Science and the Public
Pushing PUS with Science Studies

"Do you feel that science and technology will eventually solve most problems such as pollution, disease, drug abuse, and crime, some of these problems, or few, if any of these problems?" In 1972, the answer for 30 percent of the total adult US population was "most problems" (National Science Board 1973, 98). Some 25 years later, public attitudes towards science are still positive: "Science can eventually explain everything" – 53 percent of the general public agreed with this statement in a 1998 survey (National Science Board 2000: 8–14).

Surveys with questions like these have been done since the early seventies. From its first volume onward, the biannual US National Science Indicators have included a regular chapter on *Public Attitudes Toward Science and Technology*. In recent years, the title of the chapter has been changed to *Science and Technology: Public Attitudes and Public Understanding.* In fact, this change reflects a shift of interest: Although public attitudes are still a major issue, they are framed differently, namely as a complex dynamic between science and society. Notably, the nuclear accidents of Three Mile Island near Harrisburg, PA (1979) and Chernobyl (1986), and the controversial debate on nuclear energy stimulated a new public discussion on various aspects of science and technology. The institutionalization of technology assessment (TA) as a scientific discipline has been one of the results of this discussion. Moreover, the role of scientific experts in society has become heavily debated in the 1970s and 1980s, and, at the same time, scientists "discovered the media" (Weingart 1998). The "visible scientists" (Goodell 1977) appeared and "selling science" (Nelkin 1987) became a major issue. At the end of the 1980s, climate change and the ozone hole stimulated a new discourse in the arena between science, policy and the mass media (Weingart et al. 2000).

However, only with the beginning of the 1990s, the new field 'Public Communication of Science & Technology' began to intitutionalize. The PCST network was formed as a "loose international organization of individuals interested in all aspects of the relationship between science and the public" (*http://www.people.cornell.edu/pages/bvl1/pcst-net.html*). In 1992, the journal *Public Understanding of Science* was launched in cooperation with the Science Museum, London, and international conferences of the community are now held every second year.

The editor of *Public Understanding of Science*, Bruce Lewenstein, will introduce into the complex interaction of science, politics and the media. He argues that there is a fundamental contradiction between democratic ideas of equal participation and the meritocratic ideal that produces scientific elites. PUS programs produced by elite scientists who do not understand the public's perception and use of science will not serve the public well. In his view, PUS should not be about more information, but about a better understanding of the scientific process. Hence, one more reason to consider the insights of science studies.

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What Kind of 'Public Understanding of Science' Programs Best Serve a Democracy?

Bruce V. Lewenstein

Most justifications for government support of 'public understanding of science' (PUS) programs rely on the argument that responsible citizens in democratic societies need to make social decisions that involve science and technology. Yet there is a fundamental contradiction between democratic ideas of equal participation and the meritocratic ideal that produces scientific elites. One of the outcomes of this contradiction is a series of PUS programs that do not serve the public well, because they are produced by elite scientists who do not understand the public's perception and use of science. PUS programs are usually based on providing more and better information to appropriate publics. Data from various studies shows, however, that what people need is not more information, but better understanding of the scientific process. Not the mythological, 'hypothetico-deductive scientific method,' but the real, socially-mediated, patronage influenced, experimentally-underdetermined, theoretically-guided – in short, MESSY – scientific method. Natural scientists who attack the historians and sociologists who have described this method as 'anti-science' are shooting the messenger. The enemy are those members of society who deny the power of rational inquiry, not those who promote a more nuanced, contextualized understanding of how scientific knowledge is produced. PUS programs should rely more, not less, on the findings of historians and sociologists of science.

Twenty-five years ago, the astronomer Benjamin Shen offered three definitions for science literacy (Shen 1975). The first, he called *practical science literacy.* By that, he meant the knowledge of science that we need for living in modern society: that antibiotics are useful if you have bacterial disease, that automobiles work by converting fossilized potential energy into kinetic energy, that computers can do only what their programmers have instructed them to do.

The second type, he called *civic science literacy.* This kind of knowledge is what we need as citizens in Western democracies: the power of public health initiatives, the relative risks and benefits of coal and nuclear and solar power plants, the economic and political value of environmental regulations, and so on. Civic science literacy is not something you need on an everyday basis, but it is what you need to judge the decisions that your representatives in government and industry must make in *their* everyday activities.

Finally, Shen identified *cultural science literacy*. This is knowledge of science as the product of the human mind, something akin to music or art. We care about the Higgs boson, not because it helps us everyday or because it matters to our civic life; we care about it because to understand the Higgs boson is to understand something about Nature. To understand the helical structure of DNA and the amazing symmetry of As and Ts and Gs and Cs (adenine, thymine, guanine, and cytosine) is not needed to help yourself heal, or even to pass judgment on genetically-engineered foods; the DNA helix is simply an amazingly beautiful object. The ability to grasp the inherent beauty of DNA is what makes us human – both our own understanding of it, and our appreciation of the intellectual effort that went into elucidating its structure.

While other definitions of science literacy have been proposed or elaborated in the years since Shen's paper, none of them has the value of simple distinctions that Shen's definitions offer. All can be subsumed under Shen's definitions without doing terrible injustice to their meaning (Thomas / Durant 1987; Laetsch 1987).

When people talk about improving public understanding of science and technology, or supplying resources to the public communication of science and technology, they sometimes justify their remarks by calling on the need for better practical science literacy. This is especially true in developing countries, where problems of health, nutrition, water supplies, agriculture, and so on clearly can be addressed with specific scientific and technological knowledge (Schiele 1994). Sometimes, calls for more public understanding of science draw on the cultural science literacy justification; this happens most often, of course, in the developed countries, and most often in the writings of intellectuals concerned about human nature and the value of rational inquiry (cf., e.g., Holton 1965; Holton 1974; Snow 1959).

But by far the greatest support for public understanding of science activities relies on the civic science literacy argument. "Better public understanding of science can be a major element in promoting national prosperity [and] in raising the quality of public and private decision-making …," said a British Royal Society report in 1985 (Royal Society 1985: 9). "There are few, if any, public issues … that do not have a scientific or technical component. Conversely, issues that appear to be largely scientific or technical in nature mostly have major social and political implications." As one result, the Royal Society's report argued, "there is clearly a strong case for Parliamentarians, in particular, to have a much better understanding of science and its relevance to their responsibilities than they now have."

Similarly, when various provincial and federal branches of the Canadian government sponsored a major symposium on "When Science Becomes Culture" in 1994, the president of the *Conseil de la science et de la technologie du Québec* asked "Is the public able, or does it even desire to influence the political powers with regard to problems involving technology or science? Regrettably, science and technology belong all too exclusively to those who work in these fields." The general public must understand science, the minister argued, in order to guide the politicians (Berlinguet 1994).

In the United States, when the American Association for the Advancement of Science sponsored a major science education reform program, its definition of science literacy also focused on the importance of science for *citizens*, not individuals with immediate practical concerns or deep intellectual interests; the program (called "Project 2061")

> promotes literacy in science, mathematics, and technology in order to help people live interesting, responsible, and productive lives. In a culture increasingly pervaded by science, mathematics, and technology, science literacy requires understandings and habits of mind that enable citizens [*n.b.*] to grasp what those enterprises are up to, to make some sense of how the natural and designed worlds work, to think critically and independently, to recognize and weigh alternative explanations of events and design trade-offs, and to deal sensibly with problems that involve evidence, numbers, patterns, logical arguments, and uncertainties (AAAS 1993: xi).

Traditionally, promoters of public understanding of science – who almost always come from or have strong ties to the scientific community – have argued that improving the "quantity and quality" of scientific information available to the public would be the best way to help meet the civic needs of citizens (Lewenstein 1992).

The Fundamental Contradiction

Yet there is a fundamental contradiction between this pronouncement of the scientific elite and the simultaneous commitment to democracy, which specifies that individual citizens acting together should determine what best suits their needs and interests. Taken to an extreme, some attempts to resolve the contradiction lead to the various 'democratic science' movements that advocate citizen control over science and question the authority of science to govern itself (cf., e. g., Fayard 1988; Sclove 1995). Scientists recognize the contradiction, but deny that citizen control is the answer. Instead, they argue, better 'public understanding of science' will lead to better public support of scientific independence.

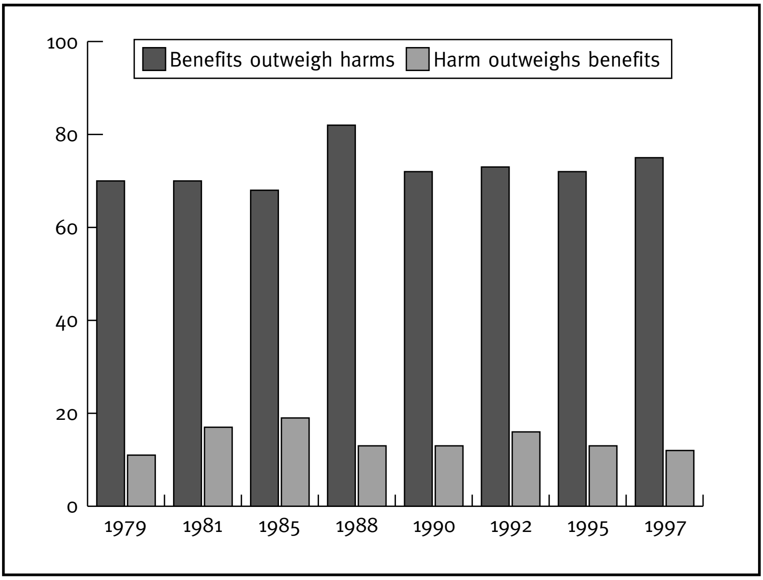
Why 'better'? While the broad public does, in general, have a good attitude towards science (though perhaps not towards technology), it also recognizes that scientists do not always have the answers – *even though* (and this may be the critical point for understanding complex public attitudes) scientists are often unwilling to acknowledge when they *do not* know the answer. That tension is the crucial issue. Given a commitment to public understanding of science that depends largely on the 'civic science literacy' idea, and given a supposed mismatch between the need for public support of science and the public's actual support of science, what kind of public understanding of science programs are needed in a democracy?

To answer that question, I want to call attention to the word 'supposed' in the previous paragraph. In the rest of this paper, I will argue (1) that public support of science (as shown by attitudes and images) *is* good; (2) that when we take seriously the idea that we must listen to citizens in a democracy, we learn something about science from them; and (3) that, therefore, our public understanding of science programs must address the issues of uncertainty and context that worry the public at large.

Public Attidudes Toward Science and Public Images of Science

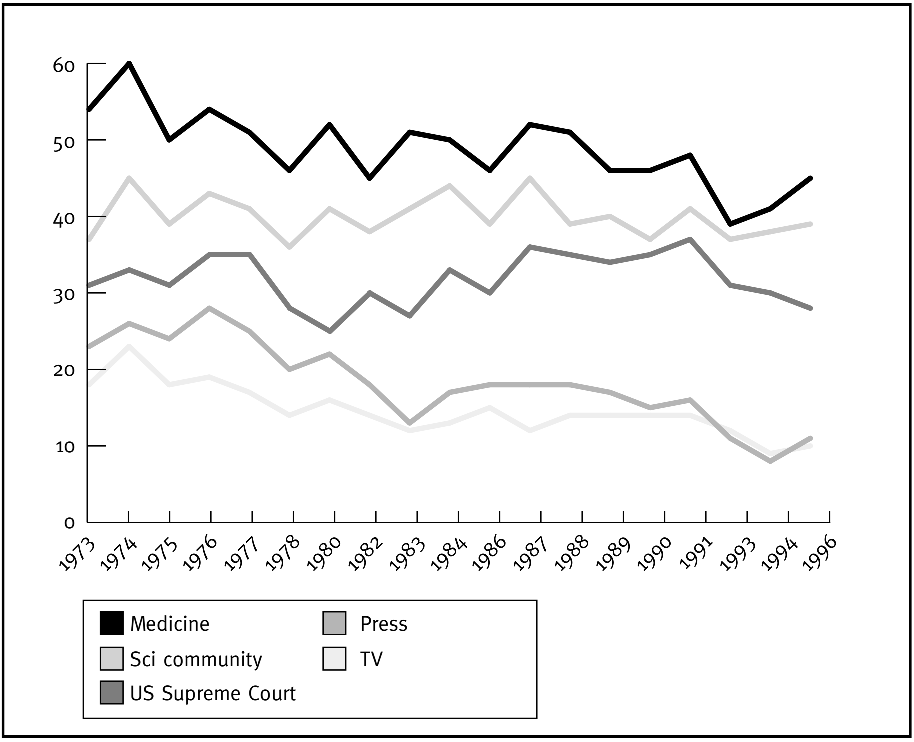
Consider first the evidence on attitudes (Figure 1). Americans overwhelmingly believe that science and technology make their lives better (NSB 1993; NSB 1998). More than 80 percent say that science and technology make our lives "healthier, easier, and more comfortable." (A comparable number of Europeans say the same thing.) Looked at from the other direction, less than 40 percent of Americans say that science and technology "make our way of life change too fast." (Here, some international differences do appear: 55 percent of Europeans and 57 percent of Japanese think science and technology are changing life too fast.) When asked about specific issues in the quality of life (such as public health, working conditions, and standard of living), generally less than 10 percent of Americans think science and technology have a negative impact. (The one exception is "world peace," where the positive impact outweighs the negative impact by only about 10 percent.)

Figure 1: Public assessments of scientific research.
Data from NSB 1998, Appendix table 7–20
(Percentage of respondents)



Equally important, science comes off well when compared with other institutions in American society. In a series of questions asked since the early 1970s, Americans consistently rank science near the top of institutions they trust, putting lower such options as the US Supreme Court, organized religion, and the media (Figure 2).

Figure 2: Public confidence in leadership of selected institutions. Data from NSB 1998, Appendis table 7–19. (Percentage of respondents expressing confidence in leadership of selected institutions)



Another way to look at the public's attitude toward science is to consider the public *image* of science. Images cannot be quantified in the same way that social scientists measure formal attitudes, but we can get some suggestive information from both impressionistic and formal content analyses of media images. A number of studies have shown that the public image of science splits into two groups – heroes and horrors. The heroes are the scientists who provide benefits – cures for disease, new computer technologies, answers to the energy crisis (Lewenstein 1989). The horrors, of course, are the demons and mad scientists who would destroy life with science and technology. Frankenstein's monster – or is it Frankenstein himself? – represent the horror image of science.

Another way to think about the dichotomy between hero and horror is to describe the image of scientists as an image of wizards. Wizards and the power they wield can be either good or bad – or both. Any fan of Tolkien or viewer of the "Sorcerer's Apprentice" in Disney's *Fantasia* knows this. But in a recent survey of children's science shows on American television, Marilee Long and Jocelyn Steinke showed that the evil images of wizards are rare, whereas the good images, the images of scientists as truth-seekers, are prevalent (Nelkin 1995; Long / Steinke 1996).

Missing from most of these images is the everyday, *humdrum*, ordinary image of the scientist and engineer as a human problem solver, doing the best he or she can to solve the problems that face the world. (These images *are* appearing in the children's TV shows, probably as a direct result of the producers' realizing that the images do not appear anywhere else. But they're absent in most other places in popular culture.) Nonetheless, despite the presence of horror images and the lack of humdrum images, the hero image remains a powerful icon in our society. Science has provided us with prosperity.

But, as Marcel LaFollette (1990) suggested in an analysis of media images in American magazines throughout this century, prosperity can be oversold. Science has claimed credit for nuclear power, improved plastics and pesticides, and outer space. Science cannot suddenly disclaim its contributions to modern life after Three Mile Island, Bhopal, Chernobyl, and the Challenger explosion. The public is not stupid. When it sees the scientific community saying that 'public understanding of science' is equivalent to 'public appreciation of the benefits that science provides to society' – but also sees that science brings us things that are not necessarily good – there's a clear disjunction between the image and the reality. That disjunction, LaFollette argued, rather than the problems themselves, makes the public distrust science. (The same problem affects politicians who do not keep their promises.)

How people respond to the images of science in their minds is perhaps the crucial point. In the United States, many physicists and chemists in the mid-1990s complained about an exhibition at the Smithsonian Institution called "Science in American Life." They said it presents a negative, anti-science message, though the curators responded that their goal was simply to show the changing attitudes of Americans toward science. After visiting the exhibit hall, however, one of the sharpest critics of the exhibition had to moderate his remarks. "The kids thought it was terrific, they did not pick up any of the negative stuff," he said (MacIlwaine 1995). Moreover, a study of visitors showed overwhelmingly positive reactions to the exhibit (Pekarik et al. 1995).

Those of us who care about science can easily highlight the images we do not like and complain about them – but we do so at our peril, ignoring our colleagues doing careful studies of how people actually respond. We know, for example, that individuals make risk decisions for very complex reasons that often go far beyond simple calculations of hazard probabilities (Kasperson et al. 1988; Slovic 1987; Hornig 1992; Hornig 1993; Priest 1995). Instead, they factor in the degree to which they dread the risk and the 'signal' effect of recent news about the risk. Perhaps most important, individuals make many risk decisions based on how much they can control the risk.

Understanding the Tensions: Control and Uncertainty

The issue of control – which is, of course, often central to political issues – is crucial if we are to understand public attitudes toward science and science literacy. Three case studies provide the data.

In 1986, after the Chernobyl nuclear accident, the Cumbrian hills of England were contaminated by fallout (Wynne 1989). Scientists at the British Ministry of Agriculture, Fisheries, and Food (MAFF) ordered sheepfarmers not to bring their sheep to market, except under certain conditions. The restrictions, they said, would be lifted shortly, after the fallout had been safely absorbed by the soil. The MAFF scientists, however, made a series of mistakes. First, they did not recognize the limits of their own knowledge. Their estimates of how long the restrictions would apply were based on soil models from a different part of England, models that had little relevance in the fells of Cumbria. The restrictions, originally imposed for three *weeks*, were still in place a *decade* later. Second, the scientists refused to acknowledge their own uncertainties. They continually asked the farmers just 'to trust' the scientists, even after the scientists had lost the trust by demonstrating how wrong their science could be. Contributing to this loss of credibility was that the scientists imposed their restrictions without considering the expert knowledge that sheepfarmers had about grazing habits, water runoff, and other issues relevant to the restrictions.

Also in England, indeed also in Cumbria, researchers were puzzled to find that workers at the nuclear reprocessing plant in Sellafield actively resisted acquiring knowledge about nuclear contamination (Wynne 1991). Surely if anyone needed to be 'scientifically literate,' it was people who work with extremely dangerous, very high technology on an everyday basis. Exploring the issue, however, researchers discovered that the workers did not want knowledge that they could not use. They functioned best when they stayed ignorant. Then, and only then, could they work efficiently by simply trusting their supervisors to design safe procedures. If the workers had developed independent knowledge – especially knowledge about the *uncertainties* of the scientific knowledge of the dangers they faced – they would have found themselves paralyzed. Without the authority to control or change their actions, but with the knowledge of the uncertain dangers they faced, their workplace would have become far more 'risky' than when they trusted their supervisors without the burden of knowledge.

Finally, across the Atlantic, a case in Canada shows what happens when you put these questions of control and scientific uncertainty into direct practice. While designing exhibits and community programs about mining to be used throughout the province of Alberta, program developers realized that members of the communities they visited were extremely aware of the uncertainties of scientific knowledge – and of the impacts these uncertainties would have on their communities (Bradburne and Wake 1993; Wake and Bradburne 1995). What the citizens wanted was not more 'knowledge,' but rather to learn ways of combining the knowledge they either had or could acquire with the uncertainties in that knowledge. They wanted guidance in action, not simple facts.

All three of these cases show us that public attitudes toward science, even if good in the aggregate, ultimately depend on the ways in which the public perceives that it can control science. In particular, when the public believes that scientists are making claims of certainty and authority that the public recognizes as untenable – then the scientific community loses its credibility. When the public sees science and technology that neither it *nor* the scientific community seems to have completely under control (including intellectual control), then it begins to fear science and give it the horror image, not the hero one.

Knowledge is Needed, But What Kind?

I want to make clear that I am not denying the problem of lack of knowledge. My late colleague Carl Sagan, the well-known astronomer and fantastically successful popularizer, once told a story about meeting a young man who was obviously enthusiastic about science. The man bubbled over with his excitement about the curiosity and cleverness of scientists. Then he began asking Sagan more specific questions, inquiring about the power of pyramids, UFO sightings, extrasensory perception, and a host of other pseudo-scientific 'findings.' Sagan was appalled. Here was someone clearly enamored of science – and absolutely missing all understanding of what constituted reliable scientific evidence, useful scientific method, and well-established knowledge about the natural world.

Like Sagan, I desperately want members of the public to learn to use their rational faculties more effectively. We must help more people learn to be skeptical, to question statements that are unsupported by facts. We need to improve education throughout our system, not just in science – in history, in language, in geography, in literature. Even in politics!

But when we consider public understanding in the context of democracy, we must recognize the conflict between the elite visions of science as a crucial component of progress in addressing national and international problems, and the democratic or popular visions of science that are much more nuanced and – sometimes – critical. When we accept that the democratic side of the contradiction as a deeply rooted, *reasonable* response to the what the public experiences, we are ready to see the conflict, not as an irrational uninformed barrier to understanding, but as a fundamental aspect of the organization of our society. Then we are ready to ask, how can we best serve the citizens of our democracies? What kinds of public understanding of science programs will help us move forward?

To some scientists, including some prominent ones, we improve science literacy by focusing on specific scientific knowledge. For example, ten years ago Robert Hazen and James Trefil, two physicists with very successful records as popularizers, put together 20 principles of science which they believed that everyone should know (things like "one set of laws describes all motion" and "everything is made of atoms") (Pool 1991). But many *scientists* disagreed with them (Culotta 1991). The absence of math and biology from their list drew widespread criticism. So did the attempt to create any such simple list. "I would object to the absolute and simple-minded terms in which [the ideas] are expressed …," wrote Elwyh Loh, a medical professor at the University of Pennsylvania. The compilation "is baby-talk that reduces Science with a capital 'S' into Saturday morning cartoons."

Perhaps even more telling is the conclusion of the AAAS's Project 2061. Based on extensive work with psychologists and curriculum evaluators, Project 2061 has rejected the model of cramming more and more facts into students.

If we want students to learn science, mathematics, and technology well, [the project's staff wrote,] we must radically reduce the sheer amount of material now being covered. The overstuffed curriculum places a premium on … short-term memory and impedes the acquisition of understanding (AAAS 1993: xi–xii).

What, then, is the alternative?

Clearly, if we move away from science as bits of knowledge, we must look at science as a process. But – and here is where I part company with many scientists – we need to focus on the *real* process, not the mythical one of developing hypotheses, gathering data, testing the hypotheses, revising and repeating the process. Many "well-intentioned calls to combat scientific or technological illiteracy" fall into the trap of advocating facts rather than context, according to LaFollette (1995). Trying to maintain the cultural authority of science, scientists use the myth of the single, clear, all-powerful scientific method to defend themselves against charges that science is a tool of corporate capitalism, or a hegemonic opinion produced by cultural elites, or other attacks from postmodern critics (Gross and Levitt 1994; Levitt 1999). As LaFollette (1995) said,

Describing scientific knowledge as if it emanated fully realized from a 'black box' does preserve scientists' cultural sanctity … It also neatly circumvents explanations of research values and goals. Effective modern citizenship [*n.b.*] demands a higher level of 'knowing about' science, however. It is enhanced by fuller explanation of why scientists recommend one thing or another, and of what underlies their standing as experts.

Like LaFollette, I believe that we need to teach something about the context and process of science. But what do I mean by process? Not the so-called 'scientific method.' Historians, philosophers, and sociologists of science over the last generation have convincingly demonstrated that while scientists often call upon a standardized method (especially the 'hypothesis, test, conclusion' model) for rhetorical purposes, the actual processes by which scientists acquire knowledge are much messier and more complex. In *Scientific Literacy and the Myth of the Scientific Method*, chemist Henry H. Bauer (1992) argued that we should be focusing on the social processes of communication, collaboration, and communal judgment to understand how random hunches, observations, and ideas about nature become transformed into reliable understanding of the world around us. The physicist John Ziman (2000) has recently made a similar argument.

The problem is that the messy reality of scientific life, including especially the degree of social interaction among scientists, government agencies, industrial sponsors, audiences, and publics that leads to reliable knowledge, is anathema to scientists who believe that science is fundamentally a search for Truth and Nature. It is very difficult to accept that scientific consensus is shaped by power relations, political contingencies, interpretive flexibility, rhetorical constructions, and other elements of social behavior that together go by the label 'social construction.' But a careful reading of historical and sociological records clearly shows that scientists use social activities to achieve their understanding (Jasanoff et al. 1995).

Robert Smith's prize-winning history of the Hubble Space Telescope (Smith 1989), for example, follows in exquisite detail the process of committees, reports, personal persuasion, political manipulation, and other fundamentally social processes by which astronomers reached consensus on what was worth studying and how – in the very technical sense of which instruments, built with which capabilities, to which tolerances, with what specifications – the astronomical community should go about studying space. The decisions made by this complex process directly affect what we know about the natural world.

Or consider a much earlier time: in 1610, as Galileo learned to use his new telescopes for observing the planets, his decisions about what he had found were shaped by his campaign to get, and then keep, a patronage position at the court of Grand Duke Cosimo de' Medici (Westfall 1985). He first observed three moons of Jupiter; but the

Grand Duke was one of four brothers. Not until he found a fourth moon could he announce his discovery of the "Medicean Stars." Similarly, his decision to engage in a systematic survey of the planets was shaped by his promise to the Grand Duke to provide "many discoveries and such as perhaps no other prince can match, for of these I have a great many and am certain I can find more as occasion presents itself." If he failed to meet his promise, his salary and support would disappear.

Implications of the Social Model of Science

What are the implications of this belief in the fundamentally social nature of the scientific process for the general effort to create greater public understanding of science? Most immediately, when we decide to focus on the 'process' of science, we must mean the *real* process by which science achieves its powerful status in society, not an idealized and abstract 'scientific method.' We cannot present scientific authority as somehow beyond the criticism we make of arguments based in religion or myths.[1] For, like each of these 'nonscientific' fields, science achieves its power only through the socially-constructed consensus among its practitioners that is then used as a rhetorical tool to fashion a broad social consensus that it provides answers unobtainable through other means. Religion and myth play continuing roles in modern life not because people are ignorant, but because the insights and satisfactions that come from these fields satisfy deep human needs. We need to understand that science achieves authority because *we* have *agreed* to give it authority – agreed based on the evidence supplied and defended through a complex social process.

To conclude, consider again the notion of civic science literacy. We do need citizens who know something about science. But we need to go beyond simple declarations of that need. For the kinds of decisions we want people to make *as citizens*, we want them to know something more than simple facts about Nature. We want citizens to know how science produces reliable knowledge about Nature – and especially how social forces at both the individual and societal levels help shape the production of that reliable knowledge. Only then will citizens be in a position to tell their democratically-elected representatives how to proceed on political issues that involve science and democracy.

Notice that I am *not* advocating the kind of 'democratic science' in which citizens *make* the decisions themselves, a sort of 'science by majority vote.' People who advocate this kind of citizen participation are deeply skeptical of scientific and technological expertise. I do not share that skepticism. The natural world imposes powerful constraints on what we can do, as individuals and as citizens. We need scientific and technological experts who use their professional skills, including their professional judgment, to tell us about those constraints. But I recognize, as many scientists who defend the so-called "scientific method" in knee-jerk fashion are apparently unwilling to recognize, that our *knowledge* of the natural world is deeply shaped by social factors. As citizens, we must understand the contexts in which knowledge of Nature is produced, and how different social forces might produce different sets of knowledge – which, in turn, might lead to different social decisions about how to move ahead on difficult public policy issues that have scientific and technological components.

Some of the scientists who I am criticizing believe there is a war between critics of science and science itself (cf., e.g., Holton 1993; Park 1994; Wolpert 1992; Gross and Levitt 1994; for more nuanced views, cf. Labinger 1995; Labinger 1997; and Labinger/Collins 2001). Most of these scientists have focused on the historians and sociologists who have produced what I believe are honest and faithful portraits of how scientific knowledge is produced by a social process. The scientists are, I think, shooting the messenger. There is an enemy, and it is those who deny the power of rational discourse (fed by evidence evaluated by a social process of testing and consensus-building and trust) to teach us something about the natural world. But the way to deal with the enemy is not to insist on the primacy of technical expertise before we even begin the discussion. That leads to war. The answer, as in any diplomatic negotiation, is to begin by talking, by listening, by *hearing* the other side. What is it about science that feeds and promotes the horror image? Why do people actively choose to be ignorant about science? What kind of information do people – nonscientist *citizens* of our democracies – want to know?

Once we have begun talking, we can build the trust and respect on which mutual understanding can build. That understanding probably will not be a commitment to cultural science literacy – because, for most of the public, science as culture will never have the appeal of rap music and earrings and the political sex scandals. Nor will mutual understanding end up focusing on practical science literacy, because the public will come to understand – I hope and believe – that developing scientific knowledge requires a level and breadth of curiosity that cannot be tied to practical concerns.

In the end, mutual understanding will focus on civic science literacy – because that is the place where the social context of science brings together the real process of science (the one I've described above) with the real interests and needs of the public.

In this paper, I have not tied my comments to theories of political systems or democracy. We still need people to do that. But, like a good scientist, I think I've mucked about in the data of public attitudes towards science, public images of science, and the nature of science itself to show that prevailing approaches that treat the public as ignorant, passive couch potatoes cannot be justified. Instead, an alternative interpretation treats the public as active members of a democracy and respects their perspective on science as one produced by realistic encounters with the products of scientific and technological inquiries.

And also, like a good scientist, I'm left with many more questions about whether the approach I'm suggesting will work. To answer those questions, we need more data.

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Note

1 I do not mean "myth" as in false, but as in "story" – a story based in reality, but abstracted for its moral lesson rather than for its faithfulness to what scientists actually do. I thank Gerald Holton for challenging my use of the term.

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