrusts science. Except for the occasional book or magazine article, this is not an issue about which the public hears much. University administrators certainly lust after the money. But few—especially outside the Boston and San Francisco Bay areas—ever make much money from technology transfer. Arguments about commercialization of the academy are heard mostly inside its administration buildings. The effect on public support for science is negligible.

Are we missing good science stories in newspapers and on TV? Indeed we are. But to discuss that gap without considering the tectonic changes that are threatening to obliterate newspapers, TV news, and other "old media" is impossible. If scientists think times are financially tough, they should spend some time in a newsroom.

But my own experiences and those of colleagues suggest that even in the current environment, editors and producers still have a huge appetite for informative, interesting articles on science. Stories like those about the death of eighteen-year-old Jesse Gelsinger in a gene therapy experiment at the University of Pennsylvania (the University and chief researcher were raking in big profits from the experiment) occasionally make headlines. But such incidents are, thankfully, rare. The public holds science in high regard and wants to hear more about it.

Which brings us back to the major topic of Borchelt, Friedmann, and Holland's paper: the public information office, or public relations specialist, or whatever terms emerge from the worlds of advertising and "crisis management." Science takes place in universities, hospitals, government labs, independent nonprofit labs, and private companies. These institutions variously compete for esteem, profit, private money, public money, students, patients, or all of the above. The public information officer's job is to interact with the press and the public to make his or her institution achieve it goals as well as possible. To see this person's function in any other light is just silly. As with any profession, the individual can carry out the task with varying degrees of integrity.

In my thirty-seven years as a reporter, I have dealt with many public information officers. They differ little from journalists or members of most professions. Some are dreadfully bad—laziness being the biggest offense—and others are fantastic. The good ones manage to assist both reporters and their employers while playing a major role in the public dissemination of science.

What makes for a good public information officer? The best will assist reporters who call with questions and help them obtain answers that confirm, refute, or enhance without trying to block access or put a false spin on the response.

Furthermore, in dealing with research, a good public information officer (PIO) will make an effort to understand what the scientists who work in his or her institution are doing. The PIO should not reflexively send press releases about the latest appointment to an assistant deanship: that makes reporters stop paying attention in a hurry. When an important piece of research is complete, the PIO should put out a press release to everyone and make certain that reporters who will do the best job know about it. In the meantime, the PIO should initiate ongoing dialogues with reporters that can lead to important feature stories on research that is interesting even if it has not just been published. That is what I believe Borchelt, Friedmann, and Holland mean about "managing the trust portfolio." And they are right: it can work very well.

CHAPTER 7

# The Scientist as Citizen

Cornelia Dean

I have been working as a science journalist for more than twenty years, and for almost all that time I have had on my mind the collective unwillingness and/or inability of scientists to talk to the public.

Lately, I have been trying to do something about it, in seminars and short courses at Harvard University and other institutions. People elsewhere have embarked on similar efforts. I believe this work has had some good effects. I believe these or similar efforts should be part of every scientist's graduate education.

This paper will discuss these efforts in the context of the public's uncertain understanding of science, the problems of science journalism, characteristics of the culture of science that feed these problems, and efforts on the part of journalists and journalism teachers to mitigate the situation—and how some of these efforts have fared.

The need for such efforts was first brought home to me, vividly, more than a decade ago, when I attended a presentation for journalists at the Smithsonian Institution in Washington. The topic was Earth's climate, in particular the possibility that human activity, chiefly the burning of fossil fuels, was vastly increasing the amount of heat-trapping gases in the atmosphere, with potentially disastrous consequences. The presentation had been organized by eminent experts on climate. They hoped that once the journalists knew the facts, they would realize climate change was an important story they would have to cover closely.

But when the scientists were making their concluding remarks, one of the journalists, Ben Bradlee of *The Washington Post*, interrupted with a question. Come on, he impatiently asked, are we really supposed to believe that this—he mimed spraying himself with an underarm deodorant—is going to change the weather?

The scientists were astonished. How could Bradlee be so dense? Did he not realize that chlorofluorocarbons, the propellants in sprays like deodorants, are factors in atmospheric ozone depletion, not climate change? Did he not realize that weather and climate were two different phenomena? Had he listened to anything they had said?

Some of the scientists later told me Bradlee's performance convinced them their effort had been a waste of time, another pointless exchange with a dull-witted journalist.

But Bradlee was nothing like dull-witted. As the newspaper's executive editor, he had presided as *The Washington Post* transformed itself from a more-or-less provincial daily into a newspaper of national importance. Reporters he led had uncovered the Watergate scandal and forced the resignation of a president. He was not stupid. But he was *ignorant*. He had obviously not been paying close attention either to efforts to preserve the ozone layer that insulates Earth from harmful ultraviolet radiation or to the debate over what the burning of fossil fuels was doing to Earth's climate. In this, he was far from alone (then and now).

In fact, it was the scientists who were making the fundamental and more important error. Rather than dismissing Bradlee as a dunce, they should have been wondering how someone in such an influential position in the nation's news media could make such a mistake. Rather than complaining that he had failed to grasp their message, they should have been thinking about how they had failed to convey it.

Later, when I became science editor of *The New York Times*, I would often address scientific groups of one kind or another, and participants would often denounce the way the news media ignored, overhyped, misrepresented, or just plain screwed up their coverage of science, medicine, and health. Though their complaints were often directed at other news outlets, we at the *Times* came in for a share of this abuse.

When I heard those complaints, especially when I had to concede they had merit, I realized something important: if covering this material challenged us in the science department of the *Times*, probably the largest, best trained, and most lavishly supported science department of any lay language news outlet in the world, it could only be much harder for journalists elsewhere. If we were having trouble—and the scientists were telling me we were—it could only be worse for our colleagues with fewer resources.

I realized then that if we journalists were going to improve the coverage of science, scientists would have to help us. But two problems existed. First, many scientists are not good at talking about their work in ways ordinary people—and journalists—can understand. Second, many scientists do not believe they have any reason, still less obligation, to do so. This belief is by far the more serious problem.

At about the time I realized science coverage would improve only with the help of scientists, I started receiving speaking invitations from organizations, notably the Aldo Leopold Program and the Pew Foundation, that hold regular conferences for high-achieving scientists. At meeting after meeting, I found myself preaching the same sermon: scientists have an obligation as citizens to participate in the nation's public discourse, particularly when the issue at hand relates to science.

There was a time, I would tell my audiences, when the disconnect between scientists and the public was not so important. But today the disconnect has big implications for the nation's public life. More and more questions of public importance, questions people address in the voting booth, have major science components. Must we take aggressive action to avoid global warming? Your answer may depend on how much faith you put in computerized climate models. Should we press ahead with the missile defense shield? The answer hangs on the physics of ballistic missile detection. Should stem cell research be financed by federal taxpayers? Should it even be legal in the United States? Decision-makers—whether in government or in the voting booth—will want to know what price society will pay for shutting off this avenue of research. Is mammography worthwhile? If so, for whom? What about prostate cancer screening? For many scientists these are open questions; few members of the public realize this.

Many scientists embraced my message. All too often, though, it was greeted with lack of interest, antagonism, even contempt. Unfortunately, there are good reasons for this response.

First, science as an institution rewards research findings and publication in scholarly literature—and that is it. As a scientist once put it to me, "Every minute away from the bench is time wasted." Scientists do not earn tenure or grants or promotion or anything else they value by spending time explaining things to reporters or seeing their names in newspapers or their images on a television screen or website.

Second, to spend time talking to a reporter only to find one's work misrepresented in print or electronically is excruciating. Regrettably, this is not a rare occurrence—not, as many scientists profess to believe, because journalists are unconcerned about accuracy but in large part because of the inability of scientists to describe their work in clear and simple terms.

Then there is "the problem of objectivity"—the reflexive desire of journalists (in the mainstream, at least) to give all sides of a story. The problem is, without the help of scientists, journalists may be unable to discern when a legitimate scientific debate exists about one subject or another and when the collective weight of science falls on one side, with only a few arm-waving fanatics on the other. The result, as science writer Eugene Linden puts it, is "the systematic overweighting of dissent." Or, as the pollster Daniel Yankelovich has written, many scientists find themselves seeming to argue in print with a crank or a shill, seemingly on hand only to provide the requisite journalistic objectivity or "balance."

Imagining how frustrating and horrifying this must be is hard for a journalist like me, but the problem will be difficult to fix without the cooperation of scientists, especially as cutbacks in the news business leave journalists with less time to educate themselves on the scientific background of the subjects they cover. But if more scientists were willing to speak candidly, and clearly, about their work and its context in the larger world of science, it would help a lot.

Even if everything goes brilliantly, the result for scientists who talk to reporters is often denigration by their research peers. Scientists call this "the Carl Sagan effect," after the Cornell University astronomer who was blackballed at the National Academy of Sciences because his television series *Cosmos* was too big a hit with the lay public.

Scientists also worry that if they speak too much about a public issue, they will seem to be taking sides. This is *their* problem of objectivity. In part, I think, worries about this problem arise from the view, widely held among scientists I have met, that "if everyone knew what I knew, everyone would think as I think—and act as I would act, if I were making policy."

In fact, as Sherwood Boehlert, the former chairman of the House Science Committee, said in a speech to the American Association for the Advancement of Science in April 2007, scientific evidence is often only one factor policy-makers consider when making decisions. If scientists tell policy-makers the facts, they will not necessarily be determining a policy outcome. But they will be helping to ensure that policy decisions are made in the best way possible, given the realities of politics.

In 2003, I stepped down as science editor of the *Times* and accepted a fellowship at the Kennedy School of Government at Harvard to start work on a book about the misuse of science in American public life. I had the idea that scientists needed to hear someone tell them about their obligations to the public and to help them communicate better. So I got in touch with people I knew at three nearby research institutions—Brown University, the Massachusetts Institute of Technology (MIT), and the Graduate School of Oceanography at the University of Rhode Island—and asked if I could offer short courses to graduate students and postdocs. The response to these short courses was gratifying.

A year later, Daniel Schrag, director of the Harvard University Center for the Environment, invited me to offer a seminar on the subject for graduate students, which I have taught once a year ever since, now also under the auspices of the School of Engineering and Applied Sciences.

The content of the course evolves, but among the topics covered are:

- The public's knowledge of and attitudes toward science—in particular, the public's collective (and well-documented) inability to reason statistically and assess risk rationally.
- The landscape of journalism and the problems journalists encounter covering science, particularly given the changes under way now in the news business. Ordinarily, scientists do not need any instruction in the widespread inability of journalists to cover science well. But scientists are often surprised to discover the high odds journalists face getting science news into the paper or on the air. And they are chagrined to discover how many journalists take their own time and spend their own money to improve their ability to tell the stories of science, especially when they compare these efforts with the minuscule efforts science, as a whole, makes to improve their side of this equation.

- How to be a good source. When I tell scientists they can do a few simple things to greatly improve their chances of telling their stories effectively, I often receive an "oh yeah—show me!" response. Luckily this challenge is easy to meet. To give just one example, scientists can greatly improve their odds of getting their points across if they ask an inquiring journalist for time—even a few minutes—to collect their thoughts before they sit for an interview and then take that time to figure out what their most important points are and how to express them clearly. This suggestion, one of scores, may seem blindingly self-evident, but it comes as a surprise to many scientists who hear it.
- How to be on television or radio. Again, I offer a host of practical suggestions—everything from standing up when you do a telephone interview for radio (it improves vocal quality), to not wearing stripes on television, to tactics for challenging erroneous statements on the air.
- How to present scientific information for lay readers on the Web—and how online formats favor different styles.
- How to request corrections when a news outlet publishes or airs content that is inaccurate. (The unwillingness of scientists to bring errors to our attention, on the grounds that the effort would be "pointless," is a matter of long-standing frustration to me.)
- How to write letters to the editor and op-ed essays. (When I became science editor of the *Times*, one of the first things I did was make it known that I welcomed submissions by scientists of possible essays for the paper's Science Times section. I braced myself for a deluge that never arrived—again, much to my frustration.)

The seminar also talks about scientists' participation in the wider public world. For example:

- How (and whether) to be an expert witness. This is an important topic given the degree to which junk science and accusations of junk science flood the nation's courtrooms. Many powerful factors discourage scientists from taking part in court proceedings. They need to know as much as possible about how to avoid bad outcomes in court, and they need to realize how court victories can do more to change the face of the world than any number of scholarly publications.
- How to offer policy advice—effectively. As with everything else, there are more- and less-effective ways for scientists to have their voices heard in Washington and other places where policy is made.

Throughout the seminar, the scientist participants write stories of their own, long and short, and practice making oral presentations—talking—about their work. I am far from alone in bringing this information to scientists. The Union of Concerned Scientists recently published a guide for talking to reporters. The American Society of Civil Engineers has produced a book on working with Congress. I am turning my suggestions into a book I hope will be published soon.

Meanwhile, the American Association for the Advancement of Science offers mass media fellowships to a small number of scientists who work as interns with newspapers, National Public Radio, newsweeklies, and elsewhere. A similar AAAS program places scientists in congressional offices and elsewhere in Washington. Seminars similar to the one I offer at Harvard are under way at the University of Wisconsin and elsewhere.

I cannot speak in detail about the results other efforts have produced. But my small programs have been greeted with enthusiasm. Participants have had many suggestions for improvements, but they have spoken, sometimes in surprise, about the usefulness of this kind of training. And I have seen its effects.

For example, soon after my first short seminar, at MIT, one of the participants sent me an op-ed he wanted to submit to his hometown paper, *The Seattle Times*. I made a couple of small suggestions, he sent it in, and it appeared in print. Since then several former students have told me of their op-ed efforts—I am always gratified to hear about them. Another former seminar student now contributes to a website of short takes on science. When he told me about it I was thrilled to be able to tell him that one of my neighbors was a regular visitor to the site, and a big fan.

Still another student realized in my seminar that his research could produce not just a number of research papers but also a useful and engaging article for lay readers on the difficulty of conserving endangered ecosystems in impoverished regions. This idea was not greeted with universal enthusiasm among the faculty with whom he works (to say the least), but he persevered and is at work on this project now.

A number of students have told me that the issues we discussed and the hints I offered helped them when their publications in scientific journals brought them to the attention of the lay press. One of them recently sent me an email message describing his first encounter with a journalist. "It was just awful," he wrote. "I fumbled, said the wrong things, contradicted myself a dozen times, you name it." He contrasted this experience with one he had later, after sitting in on one of my short seminars: "I asked [the journalist] to give me a few minutes to get ready. I went to my office to have a good quiet spot to talk, stood up while talking, and tried to follow your guidelines. It went a lot better this time!" Needless to say, he made my day.

I believe all scientists should encounter this kind of training—a short course, a semester-long program if they want it, or even an internship in a news outlet or policy-making venue. I would not give students advanced degrees in science until they had heard the message this kind of training offers.

Is this enough to solve the problem? No. But it is a start. Seeding the nation's scientific establishment with researchers who understand the importance of communicating with the lay public, and who are willing to take the time to communicate, can only be good. More important, the establishment of university programs to advance this goal tells scientists-in-training that their institutions value the effort and regard it as a worthwhile use of their time. That is perhaps their most important lesson.

CHAPTER 8

# Revitalizing Science Journalism for a Digital Age

Alfred Hermida

When a dozen U.S. newspaper science journalists gathered in New York in 1934 to form a professional association, little did they know how their vocation would change in less than a century. Since that meeting, science journalism has evolved from the "gee whiz" of early reporting to focus on the interplay between science, society, and politics. Yet science journalism must continue to evolve, and must now look beyond the print model and its inherent limitations.

Advances in information and communication technologies allow for complex and controversial issues in science to be presented in compelling and innovative forms online. With the Internet, never before have so many had access to so much, so easily, so quickly. As a result, all journalists must learn new ways to gather, distill, and communicate news. These new methods have arisen not only because the Internet is different from the forms of media that came before it, but also because the Internet has had an undisputed impact on the shape of journalism.

Online journalism is emerging from its infancy and experiencing the growing pains of its teenage years. Behind the hyperbole of the transformative potential of the Internet lies a pressing reality of how changes are taking place in the way news is produced, distributed, and consumed. Online information dissemination has transformed the way that news and science reach the public. Research shows that audiences are increasingly turning to the Internet as a source for news. Indeed, as early as 2005, Merrill Brown, founding editor-in-chief of MSNBC.com, warned of changing habits:

> The future course of the news, including the basic assumptions about how we consume news and information and make decisions in a democratic society are being altered by technology-savvy young people no longer wedded to traditional news outlets or even accessing news in traditional ways.

This message is taking its time to filter into the minds of media executives wedded to years of news habits. In November 2007, Tom Curley, the CEO of the Associated Press, echoed the words of Brown when he presented research conducted for the AP on the changing habits of news consumers:

> Young people the world over are hungry for news. They just don't prefer our traditional platforms and packaging. The irony of the disrupted news economy of the 21st century is that the news is hot, but the news business is not.

Curley's message insists that there is still a need for professional journalistic skills—sourcing, researching, storytelling, and editing—but the way these skills are used has to change to create new forms of journalism and reach new and, invariably, younger audiences. These new forms, especially those online, may be particularly important for science journalism. Horrigan (2006) found that 20 percent of all Americans, or forty million adults, turn to the Internet for most of their science news. The percentage is second only to television, cited by 41 percent of respondents, with newspapers accounting for 14 percent.

The picture changes for the generation that grew up as computers and the Internet started to occupy a prominent role in society. The Internet is the most popular source for science news and information for adults under the age of thirty who enjoy broadband at home. In this group, Horrigan found that 44 percent cited the Internet as their primary source, compared to 32 percent who cited television and just 3 percent who mentioned newspapers.

If the future is online, then the way journalism is practiced must change to take account of this new medium. The short history of online journalism shows that the adoption of new technologies is colored by the experience of past technologies. Early approaches were framed within a professional journalistic context, resulting in online practices that fit within existing newsroom norms and values.

One of the leading characteristics associated with the Internet is the notion of immediacy (Ward, 2002). This is a relatively easy concept for journalists to grasp, as it fits with the established notion of being first with the news. At the same time, it can present challenges for the traditional journalistic model. The Web creates a news environment that is always live, shifting the news business toward around-the-clock reporting. (This is, in fact, an outcome of the development of progressively faster forms of communication: the telegraph, radio, television, and, lately, the Internet.)

Online journalism can be published in real time. Breaking news can be made available on a website within seconds and updated constantly. The emergence of micro-blogging technologies such as Twitter has further accelerated the pace of news. Twitter allows for the real-time dissemination of short fragments of data from a variety of official and unofficial sources, creating what has been described as ambient journalism (Hermida, 2010).

This immediacy of news and information represents a major cultural shift for news outlets, which largely have been fixed to a specific time—the daily newspaper or the evening TV newscast, for example. With news available anytime online, audiences come to expect news when they want it, rather than when a news outlet decides to give it to them. This audience demand runs counter to established practices of science journalism, which has tended to operate like a train system: controlled by a timetable that is itself a function of the embargo system. Findings reported in the world's premier peer-reviewed journals, such as *Science* and *Nature*, are sent to journalists under embargo ahead of publication. The system is designed to provide journalists with enough time to research a scientific paper, interview scientists, and prepare a considered article on the research. However, former *Science* editor-in-chief Donald Kennedy (quoted in Hermida, 2007a) has suggested that the embargo system is unlikely to survive in its current form for much longer. Instead, peer-reviewed research would come out in "driblets," rather than in weekly packages for journalists.

At first glance, this change might appear to be a negative development for science reporting. But such an estimation overlooks the limitations of the embargo system. Critics charge that it encourages lazy reporting and props up poor science journalists (Kiernan, 2006; Whitehouse, 2007). The embargo system has led to a process whereby a handful of journals set the news agenda, even though there are hundreds of publications. Reporters tend to cover the same stories so as not to miss out, and, even then, their reporting is marked by Eureka moments, portraying science as a process of discoveries.

A shift away from this model may encourage a greater variety of stories and issues and may free up journalists to investigate science. The transition may be a messy process—but then the scientific process is messy rather than managed. Science reporting would become more like political or financial reporting, with breaking news first, followed by context, explanation, and analysis.

The Internet is suited to such a reporting process, providing a limitless news hole. Like immediacy, this is a characteristic of the Internet that fits with some existing newsroom norms but departs from others. The amount of content a news provider needs over the course of a publishing cycle is finite for newspapers, television, and radio. The Web, in theory, provides limitless space for content, freeing reporters from the temporal and spatial tyranny of the news hole. In practice, however, online space has been used largely as a repository for what has already been edited for print or broadcast (Paul, 2005). As newspapers shrink in size, editors may consider publishing online those science stories that did not make the cut for print.

This is a tempting solution, especially as science stories are being squeezed out of traditional media outlets because of the dwindling number of weekly science sections, staff cutbacks, or the trend toward more consumer-oriented, lifestyle features (Russell, 2007). But it would be simplistic to consider the Internet as a repository for extraneous content. Much of the discourse about online journalism centers around the idea of repurposing news content from one medium to another (Wendland, 2002; Kolodzy, 2006). But a two-thousand-word science article written for print does not transfer well to the Web, just as a TV script makes for a poor newspaper article. Instead, journalists should conceive of a story in ways that would play to the strengths of each medium.

This effort goes beyond introducing multimedia to a story. Online journalism is characterized by the ability to use multiple media to provide varying textures, combining elements from print—text and graphics—with those of broadcast: sound, music, and video. The mere presence of different media in a story, however, does not by itself create a multimedia story. A multimedia story involves a combination of text, still photographs, video clips, audio, graphics, and interactivity that makes each medium complementary, not redundant (Stevens, n.d.). For reporters, striving to avoid redundancy in an online multimedia story entails deconstructing a story into its main elements and considering the most appropriate combination of media.

Furthermore, online journalism creates a nonlinear environment that breaks significantly with traditional journalism. A print story or radio broadcast guides the audience through a linear narrative; a reader or listener can dip in and out, but they have little control over the flow of information. The hyperlinked nature of the Web makes nonlinear consumption of news more likely (Ward, 2002; Foust, 2005). Information can be constructed and displayed as related components linked together, with multiple navigation pathways and links encouraging audiences to explore multiple threads of a story.

The nonlinear nature of the Internet asks journalists to consider that audiences can construct their own narrative, with no set beginning, middle, or end. As a result, each element of a multimedia story must be understood as an entry point to a story. This freedom of choice could be an especially challenging reality for complex science stories. In a traditional, lengthy print article, a reporter attempts to guide the reader, adding layers of complexity along the story's path. Online, a reader may jump straight into the deep end.

The answer may be the Internet itself. After all, it stores a wealth of information that can be retrieved at the click of a mouse. The vastness of the Internet and the extent of information available may intimidate audiences and cause information overload (Hall, 2001). There are also concerns about the credibility of online sources and questions about the ability of audiences to make sense of the bewildering range of scientific information on the Internet. According to some studies, only 20 to 25 percent of Americans are able to understand basic scientific concepts (Dean, 2005). Yet at the same time, the tools for searching and retrieving online data have been constantly improving, and research shows that many Americans are using the Internet to check the reliability of science news (Horrigan, 2006).

At play here is less the reliability of information online and more so the shift of power from the journalist to the audience. The Internet allows the audience to have greater control over information, in terms of where they get the news, when they get the news, and how they get the news. Online audiences are often couched as "users" to distinguish them from "readers," "listeners," and "viewers," terms that reflect more passive activities (Ward, 2002). The interactive nature of the Internet gives the user the power to control the communication flow or even to alter a journalist's original message.

Interactivity is an elusive term, with meanings that can range from providing a set of links to facilitating direct interaction with other users and/or journalists. However defined, the intrinsic interactivity of the Internet offers the public unparalleled opportunities to take an active part in the creation, dissemination, and discussion of news. Mainstream news organizations are increasingly exploring the idea of news as a conversation with the audience, offering more ways for readers to participate, such as allowing comments on stories or soliciting photos and videos from the public (Hermida & Thurman, 2008).

How much of its Web presence to open up to an audience is a dilemma for news outlets. Science news is based on expert opinion, rather than amateur bloviation (Deuze, 2003). However, if science journalists were to move away from the "we write, you read" dogma of modern journalism, they could potentially have access to hundreds of thousands of experts. At the same time, undermining that dogma could open the door to misinformed commentary on the major scientific issues of the day.

Issues surrounding the credibility of audience contribution are not unique to science journalism. Mainstream news outlets face the challenge, too, as they shift toward a model of greater engagement and participation with the public, considering ways of tapping into the wisdom of crowds (Surowiecki, 2004) while avoiding the pitfalls of mob rule. The task for journalists is to find ways of encouraging participation that add value, rather than devalue, science reporting. Perhaps a reader's exact comment online is less important than the fact that they are taking part in a discussion and demonstrating an active interest in a scientific issue. The self-correcting nature of the Internet also means that users tend to respond to each other and point out mistakes. Providing more opportunities for user participation could have long-term benefits, as it could foster increased public engagement with science.

Blogging, in particular, is being used to engage with audiences in new ways. Blogs have been portrayed as an interactive communications technology that could create a conversation between journalists and audiences (Gillmor, 2003). The informal nature of blogs allows for a more conversational approach to science, as well as provides a platform to explore the process of science rather than just the published findings.

Science journalists who maintain blogs say feedback from readers is valuable. For example, it helps to find out how completely people understood a particular story (Hermida, 2007a). For these journalists, blogging connects them with readers in a way that was not possible before the Internet. ScienceBlogs.com, which describes itself as "the largest online community dedicated to science," is an example of how the blogging platform is being harnessed to foster dialogue online. And there are indications that blogs are starting to be recognized as a legitimate form of journalism. At the Online News Association annual conference in October 2007, five of the twenty awards went to blogs, among them blogs from the magazine *Wired* and the newspaper *Florida Today*.

Blogs are a platform native to the Web, and thus they share one of the defining characteristics of the Internet: the use of hyperlinks. The ability to create a network of ideas through the use of links, whether in blogs or other forms of online storytelling, marks a major departure from other forms of journalism. In traditional journalism formats, such as print or broadcast, the aim is to retain audiences, to keep them reading, listening, or watching. Links in online content invite audiences to explore further and construct their own narratives. Hyperlinks shift control to the audience and are part of the non-linear nature of the Web.

Cumulatively, these factors create a new architecture for journalism. First, the existing model of packaging news into print or broadcast products is being undermined by a digital environment where information can be packaged differently and more effectively (Bradshaw, 2008). Second, the networked nature of information on the Web casts knowledge as a process and the news as a service, rather than a product.

These developments require a fundamental rethinking of established journalism practices. News outlets are now seen as hubs in a distributed network of information, rather than as destinations. In this global network, the emphasis has shifted from a model in which audiences come to a news outlet to one in which news outlets reach out to audiences. Deuze (2003) argues that journalism is moving from a closed culture focused on the production of editorial content to an open culture focused on connecting with audiences. As a result, news outlets are making their content as widely accessible as possible, through syndication, social bookmarking, or technologies such as RSS. This variety of available routes to the news is particularly important for science journalism, since happenstance plays a key role in how people stumble across science news online. Horrigan (2006) found that two-thirds of Internet users in the United States encounter science news when they have gone online for other information.

Another key factor is convenience, cited by Americans as the main reason they go online for science news, as opposed to other factors, such as the reliability of information (Horrigan, 2006). By reaching out to audiences, news outlets create more opportunities for people to stumble across their content. This move toward outreach was part of the strategy behind the Great Turtle Race website, a project led by journalist Jane Stevens for the Leatherback Trust and Conservation International, which set out to make the online content available for people to share as widely as possible (Hermida, 2007b).

Online journalism requires much more than repurposing content, adding multimedia to a story, and publishing it online; it involves a shift in thinking and journalistic culture. Media tycoon Rupert Murdoch (2005) summed up the situation:

> The peculiar challenge then, is for us digital immigrants—many of whom are in positions to determine how news is assembled and disseminated—to apply a digital mindset to a set of challenges.

More than other media, such as television or newspapers, digital platforms can offer science journalism a greater diversity of coverage and voices. The multimedia, nonlinear, and networked nature of online journalism is forcing journalists to rethink storytelling for a digital age. For science journalists, the Web offers a multiplicity of ways to delve into complex issues. The participatory potential of the Internet offers the means to engage with audiences in ways that were unthinkable when those science writers came together in the 1930s to form a professional association. Today, the potential to reimagine and revitalize science journalism for a digital world is here.

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CHAPTER 9

# Responsible Reporting in a Technological Democracy

William A. Wulf

The United States and the other developed countries are the most technologically sophisticated societies that have ever existed. They are also the most technologically *dependent* societies that have ever existed.

Inevitably, a large number of important public policy issues have a technological dimension. Issues like climate change, energy policy, and even the use of computer-based voting systems cannot be meaningfully discussed without some understanding of the technology involved. Alas, the vast majority of our citizens lack that understanding. One has to wonder just what it means for a society to be a "democracy" when its citizens are unable to participate in a substantive discussion of some of the most important public policy issues facing them.

What follows are a half-dozen examples of poor and perhaps even dangerous media coverage of important issues. In each case, the problem was a failure to account for the technical dimension of the story. This paper is not intended as a condemnation of the media, however. The premise of this paper is (a) that the journalistic community *and* the technical community *share* a responsibility to inform the public, and both were AWOL in these cases; (b) that complete and accurate coverage does not require deep technical knowledge that is "over the heads" of the general public; and (c) that mainstream journalism is the most effective and most timely place to provide the information that the public needs to be responsible citizens.

## EXAMPLE 1: URANIUM ENRICHMENT BY IRAN

The impression one got from the media's coverage of Iran's uranium enrichment program is that uranium "enrichment" is equivalent to having a nuclear weapons program. The fact that the Iranians have *three thousand* centrifuges (generally intoned in a grave voice) was evidence for the seriousness of the problem.

Not once in the coverage of this issue did I see or hear an explanation of enrichment or of reasons why Iran might be doing it, other than for making bombs. Yet the reason is *so* simple to explain, and an explanation would add *so* much to informing the public's opinions.

Uranium occurs in two varieties, called U-235 and U-238. U-235 is the kind that heats up water in a nuclear reactor or goes boom in a bomb. About the only thing interesting about U-238 is that it's really heavy; it is not radioactive, and its presence actually impedes the function of both reactors and bombs. Naturally occurring uranium ore contains less than 1 percent of the "good stuff," U-235, and most of the rest is U-238. The concentration of U-235 has to be increased to 3 to 5 percent to work in a nuclear reactor and 90 to 95 percent to make a bomb. The process of increasing the percentage of U-235 is called "enrichment."

The critical question was never whether Iran was enriching uranium, but whether it was enriching uranium to 5 percent or to 90 percent. Even after the U.S. National Intelligence Estimate stating that Iran suspended its weapons program in 2003 was released, the media did not ask the question, and the technical community did not offer an explanation. That left the public, and perhaps our political leadership, assuming the worst.

But what about the number of centrifuges that Iran has? Iran's three thousand centrifuges are older and vastly less efficient than the model the United States uses—about one-one hundreth as efficient, in fact. Experts consider that about fifty thousand of the newer models are needed for a production enrichment facility. Is this something we should have seriously considered going to war about?

## EXAMPLE 2: THE 2001 ANTHRAX ATTACK(S)

In Fall 2001, two waves of anthrax attacks occurred. At the time of these attacks, the National Academies were doing a study of terrorism prompted by the 9/11 attack on the World Trade Center and the Pentagon. One of the members of the study committee was Jim Woolsey, a former director of the U.S. Central Intelligence Agency. Jim kept reminding the committee that "the purpose of a terrorist is to terrorize," and the media coverage of the attacks was surely the terrorists' best ally in accomplishing that aim. Media coverage heightened anxiety without really informing the public. In reality, only five people died from what was purported to be high-quality anthrax spores. More people than that died from lightning strikes[1] during the months of intense, frightening, drumbeat coverage. And again, the technical community was largely silent.

1. An average of slightly more than seven people *per month* died from lightning strikes between 1980 and 1995.

Perhaps the real story ought to have been just how hard it is to make and deliver anthrax that will make people sick. That story was never told. Instead the public was made to feel a real and imminent danger. The terrorist(s) probably applauded after each news story.

## EXAMPLE 3: AVIAN FLU

A more recent example of drumbeat coverage of a scary medical situation was that of H5N1 avian flu. The typical coverage emphasized that, of the something like three hundred reported cases in human beings in the last five years, there were about two hundred deaths, or a greater than 60 percent mortality rate. That compares to the less than one-tenth of 1 percent mortality rate for common seasonal flu—a difference of a factor of six hundred. The concern was expressed again and again that if the virus mutated to be transmissible to (and between) human beings, it would result in a far, far worse pandemic than the 1918 “Spanish” flu that may have killed more than fifty million people worldwide. And, as we were correctly warned, viruses *do* rapidly mutate.

I am not a biologist, but even I know that the mechanisms of infection in birds and human beings are very different—occurring in the gut of the bird as opposed to the lungs of human beings, and with very different kinds of receptor sites in the two cases. This probably explains why human cases have been rare and may suggest that while viruses do evolve rapidly, this particular kind of mutation is a big leap and hence unlikely. How unlikely? I do not know, but it certainly is far less likely than most citizens were led to believe.

I also know that although the mortality rate for seasonal flu is small, it infects twenty to sixty million people annually, resulting in thirty thousand to forty thousand deaths. Comparing risks is something that human beings do poorly—and this is a good case of why. How do we compare the two situations: (1) two hundred deaths in five years, with an unlikely but possible mutation resulting in a horrendous pandemic; (2) thirty thousand to forty thousand deaths annually from something that is just a nuisance to most of us? The avian flu coverage was a missed “teachable moment,” a chance when the media and technical community might have stepped in to help the public think substantively about risk.

By the way, if avian flu was a risk previously worthy of daily coverage month after month, why is it not still being covered? Avian flu has not gone away.

## EXAMPLE 4: THREE MILE ISLAND

The Three Mile Island reactor incident stopped the production of new nuclear power plants in the United States. I suspect that if you asked a cross-section of Americans, they would tell you that the incident was horrendous and endangered thousands, even millions of lives. The public clearly is still highly skeptical about the advisability of building new nuclear plants.

Who knows what would have happened if Three Mile Island had not occurred, but I believe more of our current power supply would be from nuclear energy—hence, less from fossil fuels, meaning we would be putting less carbon dioxide ($CO_2$) into the atmosphere. Because climate change is, in my view, the most serious problem facing humankind, possibly even making Earth uninhabitable by human beings, the consequences of the collective public decision to stop producing nuclear plants are significant.

But how much does the public—or our political leaders, for that matter—know about the safety of nuclear power? How much do they know about just how serious the Three Mile Island incident really was? Very little! And, again, neither the press nor the technical community made a serious attempt to educate Americans so that they could make an informed decision.

In reality, Three Mile Island could have been a very serious incident, but it was not—at least in part because of the safety measures built into every U.S. reactor. About two million people *were* exposed to an average of 1 to 2 millirems of radiation. However, in that part of Pennsylvania *everyone* is exposed to 100 to 150 millirems each year from naturally occurring radiation in the soil.

## EXAMPLE 5: WHO KILLED THE ELECTRIC CAR?

Often the media make things out to be worse than perhaps they actually are. The opposite can also occur, however: reality can be less rosy than it is portrayed to be.

The recent documentary film *Who Killed the Electric Car?* (2006) depicts a situation that played out in the early 1990s in California. Faced with a serious air pollution problem, the California Air Resources Board (CARB) mandated that an increasing percentage of the cars in the state had to be "zero emission"—that is, electric. General Motors (GM) built an electric car for this market, the EV-1, and for some reason only leased them to customers. The EV-1 had some drawbacks: it was a two-seater, had a limited range, and took twelve to fifteen hours to recharge. But it also was kind of sporty, quiet, and definitely "zero emission." My friends who had one really liked it.

However, after just a few years CARB rescinded its ruling requiring zero-emission cars. GM recalled the EV-1s and shredded them. The premise of *Who Killed the Electric Car?* is that behind GM's actions must be a conspiracy—maybe it was the oil companies, maybe it was the auto manufacturers, maybe it was somebody else—but it had to be a conspiracy! *Who* killed the electric car?

Unfortunately, no one asked which is better for the environment, the electric car or a gasoline one. If we focus only on the car, the answer is the electric one. But that is not the whole story. Both the electricity and the gasoline have to be made, so the right comparison is between the whole system that includes the cars, their manufacture, the production of their fuel, the disposal of the cars at the end of their life, and so on. The cars themselves are just one part of this system.

Given the present mix of sources for generating electricity, the system of which the electric car is a part puts about three-and-a-half times more $CO_2$ into the atmosphere than the system of which the gasoline car is a part. Using a mix of sources involving more renewables and nuclear, the answer would be quite different; but currently, the system of which electric vehicles—from the EV-1 to current "plug-in" hybrids—are a part puts about three-and-a-half times more $CO_2$ into the atmosphere than does the system of which the gasoline car is a part.

Again, both the press and the technical community missed a teachable moment—an opportunity to create informed, responsible citizens. Just making the point that one must look at the whole system, not just the car, would have been enormously helpful. Had we been feeling ambitious, we might also have pointed out that every conversion of energy from one form to another is done imperfectly. In the case of the electric car, a long chain of such conversions occurs. The chain is so long, in fact, that only about 7 percent of the energy in the fuels used to generate electricity is ultimately used to power the car.

I don't know who killed the electric car—but bless 'em!

## EXAMPLE 6: THE HYDROGEN ECONOMY

The argument for a hydrogen economy is that when hydrogen burns it combines with oxygen to form water. That is, the only emission of a hydrogen engine is pure water.

Again, this explanation ignores the larger system—in particular, how the hydrogen is produced. The principal method for making commercial quantities of hydrogen is a process called steam reforming of natural gas. A fossil fuel goes in, and guess what comes out? Sure, hydrogen, but also $CO_2$!

Admittedly, per unit of energy delivered, less $CO_2$ comes out of natural gas than out of coal. But the notion that the "only" emission from a hydrogen engine is pure water ignores a significant part of the story.

## CONCLUSION

To be a responsible citizen in a society as technological as ours, everyone needs some knowledge of science and technology. Some really bad public policy can come from a lack of that knowledge. The technical and journalistic communities share a responsibility to provide it, and the best way to do so is by taking advantage of the teachable moments that naturally arise. However, this needs to be done everywhere in journalism, not just in the *New York Times* Tuesday Science section, or National Public Radio's *Science Friday*.

Citizens do not need to be scientists or engineers. For most topics, what they need to know is pretty simple—for example, the notion that one needs to look at the whole system, not just the car. Journalists do not need to be scientists or engineers either, but even more than the average citizen, they need to know what kinds of questions to ask—things like the overall efficiency of the system in which the electric car is embedded. Lacking this kind of knowledge, the journalist with even the best of intentions can mislead the public into making some very bad public policy choices.

By the same token, not all scientists and engineers need to be great communicators—but we need to make space for a few, respect them for what they do, and give them a platform for reaching the public. Too often the technical community has done the opposite of this—as in the case of Carl Sagan, who was denied membership in the National Academy of Sciences for his efforts to make astronomy accessible to the general public.

The usual excuse for not including more science and engineering content in mainstream journalism is that either it is "too hard" or "just not interesting." I reject both excuses. At the level relevant to public policy, the content is not hard, and it can be made interesting. Even if I am wrong about that, the proportion of important public policy issues with a technological component is rapidly increasing. If we want to continue to have a democracy, citizens are going to have to understand some of this stuff!

# Contributors

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