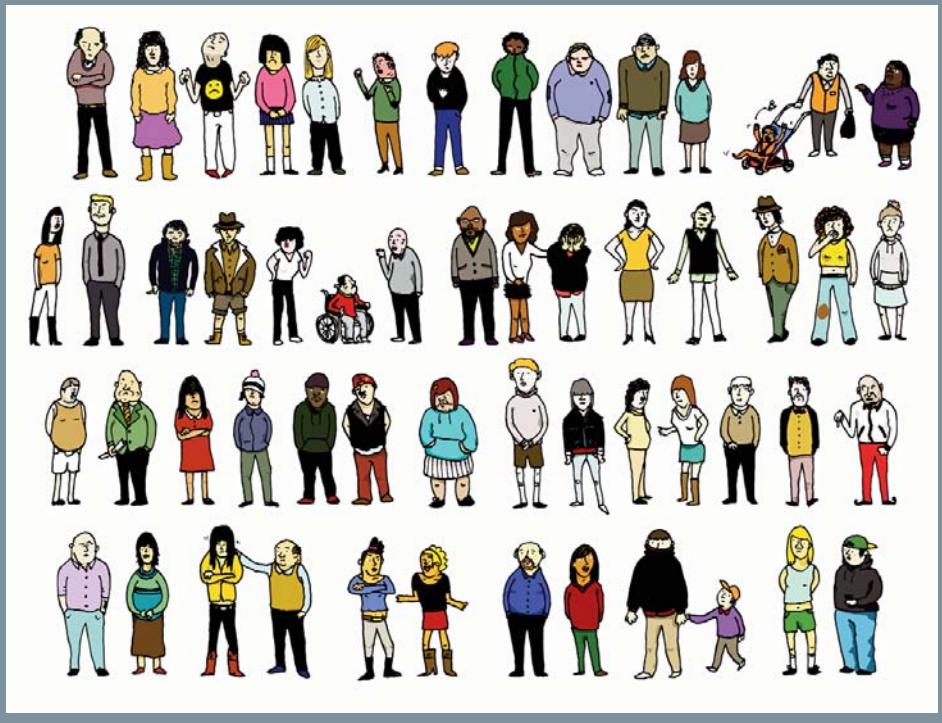
Do Scientists Understand the Public?



Chris Mooney

AMERICAN ACADEMY OF ARTS & SCIENCES

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Please direct inquiries to:
American Academy of Arts and Sciences
136 Irving Street
Cambridge, MA 02138-1996
Telephone: 617-576-5000
Fax: 617-576-5050
Email: aaas@amacad.org
Web: www.amacad.org

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Preface

Beginning in 2008, the American Academy of Arts and Sciences organized four off-the-record workshops for experts from the scientific community and representatives of the public to explore how scientists currently understand their obligation to the broader social and cultural contexts in which their work is received, and to examine ways to improve engagement between the scientific and public communities.

The Academy focused each project workshop on a specific area of research and technology: the Internet, nuclear waste, genetic information, and alternative energy. In these four areas, scientists have met with varying degrees of success in working with the public, in part because of differences in the maturity of the technologies. For instance, nuclear waste has been an issue for decades while personal genomics is a still-emerging field. These developmental time frames affected the workshop discussions as well as the recommendations for next steps that emerged from each workshop.

Nevertheless, the four project workshops identified common themes that can influence future work to strengthen the dialogue between the scientific community and the public. These themes serve as the basis for what might become a contract between society and science. The goal of such a contract should be to provide ways for society to benefit from emerging technologies while reducing risk. These themes include:

- *Heterogeneity.* It is important to remember that both the "public" *and* the "scientists/technologists" are heterogeneous.
- *Trust.* The scientific community must build and maintain the public's trust.
- *Education.* Just as the public must be educated on scientific topics, so must the scientific community be educated on public attitudes and opinions.
- *Communication.* There is a need to improve the forums for public communication.

There are many ongoing efforts to build public trust, to learn about the values of the target audience, and to address issues of concern to the public; yet more can be done to encourage the expert community to cultivate and maintain trust, as well as to listen and *respond* to public concerns. Based on the pilot workshops, the Academy has developed a series of recommendations to guide future work in this area:

1. Scientists and engineers should seek input from the public at the earliest stages of technology development and should continue to seek consensus through a participatory process.
   – One attribute of an effective participatory process will be for experts to demonstrate to the public that the scientific community is taking the public's views into account.

2. When assessing the risks and benefits of new technologies, scientists and engineers should account for the non-technical and value-based concerns of the public in addition to technical concerns.
   – Scientists and engineers should perform a thorough and publicly accessible evaluation of non-technical concerns.
   – Scientists and engineers should clearly articulate the ethical values that will guide their work, build those values into all aspects of their work, and consequently build all relationships around those ethical principles and values.

3. The expert community should value and utilize data from social scientists in order to better understand public attitudes toward science and technology.
   – Science and engineering journals should include regular columns that present data from social science studies regarding public attitudes toward science and technology.
   – Professional scientific meetings should include discussions of current public attitudes toward new scientific discoveries and why those attitudes are vital to scientific research.

4. Scientists and engineers need to create more opportunities to establish the trust and confidence of the public.
   – Open forums, tours of facilities, and science cafés are existing ways the public can interact with the expert community; these options provide the expert community an opportunity to build the trust of the public.
   – Scientists and engineers should develop effective communication strategies based on authoritative information from independent scientists and government officials. This strategy can be used both when creating new regulatory guidelines and during times of crisis.

This study provided a unique opportunity for scientists and representatives of the public to examine the scientist-public relationship from a new viewpoint. Meeting participants found the "scientists' understanding of the public" perspective refreshing and intellectually challenging. They expressed an intent to carry forward these recommendations in their own work, and we hope they will do so.

The Academy gratefully acknowledges the workshop chairs: David Clark (MIT), David Altshuler (Broad Institute), Thomas Isaacs (Stanford University and Lawrence Livermore National Laboratory), and Robert Fri (Resources for the Future). We also appreciate the contributions of the workshop participants (see page 16). The Academy expresses its gratitude to the members of the advisory committee for the Academy's Initiative on Science, Engineering, and Technology, which had oversight of this project: Neal Lane (Rice University), Greg Papadopoulos (formerly of Sun Microsystems), Hunter Rawlings (Cornell University), and Charles Vest (National Academy of Engineering).

We are especially grateful to Chris Mooney for distilling our discussions and helping bring attention to scientists' understanding of the public.

Thank you also to Academy staff Dorit Zuk, John Randell, Elizabeth Huttner, Paul Karoff, Phyllis Bendell, Micah Buis, Erica Dorpalen, and Scott Wilder, who provided organization and assistance throughout all phases of this project and also helped produce this publication.

The Academy would like to thank Ralph Gomory for proposing this study, and Doron Weber and the Alfred P. Sloan Foundation for supporting this exploration of the complexities of the science-public dialogue.

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

Kimberly Durniak
Program Officer
American Academy of Arts and Sciences

Do Scientists Understand the Public?

Chris Mooney

In March 2010, some two hundred environmental and climate scientists convened at the Asilomar Conference Center in Pacific Grove, California, near Monterey. Their goal: to head off a mounting conflict between science and the public over the emerging topic of "geoengineering"—the intentional modification of the planet or its climate system to counteract the increasingly dire consequences of global warming.

Over the past several years, as the climate problem has steadily worsened, a growing number of researchers have become convinced that geoengineering options—whitening low-level sea clouds to reflect solar radiation back to space, for instance, or injecting sulfate particles into the stratosphere to achieve the same effect—should be studied and perhaps field-tested on a small scale. These scientists would have us move, cautiously and deliberately, into a world where geoengineering might be available as a last resort, a planetary insurance policy if the warming *really* gets out of control.

But not everyone trusts scientists to exercise wisdom and restraint if handed such powers. Resistance is growing among those who suspect that researchers suffer from a steep case of hubris and are itching to "play God" with the planet. In particular, a Canada-based civil society organization called the ETC Group mobilized a bevy of left-wing organizations to criticize the 2010 geoengineering gathering (an event intentionally meant to echo a famous 1975 Asilomar meeting in which biomedical scientists assembled to set guidelines for research on recombinant DNA). Their sign-on letter labeled the conference organizers "almost exclusively white male scientists from industrialized countries" and implied that financial interests might be pulling the event's strings. The ETC Group has previously charged that scientists are part of a "geoengineering lobby," working in step with those who would make big money from the deployment of planet-altering technologies.

Meanwhile, street protests have taken place outside scientific meetings where geoengineering is under discussion. The battle has begun between scientists and activists to win over the broader public—which, at least for the moment, appears almost entirely clueless. According to survey data gathered by Anthony Leiserowitz of the Yale Project on Climate Change, 74 percent of Americans have never heard of geoengineering. Another 26 percent say they have heard of it, but most appear to be misinformed, with some confusing it with geothermal energy. Less than 1 percent of Americans appear to know what "geoengineering" really means, or what the fight is truly about.

In sum, it's yet another brewing conflict between science and society—one that seems set to explode at an unspecified time in the future, at which point there will be little reason to expect the calm voice of scientific reason to prevail over alarmism, demagoguery, and simple fear.

Here we go again.

* * *

What should the scientific community do when conflicts erupt between scientists and members of the public, as is beginning to occur over geoengineering? A steady stream of rifts has arisen over the years, on topics ranging from climate change and evolution to vaccination and genetically modified foods. In the future, as scientific and technological advances have an increasingly profound influence on policy and society, that stream may become a torrent.

From a scientist's perspective, members of the public desperately need to understand the scientific basics of a given issue in order to make good decisions about it. When scientists find their expertise rejected—especially by activists who seem biased or ill-informed, and who may even have a penchant for street theater—it's a slap in the face, a mockery of their hard work and dispassionate methodology.

One response to such offenses is simply to dismiss the public, to paint average Americans as stupid, scientifically illiterate, or emotional. During the 1970s, Nobel laureate James Watson famously dubbed those hoping to constrain recombinant DNA research as "kooks," "incompetents," and "shits." Another more recent example of such lashing out was captured in the 2006 documentary *Flock of Dodos* by scientist-filmmaker Randy Olson. Olson gathered a group of scientists around a poker table to talk about the anti-evolutionist "intelligent design" movement and how to respond to it. One offered the following strategy for addressing the creationists: "I think people have to stand up and say, you know, you're an idiot."

Whether or not these scientists recognize it, they are working in what science and technology studies (STS) scholars have dubbed the "deficit model." They assume that if only their fellow Americans knew more about science and ceased to be in a state of knowledge *deficit*, a healthier relationship between science and the public would emerge.

Yet there is another possibility: perhaps scientists misunderstand the public and fail to connect in part because of their own quirks, assumptions, and patterns of behavior. Indeed, there is no guarantee that increasing scientific literacy among the public would change core responses on contested scientific issues, for those responses are rarely conditioned by purely scientific considerations. Scientists and non-scientists often have very different perceptions of risk, different ways of bestowing their trust, and different means of judging the credibility of information sources. Moreover, members of the public strain their responses to scientific controversies through their ethics or value systems, as well as through their political or ideological outlooks—which regularly trump calm, dispassionate scientific reasoning.

The powerful influence of politics and ideology is underscored by a rather shocking survey result: Republicans who are college graduates are considerably *less* likely to accept the scientific consensus on climate change than those who have received less education. These better-educated Republicans could hardly be said to suffer a knowledge deficit; a more apt explanation is that they are politically driven consumers of climate science information—and often quite voracious ones at that. They strain information through a powerful ideological sieve and end up loudly supporting a viewpoint that is incompatible with modern scientific understanding.

A more scientifically informed public, then, is not necessarily the same as a public that will side with scientists more frequently. Perhaps what is needed instead is a public that is more familiar, comfortable with, and trusting of scientists; that is more regularly engaged by the scientific community on potentially controversial subjects; and moreover, that is engaged *before* truly fraught conflicts are allowed to emerge.

Fortunately, in recent years the deficit model has begun to lose its grip. A smattering of recent books, with titles like *Don't Be Such a Scientist* and *Am I Making Myself Clear?* exhort researchers to better understand their nonscientific audiences and the often counterintuitive dynamics of communication. In an innovative twist, meanwhile, a much noted 2009 survey by the Pew Research Center for the People & the Press, undertaken in collaboration with the American Association for the Advancement of Science, inverted the traditional "scientific illiteracy" paradigm. The survey not only polled Americans about their views of science but also polled scientists about their views of Americans. Revealingly, it found that while Americans tend to have positive views of the scientific community, scientists tend to consider the public ignorant and the media irresponsible.

The resulting headline: "Public Praises Scientists; Scientists Fault Public, Media."

* * *

Possibly the most sweeping effort yet to challenge deficit thinking took shape as a series of four workshops organized over the past year-and-a-half by the American Academy of Arts and Sciences and funded by the Alfred P. Sloan Foundation. Entitled "Improving the Scientific Community's Understanding of Public Concerns about Science and Technology," the interdisciplinary sessions homed in on four areas where conflicts between scientists and the public have either already emerged or seem ready to sprout up: the disposal of nuclear waste, the future of the Internet, the dissemination of personal genetic information, and the adoption of new energy technologies intended to fix our climate crisis and wean us off our dependence on foreign oil.

Collectively, these four sessions sought to invert the common complaint that the public needs to understand more science; instead, they suggested, perhaps scientists need to understand more *public*. As Stanford University's

Thomas Isaacs, chair of the workshop on nuclear waste, put it: "In order to be successful, we have to do more than think we know it all, and our job is simply to tell people—and if they don't understand, then our job is to tell them a little bit louder. That tends not to work." Later in the same session, Eugene Rosa, a public opinion expert at Washington State University, criticized the "hypodermic needle" view of the scientist-public relationship, according to which scientific facts are to be "injected" into Americans almost as if they are in need of medicine—a cure that rarely, if ever, seems to take.

Rather than telling the public to take its scientific shots, the American Academy sessions suggested that if there is a divide between scientists and the public, perhaps *both sides* bear a responsibility for its existence and for bridging the gap. Indeed, scientists and technical experts may shoulder an even greater responsibility, considering their dramatic advantage in the knowledge arena and the funding resources at their disposal. Most important, no one benefits from the too-common practice of lobbing missiles across the "culture war" divide between scientists and various subsets of the American public. This strategy simply leads to damaged trust, a hardening of attitudes, and long smoldering conflicts—the unending battles over the teaching of evolution and the science of climate change being the primary cases in point.

A review of the four American Academy workshops, then, sets us on a path toward a better, less contentious, and more productive means of managing—and heading off—conflicts between scientists and various publics. However, the workshops also show that there is some distance to go before scientists are accustomed to seeing the world through the eyes of the many and diverse groups of citizens affected by their work.

* * *

One of the workshops treated a decades-old and much studied American scientific dispute, one in which a wealth of data and experience can be brought to bear in discussing the causes for rifts between experts and the public: the conflict over how and where to dispose of the nation's spent nuclear fuel and high-level radioactive waste.

Although it is difficult today to remember any other reality, Americans have not always been deeply divided over nuclear power. During the 1950s and 1960s, a nation buoyed by slogans like "Atoms for Peace" overwhelmingly supported its deployment. But in the wake of the Three Mile Island and Chernobyl accidents, and then the conflicts over arms control during the Reagan years, a nuclear divide emerged. For many members of the public, the problem of how and where to dispose of the nation's nuclear waste ranked among the most contentious aspects of the debate.

For an eloquent testimony to this fact, consider the long and dysfunctional history of attempts to establish a national nuclear waste repository at the remote Yucca Mountain site in Nevada. When a 1987 amendment to the 1982 Nuclear Waste Policy Act designated Yucca as the sole site to be studied for its

suitability as the nation's central waste repository (removing several other sites from contention), the basis for the choice included highly scientific and technical considerations about geology, hydrology, and tectonic activity, among many other factors. Nevertheless, the legislation was quickly dubbed the "Screw Nevada Bill" by locals, who saw a political ploy to dump on their state. Soon, Nevadans' sense of grievance found political champions like current Senate Majority Leader Harry Reid, who has fought for two decades in opposition to the Yucca plan.

Meanwhile, the U.S. government began to spend what would eventually total $9 billion on the research and infrastructure necessary to establish Yucca Mountain as a nuclear waste repository. Beginning in 1987, teams of government scientists set to work studying the Yucca site as the law required—and found themselves "pilloried on a regular basis" by anti-nuclear activists as well as by many Nevadans, according to Hank Jenkins-Smith, a political scientist at the University of Oklahoma who has studied the Yucca case. The Yucca process, he opines, "was optimized to create as much antagonism [as possible] between the way scientists understood the world and their view or their model of the public."

Nevertheless—and however unwelcome—the research progressed, so much so that the Yucca site has been dubbed "the most studied real estate on the planet." Yet in the last year, it has become apparent that political opposition (which includes dozens of lawsuits) is more than capable of trumping long-term government financial commitments. Although the Bush administration moved to open Yucca by about 2020, the Obama administration has reversed course. Yucca Mountain is "off the table," Energy Secretary Steven Chu remarked recently. In the meantime, the nation's nuclear waste remains in more than one hundred temporary storage facilities located across the country, some quite close to populous areas.

Yucca Mountain is just one example of a long-standing but problematic strategy of identifying nuclear waste disposal sites through an approach that has been called "decide, announce, defend." In the past, sites have been selected through bureaucratic and technocratic processes. Experts, working largely outside the public's ken, have been called on to determine whether they are safe and sustainable. Often these technical decisions are then sprung upon the public—which has resisted strongly.

And no wonder: the different sides approach the issue from different paradigms or worldviews. If scientists who specialize in nuclear issues often feel unfairly attacked by the public, the reality is that for many members of the public, scientific and technical justifications alone—however sound—do not suffice to quell their fears about nuclear waste disposal, its long-term safety, and its proximity to where they live. In other words, on a topic that stirs emotions as much as this one does, the science can very easily be good enough for the scientists but not good enough for everyone else.

The American Academy workshop on nuclear waste highlighted a striking example of this phenomenon. In 1991, the American Nuclear Energy Council launched a Nevada ad campaign that employed scientific spokespersons to convince the public that the Yucca repository itself, and the transport of waste to the site, would be safe. However, observed Eugene Rosa, the campaign backfired dramatically: just 15 percent of respondents in a follow-up survey said the ads made them feel more supportive of the repository. A whopping 32 percent of respondents were moved in the *opposite* direction, and roughly half did not change their opinions. Rather than softening resistance, the ad campaign hardened the views of those who already opposed the repository—precisely the opposite effect from what was intended.

Is there a better model for handling the fraught issue of nuclear waste disposal, and can it lead to a different result than the policy mess—and gigantic waste of time, effort, and taxpayer money—that is Yucca Mountain? Finding such an approach could be especially significant in light of the growing recognition that nuclear power, because it is carbon-free, is likely to serve as a core component of any future solution to our intertwined climate and energy problems. No matter how strongly desired, a "nuclear renaissance" will not be possible without a resolution to the problem of waste disposal.

A different approach to managing potential conflicts over nuclear waste has been attempted in Canada, under the auspices of the country's Nuclear Waste Management Organization (NWMO). Instead of "decide, announce, defend," the new approach is "engage, interact, cooperate." Founded in 2002, the NWMO undertook a sustained three-year program to engage the Canadian public on how to dispose of nuclear waste and to consider—sometimes over scientists' objections—the public's views on the ethics and societal implications of any waste disposal decision. The NWMO also explicitly promised that every community would retain veto power over the location of a waste site in its neighborhood or vicinity.

While the final decision on Canada's waste repository site has not yet been made, those involved in the NWMO process report that, thus far, even critics have remained engaged and supportive. Dialogue has not broken down; rather, it has been fostered and strengthened.

This kind of thinking is also becoming increasingly prominent in the U.S. context, where the Nuclear Regulatory Commission (NRC) has undertaken new measures to strengthen public support of its activities. According to Janet Kotra, head of the NRC's High-Level Waste Public Outreach Team, these steps include improving the ability of government scientists to engage with citizens in well-designed, effective public meetings. As Kotra put it at the American Academy meeting: "I will never forget a former colleague who said, 'You mean, I have to dumb down my presentation for Ma and Pa Kettle?' And of course, the answer to that is, yes, if you see it that way. But if you see it that way, I don't want you talking to them."

* * *

If scientists want to better connect with the public on its own terms, improved communication will be vital to their success. As Thomas Isaacs stated at the conclusion of the nuclear waste workshop, "I think we're talking the talk and we're starting, some at least, to walk the walk. But that's the challenge that remains."

To unseat the deficit model and get scientists and the public talking on equal terms, a variety of institutional barriers must be overcome. One problem is that the incentive system in science remains highly inimical to greater public engagement. Scientists who value or excel at public outreach often face the explicit or implicit scorn of their peers, for whom success in technical research is the epitome of scientific achievement and all else is secondary or even a waste of time. While attitudes may be slowly changing in the academy, most young scientists today are still largely trained in the mould of their professors —although, as we'll see, some are beginning to rebel.

Furthermore, science journalism—supposedly the means of bringing scientific information to the public so that scientists don't have to—is in steep decline, at least within traditional media institutions like newspapers and television news networks. This fact makes improving the communication and outreach abilities of scientists more crucial than ever: increasingly, there is no one else to do this work for them.

How exactly should scientists go about engaging different segments of the broad American public? The nuclear waste workshop participants noted two separate communication roles for scientists, both of which are vital (and both of which have been neglected in the past). One is slow, steady engagement with the public on issues of concern—being available, being open and ready to listen, and working to defuse conflicts before they begin. Another is crisis communication, so that if and when a major event occurs with the potential for a long-term or dramatic impact on public opinion (such as the Three Mile Island meltdown in the nuclear arena or, in the realm of climate change, the infamous "Climate Gate" scandal over scientists' stolen email messages), representatives of the world of science are able to respond quickly before irreversible damage is done.

The nuclear waste workshop drew heavily on the work of social scientists, public opinion researchers, and media specialists (including current and former journalists). If scientists wish to better prepare for potential conflicts with the public—and manage existing ones to achieve better outcomes—it will be essential to involve these "experts." True, they do not hail from the hard sciences. But they have much needed skills: the ability to determine where different subsets of the public stand on a particular issue based on survey data, for instance, and experience studying issue cycles and patterns of media coverage so as to determine where the tipping points may lie and which types of arguments, or frames, seem to be gaining or losing momentum as public debate progresses and evolves. For example, social scientist Matthew Nisbet of Amer-

ican University has demonstrated that with any nascent science-policy issue (geoengineering and nanotechnology are good examples), a series of latent meanings are already present in public discourse that could gradually harden into dominant views on the matter.

Understanding the terms of a science-policy debate before it goes fully public—and grasping how a particular interpretation of the issue could rise to the fore due to a confluence of media coverage and pivotal events—would better prepare scientists for managing the issue before it becomes widely contested. This point deserves close attention from scientists thinking about geoengineering, and should also guide our interpretation of two other American Academy workshops devoted to gaps between scientists (or technical experts) and the public. Both workshops focused on areas where scientists have already begun to anticipate future policy issues or conflicts, but where the public seems largely unaware or ill-attuned. One concerned the evolution of the Internet. The second covered the uses (and misuses) of personal genetic information in an age of "personalized medicine" and direct-to-consumer marketing of genetic tests for a variety of purposes, ranging from studying one's ancestry to uncovering potential health risks.

* * *

In the American Academy workshop "The Next Generation of the Internet," participants seemed less certain than the nuclear waste experts about how to approach the inversion at the heart of the undertaking: the idea that scientists (and, in the case of the Internet, technical experts) need to understand the public, and not just vice versa. Nevertheless, the vast gap between skilled Web technologists and average Internet users was immediately recognized. "Many Internet experts or computer scientists are not trained in human behavior," opined meeting chair David Clark, an Internet expert at MIT. "They understand the public interacts with the Internet differently, yet lack the training to effectively incorporate public behaviors into Internet design."

Experts and citizens also differ widely in their outlook on the Web's future. Experts tend to be much more concerned about issues of privacy and security than most members of the public, who seem to want the Internet simply to function as a reliable utility and don't appear to worry much about entering their personal credit card information or social security numbers on any number of websites. This lack of concern raises a potentially troubling question: how would a public that thinks of the Web largely as a utility—an appliance—react to a future in which governments impose identity requirements for Web use, essentially requiring every user to be identified by the equivalent of a driver's license? Perhaps they would not worry about such a development nearly as much as they should.

The overwhelming impression conveyed by the "Next Generation of the Internet" session was that many potential problems involving security, personal identity, and privacy could develop as the Internet evolves—problems that ex-

perts can begin to anticipate but that the average citizen scarcely considers or worries about. What kinds of public reactions might be expected if any of these issues were to explode and become a matter of mass media coverage or crisis? How might we prepare citizens for different eventualities of the Internet's future? That was a subject the session largely left unresolved.

Similar questions emerged from the American Academy workshop on the "Spread of Personal Genetic Information." As human genome sequencing becomes faster and cheaper due to inexorable technological advances, it is becoming possible to envision a *Gattaca*-like world in which knowledge of one's own genetic makeup is a given, not only to oneself but potentially to others as well. Indeed, in the past half-decade genetic testing companies like 23andMe and DecodeMe have begun marketing their wares directly to consumers, but many experts wonder how valuable the information provided can be without the help of a skilled interpreter or genetic counselor. Still, some citizens will undoubtedly seize upon the results and may use them to shape their health choices.

As we move into this new world, scientists caution that there is a "mythos of the gene" that has led much of the public to think of individual tracts of DNA as directly linked to particular traits or disease susceptibilities. "There is very good historical evidence from about 100 years ago to today that the public has a very powerful notion of the influence of genes and attributes to it much more power really than the scientific community does," noted Philip Reilly, Chief Medical Officer of Genetix Pharmaceuticals in Cambridge, Massachusetts.

While observable traits certainly run in families—as do diseases—in many cases their emergence, expression, and characteristics are conditioned by hundreds, sometimes more than a thousand, separate genes, as well as by interactions with the environment and random events in human development. The increasing speed and declining cost of gene sequencing provide some access to this complexity, but the information revealed may not be particularly profound: it is not as if any single gene "causes" anything in the vast majority of cases. Yet members of the public may latch on to newly revealed genetic information anyway and scurry with their 23andMe reports straight to their doctors, who may not know how to handle or advise about the results.

Many other potential problems could arise in a world of cheaper, easier, and largely unregulated access to personal genetic information. Will there be discrimination based upon one's genes? Will there be more terminations of pregnancies based on five-week fetal genome sequencing and the alleged "flaws" it reveals? Will law enforcement agencies have universal DNA databases for all citizens? Will particular genetically based diseases become linked to particular races—echoing eugenics, Tuskegee, and other nightmares of the earlier days of genetics and biomedical science? Certainly, one of the most important recognitions about the "public" that came out of the workshop is the fact that particular segments, such as the African American community, have very good, historically grounded reasons to be suspicious of medical research and advances, particularly with regard to genetics.

In general, however, the personal genetics session featured a fair amount of "hand waving" about what the public does and does not believe about genetics. "A number of us have said, 'The public believes this, the public believes that,'" objected Harvard psychologist Steven Pinker at one point. "But what is our evidence for what the public believes? In my experience many scientists have a condescending attitude towards what the public believes." While the assembled scientists and experts could envision many potential flashpoints in the future of personalized genetics, they were less able to describe with any certainty how the public would respond to such controversies or scenarios—much less how scientists might *prepare* the public for these situations.

To be fair, the genetics workshop participants knew well what they didn't know. As Duke University's Huntington Willard put it, "There's a thousand publics out there that one could address, any of whom has to be understood by the scientists in order to know how to deal with them, how to work with them, engage them, try to benefit them and be benefited by them." It sounds, in short, like a research agenda.

* * *

From this survey of three out of the four American Academy workshops on scientists' understanding of the public, general patterns begin to emerge. On issues where a long-standing conflict exists between scientists and the public—such as nuclear waste disposal—social scientists have also been long engaged and have conducted considerable research on the conflicts and corresponding public views. What's more, scientists are probably more likely to be conversant with this social science research, and can perhaps glean from it a better path forward.

But decades into such debates, the political and societal rift already exists. The crisis-communication opportunities have probably been missed or squandered, and much analysis is retrospective and "woulda, coulda, shoulda" in nature. Battle lines have hardened (as in the Yucca Mountain case), and it may be far too late to "fix" the situation.

On issues that are new and emergent, by contrast—the future of the Internet, the spread of personal genetic information, geoengineering—there is comparatively less solid research available to help scientists glean what the public "thinks" and how it is likely to respond to future controversies. The experts are able to glimpse, or at least imagine, what some of these controversies might look like. But they are unaccustomed to mapping them onto existing public opinion configurations or understandings and, in many cases, are not particularly comfortable with doing so. Moreover, the requisite data and social science analyses may not exist in the first place.

The obvious suggestion, then, is that scientists and social scientists should team up *earlier* in the issue cycle and figure out—together—how to envision different scenarios in which a nascent field of science may impact or alarm society. They should do so based on a well-researched and *scientific* sense of

where the public stands and where it is likely to move when prompted by events. Such an anticipatory approach would not only better serve the public, it would have the added benefit of enabling the scientific community to prepare for any crises or conflicts that may occur.

In other words, a forward-looking collaboration is needed between research scientists, social scientists, public engagement experts, and trained and skilled communicators. The latter may or may not be scientists, but they should be ready to move, on a moment's notice, to address controversies and concerns. Meanwhile, in the absence of any pressing conflagration, public engagement initiatives could help sculpt a citizenry that will be less likely to distrust the scientific community, or reject its expertise, and more willing to understand the scientific perspective (so long as scientists approach the public openly and take citizens on their own terms).

In the competitive world of academia, how would such a forward-looking research-and-response infrastructure be established? How would it move gingerly across policy areas and disciplinary divides? As it happens, precisely such an initiative already exists—for one scientific issue, anyway. That issue is nanotechnology. The National Nanotechnology Initiative (NNI) is an interagency research effort that was launched in 2000 and organized and given greater prominence by the U.S. Nanotechnology Research and Development Act of 2003. This law requires federally funded research on the societal impacts of nanotechnology, thereby codifying an impulse already strongly present at the NNI's creation: that it should foster interdisciplinary research and sustained efforts in public engagement.

Why was the central U.S. initiative to fund nanotech research—an innovative technology that we hope will generate economic growth and new industries, if not a "new industrial revolution"—so sensitive to societal impacts? Nanotechnology had been viewed for some time as a potential subject for future controversy; many feared it would be the next "GMO" issue. With the release of Michael Crichton's 2002 novel *Prey*, in which nanobots wreak havoc, and Sun Microsystems cofounder Bill Joy's 2000 warning in *Wired* magazine about a world of "gray goo" that could result from nanotech run amok, the groundwork seemed well prepared for such an outcome.

Therefore, the NNI has focused heavily on engaging social science researchers to undertake the anticipatory work that will allow us to imagine how a future full of nanotech innovations may evolve and to envision the public's place in that future. As David Guston, the head of the NSF-funded Center for Nanotechnology in Society at Arizona State University, explains, "We structure dialogues between scientists, engineers, social scientists, stakeholders, and users around a variety of different socio-technical trajectories in a given technological space." Indeed, the 2003 Nanotechnology Research and Development Act is, according to Guston, the first piece of U.S. legislation that instructs researchers to conduct social science alongside pure science and engineering work and to involve the public and determine what its values are

in connection with nanotechnology. The model provides much to build on, and could easily be applied to, say, synthetic biology research and (perhaps especially) geoengineering research.

But the NNI is not the only positive sign on this front. There is also a demographic and educational phenomenon occurring right now at universities across the country that could be turned to the advantage of those who wish to bring scientific research, and scientists, into better contact with society.

Surveys of young university scientists show that many would like to do something *other* than follow in the research footsteps of their mentors—especially at a time of fierce competition for a relatively small number of traditional academic jobs. In a recent survey of one thousand graduate-level science students at a top research institution (the University of California, San Francisco), less than half designated academic research as their top career choice. Instead, these young scientists are often interested in public engagement and communication, but face limited career opportunities to pursue these goals.

In other words, if there is a crying need to forge better connections between scientists and the public, there is also an army of talent within universities looking for such outreach work. That base is young, optimistic, and stands ready to be mobilized.

* * *

The final American Academy workshop, which delved into issues surrounding climate and energy, neatly blended many of the characteristics of the workshops discussed above. On the one hand, it addressed a much studied and long-standing science-society problem, one where it is far too late to stave off massive, entrenched conflict: global warming. Anthony Leiserowitz of Yale University, a leading expert on climate change and public opinion, made this point crystal clear in his presentation. Leiserowitz has classified Americans into six now-famous groups based on reactions to the issue; as of January 2010, his results were as follows: "alarmed" (10 percent), "concerned" (29 percent), "cautious" (27 percent), "disengaged" (6 percent), "doubtful" (13 percent), and "dismissive" (16 percent). (Disturbingly, the last group has grown dramatically from just 7 percent in 2008, as climate-science denial has experienced a strong resurgence.)

As Leiserowitz's results suggest, we understand the public very well on climate change. We know Americans are thoroughly polarized and view the issue through partisan lenses—which explains why better informed and educated Republicans are more likely to reject modern climate science, whereas better informed and educated Democrats respond in precisely the opposite fashion.

At the same time, the session also showed that despite the seemingly irreversible political polarization of the public around climate change, there is much greater potential to achieve solutions if the issue is reframed around new energy innovations. Americans are broadly in favor of advancing energy technologies,

regardless of their political affiliation. (This finding neatly explains the recent trend in leaving the word "climate" out of the title of various pieces of energy legislation in the U.S. Congress.)

If we are going to throw our weight behind a variety of energy innovations, from wind farms and solar installations to smart meters and electric cars, now is the time for scientists and social scientists to work together to anticipate the kinds of public resistance that may emerge to aspects of the new energy future. The American Academy session did just that. To give but one example, the session featured a revealing presentation, by Roopali Phadke of Macalester College, about the growing anti-wind energy movement, which is motivated by a set of aesthetic concerns about the marring of landscapes that scientists and the wind industry have often treated lightly or callously. Phadke suggested that the American anti-wind movement is "growing at a rapid pace" and is mobilizing around a common platform of concerns. Statements by opposition leaders also suggest that future campaigns are less likely to take the form of polite protests and may consist of more "direct actions" against wind farms. (Incidentally, controversies over wind power installations recall a lesson from the nuclear waste saga: don't spring a wind farm on a community unawares.)

Happily, social science research is already in progress on how members of the public are responding, or are likely to respond, to new energy innovations —for while Americans express strong support for these innovations, all humans also have a tendency to resist change when it is thrust upon them quickly, as some of these technologies may be.

Moreover, whether old or new, energy systems require large facilities, which have to be put somewhere. Thus, while the public may support less carbon-intensive fuels in theory, there may also be great resistance to attempts to obtain large volumes of natural gas from newly reachable shale resources, often located in parts of the country (Michigan, the eastern United States) that are not accustomed to major extraction endeavors. Similarly, capturing carbon dioxide and removing it from the atmosphere sounds wonderful in theory—but then it has to be stored, likely underground and perhaps in close proximity to a community that feels uncomfortable with the idea.

Ensuring a new energy future does not merely require an understanding of the potential for resistance to new sources of power, or new technologies for environmental cleanup. We must also understand how members of the public make energy decisions on an individual and household level, where dramatic efficiency gains (and emissions reductions) are possible. If there was one extremely heartening theme from the American Academy meeting it was that this, too, appears to be a major growth area for research. As Jan Beyea, an independent scientist, put it after a presentation on public adoption of smart meters, smart appliances, and new auto technologies: "Almost every study I cite is 2009. This area has exploded. . . . This is the time to be in it, and I hope we can head off some of the problems ahead of time."

* * *

Overall, the four American Academy sessions represent a critical step in forging a more fruitful relationship between scientists and the public. They demonstrated how little scientists often know or understand about non-scientific audiences and technology users—and yet, at the same time, also highlighted the fact that there is reliable data on the public to be obtained, a sound methodology for doing so, and many opportunities for research collaborations awaiting those who wish to undertake such projects.

As this knowledge takes hold, the hope is that it will produce more than just interdisciplinary research. What is ultimately needed is a systematic and forward-looking way of gathering diverse thinkers—from the hard sciences, the social sciences, and among communication specialists—who can peer ahead at scientific issues, identify impending controversies, and determine methods for staving off conflict. Needless to say, these researchers will also necessarily have studied, in great detail, what can be learned from past mistakes on issues such as nuclear waste disposal or climate change.

In sum, scientists and their institutions must set up an integrated system of research *and action* that will anticipate future problems and determine how to handle them. If the goal is to preserve public trust or to head off conflicts before they become so fraught that there is no chance to defuse them, then reactive measures will not suffice.

Fortunately, there are *scientific* means available for studying the public and how it responds to scientific controversies—which can only mean that in the long term, scientists will surely come to embrace them.

About the Author

Chris Mooney is a science and political journalist and a contributing editor to *Science Progress*. He is author of *The Republican War on Science* (2005), *Storm World: Hurricanes, Politics, and the Battle Over Global Warming* (2007), and *Unscientific America: How Scientific Illiteracy Threatens Our Future* (with Sheril Kirshenbaum, 2009). Mooney and Kirshenbaum are also coauthors of The Intersection, a blog for Discover blogs. Mooney's essays have been nominated for a National Magazine Award and featured in *Best American Science and Nature Writing 2006*. He has been a visiting associate in the Center for Collaborative History at Princeton University and a Knight Science Journalism Fellow at MIT (2009–2010). For Summer 2010, he is a Templeton-Cambridge Fellow in Science and Religion.

Workshop Participants

The Next Generation of the Internet, November 13–14, 2008

David Clark (Chair)
Massachusetts Institute of Technology

Elise Ackerman
Journalist

Susan Athey
Harvard University

Marjory Blumenthal
Georgetown University

Scott Bradner
Harvard University

Daniel Geer
Geer Risk Services

John B. Horrigan
Federal Communications Commission

Paul Resnick
University of Michigan

Public Perceptions of Nuclear Waste Repositories, April 29–30, 2009

Thomas Isaacs (Chair)
Stanford University and Lawrence Livermore National Laboratory

Kennette Benedict
Bulletin of the Atomic Scientists

Wesley Cragg
York University

Cornelia Dean
The New York Times

Elizabeth Dowdeswell
University of Toronto

Ted Greenwood
Alfred P. Sloan Foundation

Hank C. Jenkins-Smith
University of Oklahoma

Carl Kaysen †
Massachusetts Institute of Technology

Carol Kessler
Pacific Northwest National Laboratory

Janet Kotra
Nuclear Regulatory Commission

Thomas Leschine
University of Washington

Charles McCombie
Arius Association

Steven Miller
Harvard University

Ivan Oelrich
Federation of American Scientists

Eugene A. Rosa
Washington State University

Robert Rosner
University of Chicago

Eugene Skolnikoff
Massachusetts Institute of Technology

† Deceased

The Spread of Personal Genetic Information, May 19–20, 2009

David Altshuler (Chair)
Broad Institute of MIT and Harvard; Harvard Medical School; Massachusetts General Hospital

Emilio Bizzi
Massachusetts Institute of Technology

Vence Bonham
National Human Genome Research Institute

Lisa Sowle Cahill
Boston College

Amelia Chappelle
Genetic Alliance

Gideon Gil
The Boston Globe

Hank Greely
Stanford Law School

Steven Pinker
Harvard University

David Reich
Harvard Medical School; Broad Institute of MIT and Harvard

Philip Reilly
Third Rock Ventures

James Schwartz
Independent Scholar and Writer

Fintan Steele
Broad Institute of MIT and Harvard

Jennifer Weisman
U.S. Department of Health and Human Services

Huntington Willard
Duke Institute for Genome Sciences and Policy

The Risks and Benefits of Emerging Energy Technologies, December 8–9, 2009

Robert Fri (Chair)
Resources for the Future

Stephen Ansolabehere
Massachusetts Institute of Technology

Jan Beyea
Consulting in the Public Interest

Peter Blair
National Academy of Sciences

Ana Unruh Cohen
House Select Committee on Energy Independence and Global Warming

Thomas Dietz
Michigan State University

Steven Hamburg
Environmental Defense Fund

Martha A. Krebs
California Energy Commission

Anthony Leiserowitz
Yale University

Nathan S. Lewis
California Institute of Technology

Michael McElroy
Harvard University

Ernest J. Moniz
Massachusetts Institute of Technology

Roopali Phadke
Macalester College

John Rogers
Union of Concerned Scientists

David Tilman
University of Minnesota

Michael Vandenbergh
Vanderbilt Law School

American Academy of Arts & Sciences

The Academy was founded during the American Revolution by John Adams, James Bowdoin, John Hancock, and other leaders who contributed prominently to the establishment of the new nation, its government, and its Constitution. Its purpose was to provide a forum for a select group of scholars, members of the learned professions, and government and business leaders to work together on behalf of the democratic interests of the republic. In the words of the Academy's Charter, enacted in 1780, the "end and design of the institution is . . . to cultivate every art and science which may tend to advance the interest, honour, dignity, and happiness of a free, independent, and virtuous people." Today the Academy is both an honorary learned society and an independent policy research center that conducts multidisciplinary studies of complex and emerging problems. Current Academy research focuses on science and global security; social policy; the humanities and culture; and education. The Academy supports early-career scholars through its Visiting Scholars Program and Hellman Fellowships in Science and Technology Policy, providing year-long residencies at its Cambridge, Massachusetts, headquarters. The Academy's work is advanced by its 4,600 elected members, who are leaders in the academic disciplines, the arts, business, and public affairs from around the world.