Environment and Society

2b

Dr. Bradley H. Brewster

SCIENCE AND SOCIETY

Framing Science

To engage diverse publics, scientists must focus on ways to make complex topics personally relevant.

Matthew C. Nisbet[1]* and Chris Mooney[2]

Issues at the intersection of science and politics, such as climate change, evolution, and embryonic stem cell research, receive considerable public attention, which is likely to grow, especially in the United States as the 2008 presidential election heats up. Without misrepresenting scientific information on highly contested issues, scientists must learn to actively "frame" information to make it relevant to different audiences. Some in the scientific community have been receptive to this message (*1*). However, many scientists retain the well-intentioned belief that, if laypeople better understood technical complexities from news coverage, their viewpoints would be more like scientists', and controversy would subside.

In reality, citizens do not use the news media as scientists assume. Research shows that people are rarely well enough informed or motivated to weigh competing ideas and arguments. Faced with a daily torrent of news, citizens use their value predispositions (such as political or religious beliefs) as perceptual screens, selecting news outlets and Web sites whose outlooks match their own (*2*). Such screening reduces the choices of what to pay attention to and accept as valid (*3*).

Frames organize central ideas, defining a controversy to resonate with core values and assumptions. Frames pare down complex issues by giving some aspects greater emphasis. They allow citizens to rapidly identify why an issue matters, who might be responsible, and what should be done (*4*, *5*).

Consider global climate change. With its successive assessment reports summarizing the scientific literature, the United Nations' Intergovernmental Panel on Climate Change has steadily increased its confidence that human-induced greenhouse gas emissions are causing global warming. So if science alone drove public responses, we would expect increasing public confidence in the validity of the science, and decreasing political gridlock.

Despite recent media attention, however, many surveys show major partisan differences on the issue. A Pew survey conducted in January found that 23% of college-educated Republicans think global warming is attributable to human activity, compared with 75% of Democrats (*6*). Regardless of party affiliation, most Americans rank global warming as less important than over a dozen other issues (*6*). Much of this reflects the efforts of political operatives and some Republican leaders who have emphasized the frames of either "scientific uncertainty" or "unfair economic burden" (*7*). In a counter-strategy, environmentalists and some Democratic leaders have framed global warming as a "Pandora's box" of catastrophe; this and news images of polar bears on shrinking ice floes and hurricane devastation have evoked charges of "alarmism" and further battles.

Recently, a coalition of Evangelical leaders have adopted a different strategy, framing the problem of climate change as a matter of religious morality. The business pages tout the economic opportunities from developing innovative technologies for climate change. Complaints about the Bush Administration's interference with communication of climate science have led to a "public accountability" frame that has helped move the issue away from uncertainty to political wrongdoing.

As another example, the scientific theory of evolution has been accepted within the research community for decades. Yet as a debate over "intelligent design" was launched, antievolutionists promoted "scientific uncertainty" and "teach-the-controversy" frames, which scientists countered with science-intensive responses. However, much of the public likely tunes out these technical messages. Instead, frames of "public accountability" that focus on the misuse of tax dollars, "economic development" that highlight the negative repercussions for communities embroiled in evolution battles, and "social progress" that define evolution as a building block for medical advances, are likely to engage broader support.

The evolution issue also highlights another point: Messages must be positive and respect diversity. As the film *Flock of Dodos* painfully demonstrates, many scientists not only fail to think strategically about how to communicate on evolution, but belittle and insult others' religious beliefs (*8*).

On the embryonic stem cell issue, by comparison, patient advocates have delivered a focused message to the public, using "social progress" and "economic competitiveness" frames to argue that the research offers hope for millions of Americans. These messages have helped to drive up public support for funding between 2001 and 2005 (*9*, *10*). However, opponents of increased government funding continue to frame the debate around the moral implications of research, arguing that scientists are "playing God" and destroying human life. Ideology and religion can screen out even dominant positive narratives about science, and reaching some segments of the public will remain a challenge (*11*).

Some readers may consider our proposals too Orwellian, preferring to safely stick to the facts. Yet scientists must realize that facts will be repeatedly misapplied and twisted in direct proportion to their relevance to the political debate and decision-making. In short, as unnatural as it might feel, in many cases, scientists should strategically avoid emphasizing the technical details of science when trying to defend it.

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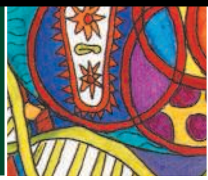

LETTERS

edited by Etta Kavanagh

The Risks and Advantages of Framing Science

THE POLICY FORUM "FRAMING SCIENCE" BY M. C. NISBET AND C. MOONEY (6 APRIL, P. 56) argues that because different audiences respond differently to certain science-based public policy issues, scientists should trade their reliance on fact-based arguments for ones more slanted toward the interests of specific groups. Their examples—climate change, evolution, and stem cells—seem all too similar to the parable of the blind men and the elephant, each man describing the beast differently based on his own limited data. In the end, although each describes a portion of the elephant accurately, none can picture the entire animal. That seems more a model for politicians than scientists, and Nisbet and Mooney's advice that "scientists should strategically avoid emphasizing the technical details of science when trying to defend it" seems somewhat dishonest. I would hope that researchers continue to rely on their data, rather than on what "spin" on an issue might prove more convincing.

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NISBET AND MOONEY'S PRESCRIPTION OF framing falls short of a comprehensive diagnosis and treatment plan for what ails science. The authors correctly argue that framing is one, albeit of many, powerful communication tools potentially useful to scientists. However, using framing for persuasion, political communication, or public relations ends does not necessarily empower people to make better decisions about complex issues (*1*, *2*).

The authors' argument may inadvertently perpetuate two commonly encountered science communication myths. The first is that complexity cannot be successfully communicated (*2*). The second is a counterproductive "two communities" notion that blames the public as eternally deficient and alienates science from society (*3*, *4*). Nisbet and Mooney can claim this misrepresents their intent, but that illustrates the inherent vulnerability of even a well-intended frame to differing interpretations (*5*). For instance, readers of *Science* may interpret the authors' advice to strategically sequester the "technical details of science" as equating framing with "dumbing down" science, even though Nisbet and Mooney certainly recognize that framing and technical complexity are distinct elements of language and communication.

Finally, what framing strategy wins the daily mass media wars may not enhance long-term relationships between science and society. Toward that end, evidence indicates that scientists should engage in more and ongoing dialogue with policymakers and the public to help build shared understanding and effective policy solutions (*1*–*4*, *6*). As Irwin wrote, "The relationship between science and society should not be about the search for universal solutions and institutional fixes, but rather the development of an open and critical discussion between researchers, policymakers and citizens" (*3*). At stake are not only relevance and increased adoption of science, but also long-term support for science, social cohesion and equity, trust, and well-being (*1*–*4*, *6*).

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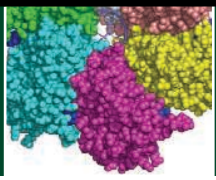
CREDIT: PETER HOEY

IN THEIR POLICY FORUM, NISBET AND MOONEY assert that scientists need to become adept at communicating their science in public using frames "to make it relevant to different audiences." Although I agree, suggesting that scientists accept and use popular frames presents certain risks.

First, many scientists would prefer to "stick to the facts" in public for very good reasons. Frames are much more than simply "leaving out details," reducing jargon, or providing more context. When speakers frame "the problem of climate change as a matter of religious morality," for example, they are using science to support a philosophical argument. Scientists are reluctant to use frames like this one, not because of the details they have to omit, but because of the details they have to add. It's philosophy, not science.

Second, although others have used science in "foreign" frames to shape public opinion, when they dominate science media, important ideas are entirely absent. Frames work because they distill complex issues and emphasize what the audience already knows to be true. But we should be concerned if the dominant frames in the media omit the authoritative basis of science in empirical observation, experimental methods, and rational argument, for example. We're left with science "facts" in an alien frame. Without these concepts, how can society cope with scientific controversy or the implications of new and challenging discoveries?

Despite these drawbacks, "foreign" frames are important, and more scientists should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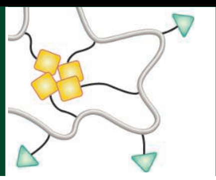
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learn to use them. It is perfectly reasonable and legitimate to use emotional, religious, political, and economic metaphors, stories, and messages to frame science. Scientists are also citizens and have a right—even a responsibility—to frame their science in their own voices. Framing science in these ways does make science more accessible. But it's important to understand the risks of saturating the media with these popular frames, as well as the potential rewards.

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NISBET AND MOONEY ARGUE THAT "WITHOUT misrepresenting scientific information on highly contested issues, scientists must learn to actively 'frame' information to make it relevant to different audiences."

I would argue that framing the debate will lead to (i) having to misrepresent scientific information or (ii) sacrificing scientific credibility, both of which will only reduce the public acceptance of what science has to say.

For example, the authors say that the United Nations Intergovernmental Panel on Climate Change (UNIPCC) has "steadily increased its confidence that human-induced greenhouse gas emissions are causing global warming. So if science alone drove public responses, we would expect increasing public confidence in the validity of the science, and decreasing political gridlock." However, this would be true only if UNIPCC is seen by the public as solely presenting technical complexities as matters of science.

UNIPCC framed itself as a political institution seeking not just scientific conclusions, but acceptable social, economic, and political solutions. Because of this, critics can easily attack UNIPCC's scientific credibility as being influenced by a political or social agenda. As a result, we have decreasing public confidence and increasing political deadlock. Had UNIPCC stuck exclusively to the science, the public would have been far more receptive to the findings of the organization and critics would be much less able to dismiss UNIPCC's science as politically or socially motivated.

Science has credibility with the public precisely because the public believes that science is neutral, that it doesn't take positions or adopt particular frames. If we are going to adopt a strategy of adopting frames when communicating to the public, we should at least consider the possibility of the unintended outcome of sacrificing scientific credibility in the process.

Another example presented is the public debate concerning evolution versus creation. According to Nisbet and Mooney, "antievolutionists promoted 'scientific uncertainty' and 'teach-the-controversy frames,' which scientists countered with science-intensive responses. However, much of the public likely tunes out these technical messages. Instead, frames of 'public accountability' that focus on the misuse of tax dollars, 'economic development' that highlight the negative repercussions for communities embroiled in evolution battles, and 'social progress' that define evolution as a building block for medical advances, are likely to engage broader support."

Although not quite a public debate, recent events in Dover, Pennsylvania, and the findings of Judge Jones came close. The antievolutionists lost.

I think one reason why is that the creationists adopted "scientific uncertainty" and "teach-the-controversy frames" while science and evolution refused to adopt any frame at all. Those representing evolution made no appeals to "public accountability" or "economic development" implications. Rather, they stuck to the science. In so doing, they built their arguments on a rich intellectual tradition that, more than any other in our society, is seen as unbiased and credible. Ask any trial lawyer: The jury buys the testimony of the most credible witness. So does the public.

In contrast, those testifying for the antievolutionary camp were tainted. They destroyed their own credibility and diminished the power of any countering arguments.

The authors observe that "many scientists not only fail to think strategically about how to communicate on evolution, but belittle and insult others' religious beliefs." I have witnessed quite the opposite. The scientific community has been much too respectful of the religious beliefs of others. When someone claims that the world is 6,000 years old, that is belittling and insulting the work of science, and just plain dumb. Scientists have to say that, and say it more often.

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Response

IN SPINNING OUR SUGGESTIONS AS "DIShonest," Holland assumes that framing is absent from traditional science communication. Yet, whether writing up a grant proposal, authoring a journal article, or providing expert testimony, scientists often emphasize certain technical details over others, with the goal of maximizing persuasion and understanding across contexts (*1*). Moreover, press officers and science reporters routinely negotiate story angles that favor particular themes and narratives (*2*) or, at the expense of context, define news narrowly around a single scientific study (*3*).

When attention to science shifts from the science pages to other media beats, new audiences are reached, new interpretations emerge, and new voices gain standing in coverage. These rival voices strategically frame issues around dimensions that feed on the biases of journalists, commentators, and their respective audiences (*4*). If scientists do not adapt to the rules of an increasingly fragmented media system, shifting from frames that only work at the science beat to those that fit at other media outlets, then they risk ceding their important role as communicators.

In response to Pleasant, we agree that a well-informed public is an empowered public. The problem, however, is that the availability of scientific information in the media does not mean people will use it. Only by framing issues in a manner that makes them personally meaningful and accessible to nontraditional audiences can scientists and their organizations boost public attention and thereby sponsor informal learning (*5*).

We also agree with Pleasant that the type of dialogue featured at deliberative forums and community meetings remains important. Unfortunately, at these forums, the citizens who are most likely to attend and speak up are those who are already informed and active on an issue (*6*). In contrast, carefully framed media presentations can effectively promote dialogue and trust with a larger and more diverse audience.

Consider, for example, E. O. Wilson's *Creation: An Appeal to Save Life on Earth* (*7*). By recasting environmental stewardship as not only a scientific matter, but also one of personal and moral duty, Wilson has generated discussion among a religious readership that might not otherwise pay attention to popular science books. A second example is Karen Coshof's documentary *The Great Warming* (*8*). Narrated by Keanu Reeves and Alanis Morissette, the theatrical release combines interviews of climate change experts with testimonials from religious leaders. Endorsed by national religious organizations, forums featuring the film have also been hosted by churches and synagogues. In addition, both of these examples function as news pegs for journalists at religious media outlets to write stories about climate change, thereby facilitating exposure among nontraditional audiences.

Contrary to Quatrano's warnings, in neither the Wilson nor the Coshof examples does science appear to support a particular religious philosophy or argument. Instead, framing is used to create a narrative bond between scientists and religious citizens, communicating a shared interest in what science can tell us about the nature of environmental problems.

In response to Gerst, scientists and their institutions are motivated to discover what is true about the world and to inform the public about the implications of their research. In translating this knowledge for popular consumption, should scientists rely solely on their instincts and their personal experience, or should they rely on a systematic understanding of communication? Applying research about the public and the media will only help the scientific community tell the truth more effectively and to a wider audience.

Framing is not all-powerful, nor should it be considered a magical key to unlocking public acceptance. Research on framing suggests that establishing a connection with audiences derives from the fit between the frames embedded in a media message and the interpretative schema that a particular audience possesses. One common source of science-related schema are long-term socialized world views such as political ideology, partisanship, ethnicity, or religious belief. Other sources are the stereotypes, narratives, and images learned through popular culture and the entertainment media. As shortcuts for reducing complexity, these schema allow any individual—whether a lay citizen, journalist, or policymaker—to categorize new information quickly and efficiently, based on how that information is framed in the media (*5*). In sum, a one-size message about science will not fit all audiences.

We suggest that science organizations work with communication researchers, conducting focus groups, surveys, and experiments that explore how different audiences interpret topics such as climate change or evolution. On the basis of this research, messages can be tailored to fit with specific types of media outlets and to resonate with the background of their particular audience.

It is encouraging that the Letter writers agree on a few central principles. First, framing as a concept has strong roots in the social sciences. Second, framing is already central—intentional or not—to traditional science communication efforts. Third, when applied responsibly and ethically, framing can be a valuable tool for scientists in engaging nontraditional audiences.

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CORRECTIONS AND CLARIFICATIONS

News Focus: "Exploring the prehistory of Europe, in a few bold leaps" by J. Bohannon (13 July, p. 188). On page 189, the caption to a photograph of stone tools incorrectly calls them "Neolithic" in date. It should have read "pre-Neolithic."

TECHNICAL COMMENT ABSTRACTS

COMMENT ON "Deep Mixing of ^{3}He: Reconciling Big Bang and Stellar Nucleosynthesis"

Dana S. Balser, Robert T. Rood, T. M. Bania

Eggleton *et al.* (Reports, 8 December 2006, p. 1580) reported on a deep-mixing mechanism in low-mass stars caused by a Rayleigh-Taylor instability that destroys all of the helium isotope ^{3}He produced during the star's lifetime. Observations of ^{3}He in planetary nebulae, however, indicate that some stars produce prodigious amounts of ^{3}He. This is inconsistent with the claim that all low-mass stars should destroy ^{3}He.

Full text at www.sciencemag.org/cgi/content/full/317/5842/1170b

Undergraduate Education in Jordan

I WAS SURPRISED THAT THE MIDDLE EAST WAS not mentioned in the Special Section "The World of Undergraduate Education" (6 July, p. 63–81). The Middle East constitutes 2.9% of the world's population and plays a prominent role in international politics, and the education of its population is a relevant international issue. For details on undergraduate education in various Arab states in the Middle East, go to the UNESCO Web site (www.unesco.org).

In 2005, the gross enrollment ratio (*1*) for undergraduate universities in Jordan was about 39%, and females make up 49% of those enrolled (*2*). There are 22 (private and public) universities in Jordan, which is a high number since the population of Jordan is only 5.375 million.

We have many of the problems discussed in the Special Section, such as using English as the language for science as in the Austrian example ("'Can't have a career… without English,'" J. Bohannon, p. 73) and changing the curriculum from heavy memorization to a more hands-on approach, as has been done in South Korea ("'A strong voice' for course reform," R. Stone, p. 76). Also, our teaching load is very heavy, leaving little time for research.

We are pioneering problem-based learning (PBL, as mentioned in the UK article, "'Much of what we were doing didn't work,'" D. Clery, p. 68) in Jordan, and resistance is high. Older faculty are not interested. It would be nice to have an open dialogue to share experiences and tactics for introducing such methodology and addressing problems. I would suggest having a forum and in the future an international conference to discuss these issues.

RANA DAJANI

We Have Met the Enemy
and it isn't ignorance

Whenever controversies arise that pit scientists against segments of the U.S. public—the evolution debate, say, or the fight over emissions regulations—a predictable dance seems to unfold. On the one hand, the nonscientists appear almost entirely impervious to scientific data that undermine their opinions, and they are prone to argue back with technical claims of dubious merit. In response, the scientists shake their heads and lament that if only the public weren't so ignorant, these kinds of misunderstandings wouldn't occur. But what if the fault actually lies with both sides?

We've been aware for a long time that Americans don't know much about science. Surveys that measure the public's views on evolution, climate change, and even the idea that the earth revolves around the sun yield a huge gap between what science tells us and what the public believes.

But that's not the whole story. The American Academy of Arts and Sciences convened a series of workshops on this topic over the past year and a half, and many of the participating scientists and other experts concluded that, as much as the public misunderstands science, scientists misunderstand the public. In particular, they often fail to realize that a more-scientifically informed public is not necessarily a public that will more frequently side with scientists.

Take climate change. The battle over global warming has raged for more than a decade, with experts still stunned by the willingness of their political opponents to distort scientific conclusions. Scientists conclude, not illogically, that they're dealing with a problem of misinformation or downright ignorance.

Yet a closer look complicates that picture. For one thing, it's political outlook, not education, that seems to motivate one's belief on this subject. According to polling by the Pew Research Center, Republicans who are college graduates are considerably less likely to accept the scientific consensus on climate change than those who have less education. These better-educated Republicans probably aren't ignorant; a more likely explanation is that they are politically driven consumers of climate science information. Among Democrats and independents, the relationship between education and beliefs about global warming is precisely the opposite—more education leads to greater acceptance of the consensus climate science.

In other words, it appears that politics comes first on such a contested subject, and better information is no cure-all—people are likely to simply strain it through an ideological sieve. In fact, more education probably makes a global-warming skeptic more persuasive and more adept at collecting information and generating arguments sympathetic to his or her point of view.

The moral of this controversy is that experts who want Americans to take science into account when they form opinions need to do far more than just lay out the facts or "set the record straight." What science says is important, but in controversial areas, it's only the beginning. It's critical that experts and policy makers better understand what motivates public concern in the first place; they mustn't be deceived by the fact that people often appear to be arguing about scientific facts. Rather than simply crusade against ignorance, the defenders of science should also work closely with social scientists and specialists in public opinion to determine how to defuse controversies by addressing their fundamental causes.

They might find a few pleasant surprises in the process. For one thing, the public doesn't seem to disdain scientists, as scientists often suppose. A 2009 study by the Pew Research Center for the People & the Press found that Americans tend to have positive views of the scientific community; it's scientists who are wary of the media and the public. ❧

—Chris Mooney

Chris Mooney is co-author, with Sheril Kirshenbaum, of *Unscientific America: How Scientific Illiteracy Threatens Our Future.* Basic Books, 2009.

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1

Science is Political/Technology is Social: Concerns, Concepts, and Questions

As the twenty-first century dawns, science and technology are central features of the lives of people worldwide. Whether it is the medical tests received by a loved one, the threats to one's job posed by mechanization or computerization, the chemical factory in one's neighborhood, or policies about global warming, in ways large and small science and technology affect our lives. This is as true if we live in Ames, Iowa as in Bhopal, India. Technoscience is a feature of our lives, whether we work in the dairy industry in Vermont, the computer industry in Japan, or the apparel industry in Korea. Certainly, depending on our location we will be affected in different ways, but we will be affected all the same.

Citizenship in this technoscientific world demands that we learn to grasp the issues raised by our environment. We must nurture the building of tools that will allow us to engage in a critical understanding of developments in science and technology. The aim of this book is to provide a set of such tools – critical concepts for the assessment of science and technology. In doing so, I do not mean to imply that these are the only concepts that can be used to analytically engage the world of science and technology. They are one lens through which to study, analyze, and evaluate the practices and products of technoscience. The concepts I elaborate have been useful for me. I believe they are cogent and compelling. Some readers may feel the same. But this book will count as a success if the arguments I present in the pages to follow prompt readers to think about science and technology differently, whether or not they agree with my approach.

To say that this book is about the provision of tools for looking at science and technology is somewhat misleading. In fact, in only one part of this chapter do I actually explicitly lay out the kinds of orienting concepts that I use in thinking about technoscience. This is preceded by a discussion of why it is so difficult for many people – especially Americans – to think critically about science and technology.

The remainder of the book uses these concepts in discussions of several distinct cases that deal with matters of science and technology. In chapter 2 ("Ceding Debate: Biotechnology and Agriculture"), I consider how recent developments in biotechnology are affecting the social organization of agriculture. Here, I pay special attention to farming and the relationship between farming and agribusiness. Among the specific technologies I consider are: herbicide resistant crops, the so-called "terminator technology," recombinant bovine growth hormone/bovine somatropin, and the genetically engineered use of *Bacillus thuringiensis*. In addition, I explore the way in which the public controversy over agricultural biotechnology has been framed by the proponents and opponents of the technology.

In chapter 3 ("Rethinking Information Technology: Caught in a World Wide Web"), I stress that to understand the possibilities for computers and the internet we must be attentive to the world into which they enter. My discussion has three parts. First, I consider the so-called digital divide in computer and internet access. Here, I analyze the ways in which computer and information access are stratified across different social groups and regions. Next, I investigate the use of information technologies in educational settings, and finally, I consider what information technology means and is likely to mean for politics and civic life.

Chapter 4 is entitled "Owning Technoscience: Understanding the New Intellectual Property Battles." Intellectual property considerations are central to debates about developments in technoscience. Scientists, business people, and government officials disagree over who should own the human genome, and college students and record executives argue about the free circulation of music on the World Wide Web. How necessary is intellectual property protection to the promotion of innovation and economic growth? Who benefits from patents and copyrights and who is harmed? In this chapter, I interrogate our social common sense about the virtues of intellectual property protection. The chapter suggests the evidence in support of its importance is questionable and that in some instances intellectual property protection may hinder innovation and economic growth. In the second half of the chapter, I discuss the issues of innovation promotion, equity, and social stratification raised by several recent technoscientific developments. This portion of the chapter deals first with digital technologies and later with developments in biology.

Chapter 5 ("Technoscience in the Third World: The Politics of Indigenous Resources") has three sections. First, I investigate the relationship between colonialism and genetic resources, paying special attention to the centrality of these resources in the development of the economic infrastructures of colonial powers and the ways divergent views of knowledge

and property are woven through colonial history. Next, I consider how colonial history laid the foundations for current international relations and practices around biological resources. Finally, I provide a discussion of three recent instances where some effort was made to correct historical inequities in north–south relations around biological resources.

In chapter 6 ("Gender and the Ideology of Merit: Women, Men, Science, and Engineering"), I explore the divergent experiences of men and women in science and engineering training and careers. I begin by critiquing the idea that the world of science is meritocratic. I contend that technoscience is a fundamentally social institution and that the experiences of men and women in it are shaped by its social organization and the larger social world in which science and engineering are embedded. The chapter considers the experiences of men and women both in academia and science-based industry.

Finally, in chapter 7 ("Democracy and Expertise: Citizenship in the High-Tech Age"), I consider the roles of lay citizens and experts in a world infused by technoscience. I draw on several case studies to illustrate the often partial character of experts' knowledge on matters of crucial importance to specific communities. Using these cases and several others I also show how the knowledge of people who are not certified experts can improve the quality of understanding on some highly technical matters. In addition, I consider several instances that suggest that arguments of lay incompetence are not valid justifications for excluding non-experts from technical decision-making in areas that affect their lives. Finally, I point to what I believe are the most important barriers to lay understanding in what are traditionally considered expert realms, and suggest ways in which these barriers might be surmounted.

Why is Thinking about Science and Technology So Hard?

I believe two features of our discursive landscape – the realm of ideas, concepts, categories, and the many beliefs we take for granted – make it difficult to think critically about science and technology. I call these discourses *scientism* and *technological progressivism*.[1] Scientism has and long a varied history. Roughly speaking it is the notion that there is an inherent divide between facts and values – that they are intrinsically different categories of phenomena. This idea can be seen in Plato's claim that contemplative thought and practical action should be separated, in the efforts of seventeenth-century European natural philosophers to protect their work from attacks by the church and the state, and in early twentieth-century debates in Germany over values in social science (Proctor 1991). The study of science, according to this way of thinking, demands bracketing values and studying only facts. So not only are facts and values distinct, facts are superior to values in terms of credibility and cognitive authority. This belief in the cognitive superiority of facts over values leads to the conclusion that only trained scientists – *experts at unearthing facts* – can appropriately participate in decision-making on technical matters, where data (the facts) is the product of the scientific method (Kleinman & Kloppenburg 1991).[2]

In this context, the authority of science rests on its claims to be value-free and politically neutral (Nelkin 1995; Proctor 1991). We tend to believe that "the interpretations and predictions of scientists . . . [are] rational and immune from political manipulation because they are based on data gathered through objective procedures" (Nelkin 1995: 452). As a result, we accept that science and scientists are the best possible arbiters of controversy, clearing away the tangle of politics and opinion to reveal the unbiased truth.

Evidence of the unflagging resilience of scientism can be found in controversies over new technology. In many such disputes, those who oppose the technology because of the expected undesirable social effects or moral/ethical concerns gain legitimate entry into the debate only when they focus on issues, such as the environment or health and safety, that are believed to be assessable using recognized scientific methods. A good example of this is the reduction of moral concerns about fetal research into technical debates about the precise point at which life begins (Nelkin 1995: 453). Similarly, US activists opposed to genetically engineered foods have found it strategically effective to focus on their environmental impacts and on worries about food safety and not to openly base their opposition on concerns about, for example, the socioeconomic impacts on small farmers or moral opposition to the commodification of nature. Social impacts and moral concerns are typically considered to be based on value-judgments and are, therefore, viewed as less credible; by contrast, debates about health and safety issues are viewed as adjudicable in scientific terms (cf. Kleinman 1986; Kleinman and Pastor 1989). Thus, such discussions are considered more legitimate.

The second discourse that I believe often inhibits the ability of citizens to view science and especially technology as reasonable subjects for wide-ranging public debate I term *technological progressivism.* This is an idea with roots in the Enlightenment, when progress became a synonym for the good and technology came to be viewed as a tool in all progressive projects (cf. Schatzberg 1999; Smith 1995). Founding leaders of the United States viewed new technologies as a means of realizing the goals of the American revolution (Smith 1995), and by the nineteenth century the equation of technology and progress was firmly established in the American imagination (Noble 1983; Smith 1995; Hard & Jamison 1998; Schatzberg 1999). Thus

we have come to take the virtues of technological development for granted and to see technology as self-propelling, moving forward along a singular path without human intervention. In this context, debating technology is generally inappropriate. There are no social choices, as technology has only one path, which is intrinsically determined, and there is no point in blocking the road down which technology proceeds, as it is always for the good.

This view of technology is evident in a wide array of cases. We see it in instances in which certain technologies come to be viewed as progressive, while others are seen as old fashioned. In the development of airplane technology between 1914 and 1945, for example, engineers were captivated by the idea of replacing wooden parts with metal, despite evidence for the virtues of wood, because metal "symbolized progress and science" while wood was viewed as outmoded (Schatzberg 1999: 44). More recently, some analysts have pointed to "technological utopianism" as responsible for pushing computer technology, with relatively little critical examination, into primary and secondary educational settings (Sophia 1998).

If this view drives the development of technology, it is also the basis for dismissing critics of new technologies. Despite the often thoughtful assessment of developing industrial production by nineteenth-century Luddites, the term has taken on a disparaging tone as the twenty-first century begins.[3] In recent years, proponents of biotechnology have attempted to marginalize critics by referring to them as Luddites, alarmists, and champions of technological stagnation. With this kind of overblown rhetoric, one can imagine that there would be little room for careful and deliberate questioning of new technological developments.

Technoscience is Social

What does it mean to say that science and technology are social phenomena? The views of science and technology embodied in scientism and technological progressivism leave little room for thinking about technoscience as social. About all we can say is that since science is undertaken by and technology developed by people, and people are social, science and technology are social. But this view of the social character of technoscience is terribly limited. It cannot provide the basis for capturing the complexity of science and technology in the contemporary world. We need a more textured understanding.

The most traditional view of science understands knowledge to be the product of reading reality off of nature. There is nothing between the reader and what is read, and a good reader produces something like truth. From this perspective, the social character of science is not really part of the knowledge production process. Because scientists are human they might, for example, commit fraud, self-consciously misrepresenting their reading of nature, and science could be said to be social in this sense. Adherents to a traditional view would likely also accept that science is social in the sense that who gets to be a scientist may be the result of the social stratification of society at large. Similarly, a traditionalist might view science as social in the sense that what research gets done is determined by what funders – the government, foundations, industry – are willing to support.

These examples are all legitimate cases of the social nature of technoscience. But they construe the social character of science too narrowly. I believe that technoscience is absolutely and thoroughly social. Even the idea that researchers cull truth from nature in an unmediated fashion is mistaken. We never look outside ourselves and see phenomena through entirely naive eyes. How we understand what we see – indeed, for all practical purposes, what we actually see – is shaped by a wide array of prior assumptions, commitments, worldviews, what have you. We are not infinite beings capable of what one analyst calls the godtrick – of seeing everything from nowhere (Haraway 1988). As a consequence, we make selections about where to look, and this affects what we see. By looking to the left instead of the right we end up with a different picture of the world. If we study a prairie, the kinds of *facts* we will *see* will depend on, for example, whether we are looking at a macro level – exploring, for example, the relationship between weather, flora, and fauna – or at a micro level, training our sight on the interactions between bacteria in the soil and the plants growing in the earth. Scientists's training affects where they look, how they look at phenomena they study, and consequently what they see. And, of course, the content of training is thoroughly social. It is developed in educational systems through the interaction of certified scientists. It develops and varies over time and place.

Some philosophers have argued that facts are theory-laden. By that they mean that something we might call "reality" is never seen independent of the theories that allow scientists to think about what they see. In terms used in the philosophy of science, no experience is unmediated (Kuhn 1970; Wing 2000). Theory lies between experience/reality and facts. Scientists are exposed to theories during their training, and again, these shape where scientists look, how they view what they see, and what they see. Consequently, as many analysts have noted, it can happen that unexpected events take place before a scientist's eyes and provoke no response. When no meaning is attached to an experience, the experience may be ignored (Bloor 1976; Angier 1988).

The categories, orientations, and at some level the values on which scientists draw are affected by their disciplinary orientation. Thus, for example, ecologists are likely to look at a biological environment as a system, paying special attention to the interaction of its many components. A geneticist might, instead, be interested in the role that a particular gene plays in the life or fitness of an animal, plant, or microbe.

Or take the case of epidemiology. Epidemiologists study health and disease in populations. The approach used to study this problem is typically modeled on a traditional experimental research design in which, for example, some randomly determined subjects are given a drug and others are given a placebo. Here, other factors that could muddy an assessment of the efficacy of the drug under investigation are held constant or controlled for. In epidemiological research, beyond exposure and non-exposure to the hypothesized disease inducer, other factors are held constant. Where differences in frequency of disease outcome vary by exposure/non-exposure, researchers conclude that the hypothesized inducer causes the disease. But importantly, the orientation of epidemiology does not typically lead analysts to ask questions about "why some individuals but not others were exposed, or what other changes occurred in order to produce the exposures" (Wing 2000: 31). Thus, although epidemiologists identified smoking as a cause of lung cancer, they focused on this as an individual behavior. They did not integrate the role of the tobacco industry, commercial sale of cigarettes, or "the social circumstances that make smoking a rewarding habit" into their analysis (Wing 2000: 37).

There are many other cases that illustrate how disciplinary orientation affects what a scientist sees, but let me just describe one: the case of toxicologists who work on food-safety issues (Busch, Tanaka, & Gunter 2000). These researchers often model their work on the metaphor that "rats are miniature people." This allows toxicologists to study how rats react to suspected food toxins in a controlled experimental setting. They avoid experimenting on humans, which permits them to bypass the practical difficulty of keeping humans in a laboratory setting for months on end to make certain they consume proper quantities of the expected toxin, and they avoid the potential ethical difficulties that might result if human exposure to the suspected toxin led to serious illness. Rats offer other practical advantages: they have a short life-cycle and are relatively inexpensive to maintain. Thus, ethical, temporal, and financial considerations affect the decision to treat rats as people. But this decision is consequential, since rats are not, in fact, people. People and rats are biologically different in ways that could mean that the results of research on rats are not valid for humans.

Beyond disciplines, professional norms can affect the ways in which scientists look at phenomena. In this context, it is helpful to return to the case of epidemiology. Under what conditions do epidemiologists recognize the presence of a carcinogen in an environment they are studying? Scientists talk about two varieties of error: type I and type II. Type I errors amount to false positives. The epidemiologist who makes a type I error might, for example, conclude that a particular environmental contaminant is the cause of a cluster of cancers in a community, when it is not. The researcher who makes a type II error, by contrast, would conclude, in a similar case, that a specific factor is not causing disease, when in fact it is. The issue of values is not far from the surface here. Publishing research containing a type I error could be professionally embarrassing when it is revealed and leads the scientist to retract his or her findings. This could have future impacts on the scientist's career. By contrast, a type II error would lead a scientist to mistakenly miss a discovery, but her or his reputation would not be harmed. Unlike professional epidemiologists, one could imagine that citizens in a community that might have been affected by an environmental carcinogen would have preferred scientists to err on the side of caution and make a type I error, instead of a type II error (Brown & Mikkelsen 1990).

The mediation of experience by theory, worldview, or discipline points to how what scientists see and what they say is affected by social factors. But beyond this, what is accepted as legitimate knowledge is also a product of interpretive practices. One might assume that reproducible experimental results would allow scientists to draw relatively unambiguous conclusions about the piece of nature that is the object of study in the experiment. If this experiment is done following agreed upon methods, should we not imagine that while the social may enter into the equation of how the piece of nature was seen, it stopped there? Perhaps sometimes. However, on other occasions, scientists disagree about how to interpret the results of an experiment or even whether the experiment was properly or competently done. Judgments about these matters are inevitably social. They affect the resolution of controversies in research, and they affect what we take to be knowledge of a phenomenon (Collins 1985; Collins & Pinch 1993; Martin 2005). Harry Collins shows that researchers's ability to replicate a laser technology also depended on informal communication, not solely formal technical rules (Hess 1997: 96). Collins has also provided evidence that a series of negative experiments on gravity waves did not solve a controversy among researchers. Instead, *rhetorical factors* were central in solving the controversy.

Another way we can see science as social is by looking across history at the variation in the definition of science by time and place. If there was something intrinsic or asocial about science, there would be no variation in what counts as science. Instead, what we see is struggles over what should count as science and what should not (see Gieryn 1999). In Victorian England, one leading scientist simultaneously stressed the abstract character of science to distinguish it from mechanics, and the concrete nature of science to distinguish it from religion. Arguing to the religious establishment that science was abstract would have suggested that science might interfere with the theological realm. Suggesting to mechanics that science was concrete would have led mechanics to believe scientists were likely to encroach on their territory.

In the mid-twentieth century, natural and physical scientists differed with social scientists in the United States over whether social science was, indeed, science. In the first skirmish, natural and physical scientists argued that social science was not science, while many social scientists suggested it was. When the issue was revisited a few years later, the position was reversed, with social scientists arguing for difference and natural and physical scientists arguing for similarity (Gieryn 1999). Along similar lines, the definitions of basic and applied science do not reflect the intrinsic character of the work, but are social products (Kloppenburg 1988; Stokes 1997). It is precisely because the line between technology and science is not intrinsic but a social outcome that I often refer to technoscience to avoid making an arbitrary distinction (Latour 1987). In making this point about the social basis and arbitrariness of what counts as science, I do not mean to suggest that absolutely anything could be called science. At the same time, the finite number of characteristics is overwhelmingly large, and the borders of science are "flexibly and discursively mapped out," often "in pursuit of some observed or inferred ambition" (Gieryn 1999: 23).

When we are speaking of artifacts – those things we commonly understand as technologies – their social nature can be seen in many ways. First, the history of technology is replete with cases in which, instead of the one path implied by technological progressivism, there are multiple paths along which a given variety of artifact might proceed or might have proceeded. In other words, there were choices to be made, and there is no evidence that the selection that we came to live with was intrinsically better than the artifact lost to history. The case of airplane-wing technology that I described earlier is one such instance. According to performance criteria, wood might conceivably have been the better choice at the time, but metal symbolized progress – a value held in high regard by involved engineers – and so won out (Schatzberg 1999).

The early history of machine tools – technologies used to make other machines – has similar contours (Noble 1984). It involves choices, and the choices were predicated on values. In the late 1940s, users of machine tools were faced with two types, one called numerical control and the other termed record playback. Numerical control technology was favored by the military because it was more precise than record playback, and the parts the military needed crafted depended on this higher level of precision. On the other hand, numerical control technology was not affordable for small machine shops, and because this technology removed control from the shop floor, workers opposed it. Management in larger firms, however, favored it. In the end, numerical control became the industry standard.

These cases illustrate the social nature of technology by showing that there was a choice to be made and that the criteria for making the choice were not in any reasonable sense technical. These cases also illustrate the fact that technical artifacts embody or are associated with values: valuing progress versus efficacy in one instance, and worker control and small shop affordability versus management control and technical precision in the other instance. There are also cases where artifacts seem to literally embody values. Take, for example, the overpasses that cross Wantagh Parkway to Long Island, New York, and in particular to Jones Beach (Winner 1986). Robert Moses, the designer responsible for these bridges, very consciously decided that they should be built at a height above the parkway that would make it impossible for buses to pass under them. This decision, according to Moses' biographer (Caro 1974), reflected Moses's racial prejudice and social class bias. The low overpasses meant that while more well-to-do whites could use the parkway for commuting and to reach destinations along it for recreation, it would not be accessible for low-income citizens, many of whom were people of color, who needed to rely on public transportation.[4]

Technoscience is Political

In my lexicon, to say that a phenomenon is political means that power of some form is implicated. I believe that science and technology are fundamentally and thoroughly political. In fact, it is rather difficult to separate out the social and the political; I have done so for analytical purpose only. In reality, the social and the political are inextricably intertwined. If we see that selection and choice is involved in the practice of science and technology, we must ask why one selection is made over some other. Why is this theory used instead of another one? Why was this technology commercialized and not the other? Surely, nature or reality plays a role here, but as I have shown already, so do values. But showing that values play a role in selection or choice begs the question of why one value instead of another value? The answer, I submit, is power. Power is enabling for actors "on its side" and constraining for actors who oppose it. To say this, I do not mean to suggest that power is an all-or-nothing phenomenon, but that will become clearer in the pages that follow.

Social theory abounds with approaches to power (cf. Marx 1977; Foucault 1972, 1980; Lorber 1994; MacKinnon 1989; Lukes 1974). The way I find most helpful is to think in terms of structures, resources, and discourse. This three-fold distinction is analytical. In the world that humans inhabit – what we sometimes call the social world – the boundary between structures, resources, and discourses is blurry at best. Still, understanding technoscience demands that they be disaggregated. At the most general level, I understand structures to constitute formal and informal, explicit and implicit "rules of play." These entities define specific constraints and opportunities for actors depending on their location in a structural matrix. This matrix might be something as amorphous as the system of class or gender relations or as concrete as a national state or a university laboratory.

What does this mean less abstractly? Let us begin at the most micro level: a university laboratory. Here, there are formal rules that grant certain rights to professors who head them. The laboratory leader is entitled to make decisions about the kind of research that is undertaken, how it is done, and who is responsible for doing the research. The informal cultural authority attributed to the professor who leads the lab – a more diffuse source of power located in the larger society – by students may also make it unlikely that students will challenge the professor's judgment, even when there is no formal prohibition against doing so (Owen-Smith 2001); and, indeed, if this informal cultural authority is sufficiently powerful, the student may never actually consciously contemplate the possibility of posing a challenge. Thus, we can say in this instance that the professor has power over her students.

Looking at a more intermediate level, we might consider national states as structures. Comparing the US state and the states of certain European countries, we can see how structure creates different opportunities and constraints and distributes power differently. The US state is often described as highly fragmented and permeable with multiple points of entry (cf. Kleinman 1995; Skocpol 1985). American political parties are described as undisciplined and non-programmatic. Many European states are seen as considerably less fragmented and permeable, and political parties in many European nations are highly disciplined and programmatic (Lowi 1967; Shefter 1977). In fragmented states, governmental units may have overlapping and conflicting jurisdiction. This makes power more diffuse, as any specific unit is likely to have difficulty realizing its policy vision. Permeability means it is possible for social interests (e.g. trade unions and business associations) outside the state to influence government policy, and when there are multiple points of entry, these interests can try to influence policy by making contact with the diverse range of governmental actors involved in the policy of interest. Again, this diffuses power at one level, but it also makes it possible for interests with greater economic resources and informal connections to governmental officials to influence policy-making (Domhoff 1983). By contrast, of course, in less fragmented systems where policy-making is more centralized and there is less permeability, governmental units responsible for specific policies are relatively more powerful – more able to enact their policy agendas.

Political parties in the US lack programs to which elected party members are required to adhere. In addition, there is no requirement that elected officials vote a party line in Congress, for example. US political parties have difficulty disciplining their recalcitrant members. Thus, these parties have a relatively limited capacity to enact their vision. They are not very powerful. By contrast, political parties – generally in parliamentary systems – that are able to enforce discipline are better able to enact their programs. They are more powerful.

Finally, take a more macro or general case still: gender. Gender itself can be understood as a social structure. Judith Lorber understands gender as a structure "that establishes patterns of expectations for individuals, orders the social processes of everyday life, is built into the major social organizations of society, such as the economy, ideology, the family, and politics, and is also an entity in and of itself" (1994: 1). At the most general level, there are no formal rules defining gender relations. Instead, they are typically informal but deeply entrenched, and create a stratified system in which, in general, women experience more constraints and men more opportunities.

I understand power in terms of capacity and constraint. We must consider how formal and informal "rules of play" make possible certain actions and the realization of certain goals by some actors, while making the actions of other actors and the realization of their goals less likely. A professor's formal position may make the realization of her goals as against a student's more likely. But it may not be just the formal rules that define the professor's position in the laboratory and university, but a host of resources that are associated with that position. The professor's grants may pay to run the laboratory. Here is an empowering economic resource. But in addition, the professor has pivotal cultural resources – the informal system of classification that allows her to know in an unthinking way what it means to be and behave like a scientist (Bourdieu 1984). Another component of the professor's cultural resources is the unreflected-upon assumptions about the rights and abilities of the scientist.

To this point, I have distinguished economic and cultural resources. Again, this is ultimately an analytical distinction, not something that exists intrinsically in society. "Economic" refers to financial resources that can be used to enable some actors and constrain others. "Cultural" refers to norms, beliefs, and values that may be drawn upon consciously or unconsciously and thereby define opportunities and constraints. This notion of cultural resource is closely related to the way in which I will use discourse. The realm of discourse is the sphere of meaning. It is a thoroughly social realm from which the categories through which we make sense of the world come.

The discursive terrain is not constituted by a singular discourse. Instead, it is made up of overlapping and often contradictory discourses (S. Hall 1982). But although there are always secondary or subordinate discourses,

generally it is dominant discourses that define what is sayable and what is a legitimate. Whether articulated consciously or not, dominant discourses are the most efficacious resources. They provide a kind of cultural authority to actors who deploy them (Schatzberg 1999: 5). The power of these discourses is greatly enhanced by the extent to which the truth of their basic claims is taken for granted (Meyer & Rowan 1977; Kleinman & Kloppenburg 1991; Schatzberg 1999). Actors draw on a particular set of discourses, and those with historical resonance and deep social legitimacy are the ones that are likely to hold the discursive high ground, eclipsing discourses that lack historical force and consequently legitimacy (Kleinman & Kloppenburg 1991; see also P. Hall 1986). In fact, actors pursuing a line of argument that challenges the dominant discourse will often attempt to manipulate that discourse in a way that can increase the legitimacy of their position (Kleinman & Kloppenburg 1991). They will use a dominant discourse to make their case.

I should make a couple of closing remarks about viewing the social world as a world thoroughly infused by power. A focus on power does not imply that social actors always act strategically and self-consciously to achieve their ends. One can imagine, for example, a small group of citizens appointed by a local government to make policy recommendations on biotechnology gathering to discuss the issues at stake. One can imagine further that all participants were formally equal. In this context, however, gender norms could result in men speaking more often and more determinedly and consequently having more of their points win the day. In addition, the taken for granted beliefs about the validity of expertise (call this a discourse of expertise) could lead some members of this group of citizens to unquestioningly accept the views of "certified experts" on the citizen body, whose opinion would then win the day. In this example, participating actors may not conclude that one group emerged victorious over another. However, as analysts we may conclude that the social organization of power – here understood in terms of gender and a discourse of expertise – shaped the outcome of this situation.

A second point I need to make concerns the status of "social construction." I believe, with many in the social sciences and humanities writing today, that the social world is constructed. But I differ with those who focus only on the processes of construction themselves – that is, with those who explore how, for example, gender, race, or science is constructed at site "x." I believe this is important work; however, it is also the case that our social world is relatively stable. At any given point in time, the already established features of that world – factors that have been constructed over time – serve to define the opportunities and constraints faced by actors. They shape actors's practices and the outcomes of social struggles, policies, and programs. In this book I am interested, then, in how relatively stable features of our social world shape practices, struggles, policies, and programs in the realm of technoscience.

Notes

1 When I use the term "discourse," I do so in the limited sense of "systems of symbolic meaning codified in language that influence how actors observe, interpret, and reason in particular social settings" (Campbell & Pedersen 2001: 9). On scientism and technological progressivism see Kleinman and Kinchy (2003a and 2003b).

2 Kleinman (2000a) provides a number of cases that powerfully contradict this claim.

3 For a view of Luddites as thoughtful critics, see Noble (1984).

4 Recent research has shown this case to be more complicated than Winner's portrayal suggests (see Joerges 1999). But as Sismondo points out, there is a slew of other cases that make Winner's point. Thus, Sismondo suggests that speed bumps serve a political purpose. They reduce and slow traffic and simultaneously increase the property values of family-oriented neighborhoods where they are installed (2004: 80). Such speed bumps embody the interest of home owners over those attempting to maneuver through the streets efficiently.

2

Ceding Debate: Biotechnology and Agriculture

The US and global economies are in the midst of a massive transformation. A complete outline of the new economies that will emerge is by no means certain, but some of the central characteristics of the new economies are clear. Many countries in the northern hemisphere are moving away from their post-Second World War foundation in heavy industry, and to some extent, the smokestack firms that remain are replacing rigid mass-production models with various forms of flexible organization (see Kenney & Florida 1993; Graham 1995). Much unskilled work is being farmed out to countries in the southern hemisphere. At the same time, the US and other western countries are shifting increasingly to a high-technology, knowledge-intensive mode of production. The industries that feature centrally in this new economy are information technology and biotechnology (see Kleinman & Vallas 2001).

These two engines of economic growth mean different things for countries in the north and the south. For highly industrialized nations, while creating new social class cleavages, these sectors promise increases in economic efficiency and productivity. They could lead to reductions in pollution, improved transportation safety, life saving drugs, and new foods. For countries in the south, the advantages of the new economy are less clear; disputes about ownership of biological materials crucial to the economic revolution underway, dangerous working conditions in firms owned by US- or Europe-based multinationals, and growing disparities of wealth and access to new technologies cloud optimistic visions of a high-tech future.

Consideration of the broad social impacts of the emerging new knowledge economy could fill several volumes. In this book, I will consider a limited number of what I consider to be some of the most important societal implications of recent developments in this "new world order." In this chapter, I begin with biotechnology. Here again, the topic is vast, and I will

U.S. Fish & Wildlife Service

Traditional Ecological Knowledge

for Application by Service Scientists

Fishing at Ninepipe National Wildlife Refuge, Montana / USFWS

Working Definition of Traditional Ecological Knowledge

Traditional Ecological Knowledge, also called by other names including Indigenous Knowledge or Native Science, (hereafter, TEK) refers to the evolving knowledge acquired by indigenous and local peoples over hundreds or thousands of years through direct contact with the environment. This knowledge is specific to a location and includes the relationships between plants, animals, natural phenomena, landscapes and timing of events that are used for lifeways, including but not limited to hunting, fishing, trapping, agriculture, and forestry. TEK is an accumulating body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (human and non-human) with one another and with the environment. It encompasses the world view of indigenous people which includes ecology, spirituality, human and animal relationships, and more.

The Use of TEK is Nothing New and Continues to Evolve

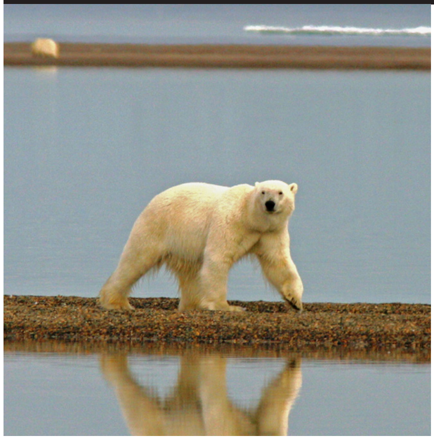
Local biological knowledge, collected and sampled over these early centuries, most likely informed the early development of modern biology. For example, during the 17th century the German born botanist Georg Eberhard Rumphius benefited from local biological knowledge in producing his catalogue, Herbarium Amboinense. Rumphius' index included the plant's name, illustrations, description for nomenclature, place, discussion of the plant's use to the local inhabitants, stories, folklore, and religious practices. During the 18th century, Carl Linnaeus referenced and relied upon Rumphius's work, and also corresponded with other people all around the world when developing the biological classification scheme that now underlies the arrangement of much of the accumulated knowledge of the biological sciences. In addition, during the 19th century, Charles Darwin, the 'father' of evolutionary theory, on his Voyage of the Beagle took interest in the local biological knowledge of peoples he encountered.

Contemporary naturalists and biologists also acknowledged the importance of TEK as it relates to Western science. For example, C. Hart Merriam was one of the great naturalists of his generation. In 1886, Merriam became the first chief of the Division of Economic Ornithology and Mammalogy of the United States Department of Agriculture, predecessor to the National Wildlife Research Center and the United States Fish and Wildlife Service. He was one of the original founders of the National Geographic Society in 1888 and developed the "life zones" concept to classify biomes found in North America. Although not widely recognized, C. Hart Merriam was also an amateur anthropologist who spent decades of five to six months each year traversing the country interviewing Native Americans and writing down voluminous records of what they were still able to tell him. He recorded the distribution of words to ascertain the precise distribution of dialects, languages, tribes, families, and their beliefs and customs, similar to the way he recorded the distribution of song sparrows, grizzly bears, and wolves in order to delimit life zones. The idea that TEK has guided modern biology (or Western science) should encourage conservation biologists to investigate TEK more thoroughly.

U.S. Fish and Wildlife Service's Use of TEK

An increasing number of scientists and Native people believe that Western Science and TEK are complementary. Although an integration of indigenous and western scientific ways of knowing

Grizzly bear in Wyoming / USFWS



Polar bear / USFWS

and managing wildlife can be difficult to achieve, successful integrations have occurred. For example, during the 1989 Exxon Valdez oil spill in Prince William Sound, Alaska, Federal and state agencies recognized the vast traditional knowledge of the Native community who could provide detailed information on conditions in the years prior to the spill. The Native community had knowledge of the historic population sizes and ranges of many of the species injured by the spill as well as observations concerning the diet, behavior, and interrelationships of injured species. Optimal use of scientific data and traditional knowledge while increasing the involvement of communities in oil spill restoration enhanced the success of restoration effort.

Most recently, the U.S. Fish and Wildlife Service used both western scientific data and TEK to justify listing the polar bear *(Ursus maritimus)* as a threatened species under the Endangered Species Act. Ecological knowledge provided by Chukotka, Inuit, and other indigenous coastal residents with regard to polar bear habitat, density estimates and population numbers provided valuable data used in making the decision. The final listing rule stated that both traditional and contemporary indigenous knowledge recognized climate-related changes occurring in the Arctic, and these changes are negatively impacting polar bears.

In Alaska, the Service, as well as the State of Alaska Department of Fish and Game Subsistence Division, collect and use TEK for research and monitoring fish populations under the Federal Subsistence Management Program. The primary objective is to collect and catalogue TEK observations from local residents through interviews with local experts on the ecology, harvest, and use of salmon and non-salmon fish species. Another more recent objective has been to produce a drainage-wide portrait of climate and environmental change, emphasizing those that are related to subsistence fisheries. Use of TEK also contributes to local capacity building by utilizing a framework of community involvement in research.

Collection of TEK

Methods for documenting TEK derive from the social sciences and include ethnography. Social scientists and cultural anthropologists use a wide range of techniques to collect ethnographic data. Below are some of the methods that can be used, but they are not necessarily in the order TEK should be collected. Permission from the indigenous government should be received prior to beginning any research project.

Literature review is an important component in any research project. All most all of the Tribes in the United States have been studied by an anthropologist at one time or another. During a literature search, ethnographies as well as collections of stories/myths/legends and songs will be instrumental to one's research for information on societies, clans, keepers of knowledge, ceremonies, uses, processes, and interactions.

The semi-directive interview is a standard ethnographic method for gathering information and can use both an open-ended and close-ended (yes or no questions) format. A skilled and experienced ethnographer can help a novice to determine the appropriate reach of the interview questions. For example, questions about a species may include such topics as the species itself, its habitat, interactions with other species, traditions and ceremonies surrounding the species or its parts, identification of who or what positions hold knowledge and rights to the species, taboos, cyclical events, and vocabulary.

Focus groups have also been used to provide direction for additional subject matter and identification of experts. Focus groups can be helpful to determine who within an indigenous Tribe holds the knowledge for the species being studied.

Participant Observation is another research method used, which involves extensive time in a culture watching and recording what people do. Participant Observation can be a source of information to verify that which has been spoken and a source of information for that which the Tribe forgets to tell because it is considered either universally known or assumed.

In addition, Linguistics can provide insight into a culture and its view of the natural world. Some Tribes now have written dictionaries for their languages. A native speaker can provide information about words, their meanings, associations and similarities. For example, the Yupik language on Nelson Island in Alaska is very intrinsically tied to the environment – there are words to describe plants, activities, and elements in the Yupik language that are non-existent in other languages. These words help Yupik people to

Alaskan salmon / USFWS

determine how they interact with their immediate environment.

Ethnography is the process which non-indigenous people interpret indigenous people's lifeways. The ethnographic process for collecting TEK results in a wealth of information that must be carefully considered for its use in a specific project. The researcher will get more than he needs and should accept all that is given during the collection phase. The one providing the information during an interview will be sharing lifeway surrounding the topic. Only afterwards should the researcher begin to decide on what is relevant to the project and what is not needed at the time. To try to edit the one speaking would be considered a lack of respect and would potentially stymie the researcher from obtaining information that on second consideration could be instrumental to the project. Retaining all of this information is important because it may be helpful for another project, although it may be more appropriate for a tribal college or other tribal institution to retain the interview transcripts. The researcher could retain those data needed for the project. Ethnographers are experts in this process.

Better Partnerships with Native American Communities

Although the collection of TEK is not government-to-government consultation, TEK is one way federal employees can honor the federal trust responsibility to tribes with regard to resources of mutual interest. Using TEK allows a mutually beneficial relationship to be created between conservation biologists and local people. Indigenous scholars and the scientific community can benefit by mutual exchange of information and interpreting the information collaboratively. A critical aspect of conservation biology and associated environmental management is acquiring information that is not only accurate, but trusted by those who make and abide by decisions based on that information. In cross-cultural settings, the latter is often difficult. The use of TEK offers one way of bridging gaps in perspective and understanding, especially when used in conjunction with knowledge derived from the scientific method.

TEK and Climate Change

As mentioned above, the Service often uses TEK in Alaska. For example, comments from Yukon River subsistence users in Alaska are beginning to identify a suite of environmental changes attributed to climate change that impact fish, fish habitats, and fishing activities. Observations include the drying-up of wetland areas, lakes, and waterways, as well as changes in weather patterns, which in turn affect river levels and average dates of freeze-up and break-up. What is currently needed is a directed, systematic, drainage-wide effort to collect and understand these changes and their impacts. Traditional Ecological Knowledge is particularly well suited for identifying environmental changes attributable to climate change at the local and regional level. Understanding the potential impacts of climate change on landscapes, wildlife, and subsistence users is important for Federal managers in order for them to carry out the mandates for which the various conservation units were established and to build flexibility into formal management structures to address a changing environment.

TEK in Journals and Professional Organizations

Interest in TEK has been growing in recent years, partly due to a recognition that such knowledge can contribute to the conservation of biodiversity and sustainable resource use in general. In 2000, the journal Ecological Applications produced an invited feature which focused on the subject of TEK in order to encourage the discussion of TEK in environmental management.

The Ecological Society of America has a Traditional Ecological Knowledge Section. The purpose of this Section is to: (1) promote the understanding, dissemination and respectful use of traditional ecological knowledge in ecological research, application and education; (2) to encourage education in traditional ecological knowledge; (3) to stimulate research which incorporates the traditional knowledge and participation of indigenous people and; (4) to increase participation by indigenous people in the Ecological Society of America (see http://www.esa.org/tek/).

In addition, The Wildlife Society has a Native Peoples' Wildlife Management Working Group which promotes improved relationships between state/provincial/federal

Yukon River, Alaska / USFWS

wildlife managers and tribal wildlife managers through improved communications. The Working Group provides a forum for tribal and agency wildlife professionals to discuss wildlife management on reservations and aboriginal lands and to share viewpoints on proposed policies affecting wildlife management on those lands. The Working Group also works to enhance wildlife management on and off reservations through joint activities (see http://joomla.wildlife.org/Native). The Wildlife Society has a Native Peoples' Wildlife Management Working Group recently held a half day symposium titled; "Implementation of Traditional Ecological Knowledge in Natural Resource Management" at their annual conference in 2010. Another whole day symposium on TEK will be hosted again during The Wildlife Society's 2011 annual conference.

How can I learn more?

Collecting TEK is not for a novice without research and guidance. Reading literature about TEK and speaking with professionals or those experienced in the field can help one determine if one would like to directly pursue collection of TEK. It is a good idea to have a professional mentor for several projects before attempting such work independently. In addition, even though one's intent in the collection of TEK may be altruistic, how the information is used can have unintended consequences. It is important to contact the Regional Tribal Liaison if TEK is pursued. The liaison may have experience with TEK and/or will be able to provide insight when working with Tribes. Indigenous ways of understanding and interacting with the natural world are characterized as TEK, which derives from emphasizing relationships and connections among species. There are a number of books and publications that examine TEK and its strengths in relation to Western ecological knowledge and evolutionary philosophy. Some of these books address the scientific basis of TEK, focusing on different concepts of communities and connections among living entities, the importance of understanding the meaning of relatedness in both spiritual and biological creation, and a careful comparison with evolutionary ecology. They may examine the themes and principles informing this knowledge, and offer a look at the complexities of conducting research from an indigenous perspective.

Once TEK is collected, combined with western knowledge, and decisions are being considered for managing the resources, take time to think about what the long-term impacts of these decisions could be beyond addressing the most pressing issue. New methodologies or technologies can have unintended consequences. Case studies are a way of learning to think beyond the hoped for result to the sometimes unintended consequences. The Suggested Reading List below provides information on the topics expressed in this Fact Sheet from several authors.

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Mexican gray wolf / USFWS

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