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SPECIAL INVITED PAPER—YEAR OF SCIENCE

What's next for science communication? Promising directions and lingering distractions[1]

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In this essay, we review research from the social sciences on how the public makes sense of and participates in societal decisions about science and technology. We specifically highlight the role of the media and public communication in this process, challenging the still dominant assumption that science literacy is both the problem and the solution to societal conflicts. After reviewing the cases of evolution, climate change, food biotechnology, and nanotechnology, we offer a set of detailed recommendations for improved public engagement efforts on the part of scientists and their organizations. We emphasize the need for science communication initiatives that are guided by careful formative research; that span a diversity of media platforms and audiences; and that facilitate conversations with the public that recognize, respect, and incorporate differences in knowledge, values, perspectives, and goals.

Key words: informal learning; popular science; public engagement; science and society; science communication; science literacy; science policy.

Over the past few years, there have been signs of a gradual shift in how the scientific community in the United States views public engagement. One can detect a growing recognition that effective communication requires initiatives that sponsor dialogue, trust, relationships, and public participation across a diversity of social settings and media platforms. Yet despite notable new directions, many communication efforts continue to be based on ad-hoc, intuition-driven approaches, paying little attention to several decades of interdisciplinary research on what makes for effective public engagement. Many of these initiatives start with the false premise that deficits in public knowledge are the central culprit driving societal conflict over science, when in fact, science literacy has only a limited role in shaping public perceptions and decisions.

In this article, we describe what we know from social science research on how members of the public from diverse backgrounds are likely to use information and reach decisions about science. We then offer recommendations on how this research should inform effective public engagement and communication. To clearly demonstrate these principles, we highlight notable successes and mistakes specific to the cases of climate change, evolution, plant biotechnology, and nanotechnology. Across each of our recommendations, we emphasize the following basic premise: any science communication efforts need to be based on a systematic empirical understanding of an intended audience's existing values, knowledge, and attitudes, their interpersonal and social contexts, and their preferred media sources and communication channels.

Several recent edited books offer excellent introductions to elements of the research that we review (Bucchi and Trench, 2008; Cheng et al., 2008). These volumes along with the journals *Science Communication* and *Public Understanding of Science* are evidence of the growing international network of scholars and practitioners who are focused on science communication research and related applications (See also the International Network on the Public Communication of Science and Technology at http://pcst-10.org/). In this essay, we build on the work of others while also drawing heavily upon research that we have published over the past decade. In addition, we incorporate insights and lessons from our efforts at translating and applying the implications of this research.

We specifically elaborate on arguments that we first introduced in articles published in *Science* (Nisbet and Mooney, 2007) and *The Scientist* (Nisbet and Scheufele, 2007). These articles challenged prevailing assumptions within the scientific community about public communication and engagement, leading to widespread attention and debate (see Holland et al., 2007). Over the past two years, we have also given more than four dozen presentations in the United States, Canada, and Europe, discussing ideas and proposals with several thousand scientists, educators, policymakers, and journalists. We have additionally worked with several leading science organizations to incorporate research-based principles into their science communication initiatives. These experiences have fueled additional insights and recommendations that we detail in this essay.

Myths about public communication—Historically, a prevailing assumption has been that ignorance is at the root of social conflict over science. As a solution, after formal education ends, science media should be used to educate the public about the technical details of the matter in dispute. Once citizens are brought up to speed on the science, they will be more likely to judge scientific issues as scientists do and controversy will go away. In this decades-old "deficit" model, communication is defined as a process of transmission. The facts are assumed to

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speak for themselves and to be interpreted by all citizens in similar ways. If the public does not accept or recognize these facts, then the failure in transmission is blamed on journalists, "irrational" public beliefs, or both (Bauer, 2008; Bauer et al., 2007; Nisbet and Goidel, 2007; Scheufele, 2007).

The heavily referenced symbols in this traditional paradigm are popular science outlets such as *Scientific American* or the Public Broadcasting System (PBS) program *NOVA* along with famous popularizers such as Richard Feynman and Carl Sagan. Often when the relationship between science and society breaks down, science illiteracy is typically blamed, the absence of quality science coverage is bemoaned, and there is a call put out for "more Carl Sagans."

Deficit model thinking also includes a fall from grace narrative, with various mythmakers hyperbolizing that in contrast to today's culture of "anti-science," there was a point in the past when the public understood—and as a direct consequence—deeply respected science. In the United States, this so-called golden era is often described as the dozen or so years of the "Space Race," the period that stretched from the 1957 Russian launch of the Sputnik satellite to the U. S. lunar landing in 1969.

As we explain in this essay, continued adherence to the deficit model only likely fans the flames of science conflicts. Condescending claims of "public ignorance" too often serve to further alienate key audiences, especially in the case of evolutionary science, when these charges are mixed with atheist critiques of religion (Nisbet, 2009b). Myths such as Sputnik oversimplify the past, making it easier to falsely define contemporary debates in terms of "anti-science," "illiteracy" or "denial" (Goldston, 2008). Moreover, by emphasizing what is wrong with the public—or by pinning their hopes on a major focusing event such as Sputnik—many scientists ignore the possibility that their communication efforts might be part of the problem (Irwin and Wynne, 1996).

Perhaps worse, the assumptions of the deficit model cut against the conclusions of several decades of research in the area. For example, a recent meta-analysis shows that science literacy only accounts for a small fraction of the variance in how lay publics form opinions about controversial areas of science (Allum et al., 2008). Far stronger influences on opinion derive from value dispositions such as ideology, partisanship, and religious identity (Nisbet, 2005; Nisbet and Goidel, 2007; Ho et al., 2008; Scheufele et al., 2009). In addition, no matter how accurately communicated and understood the science, policy decisions cannot be separated from values, political context, and necessary trade-offs between costs, benefits, and risks (Jasanoff, 2005; Pielke, 2007; Guston et al., 2009).

Given these realities, to focus on science literacy as both the cause and the solution to failures in public communication remains a major distraction for science organizations. If scientists had a better understanding of the complex factors that shape public preferences and policy decisions, they would be less likely to define every debate in terms of "crisis" or "politicization," interpretations that often only further fuel polarization, alienation, and/or political gridlock (Goldston, 2008; Nisbet, 2009a). Moreover, arguing that a policy debate is simply a matter of "sound science" reduces scientific knowledge to just another resource that interest groups can draw upon in political battles, threatening the perceived integrity of science. As we will discuss relative to climate change, under these conditions, an inevitable part of the framing of an issue will involve a contest over uncertainty, with each side potentially hyping or distorting the objective state of expert agreement. Each time an exaggerated scientific claim is proven false or inaccurate; it risks further alienating those already distrustful of the science and scientists (See Pielke, 2007 for more on this perceptual trap).

Finally, there is little reason to expect that traditional popular science approaches if applied to informing a *wider public* about science will ever be effective. These initiatives instead tend to reach a small audience of already informed science enthusiasts. The reason is that individuals are naturally "cognitive misers." Science communication efforts grapple with a wider public that is for the most part unable or uninterested in developing an in-depth understanding of scientific breakthroughs, and instead rely on cognitive shortcuts and heuristic decision making to help them reach opinions about policy-related matters (Popkin, 1991; Scheufele, 2006). The nature of the media system further exacerbates this human tendency. The increase in content choices available to a general audience, paired with decreasing public affairs news consumption across all age cohorts, makes widespread messaging difficult. Second, even leading national media outlets are investing less and less money in staffing their newsrooms with science writers, meaning less coverage devoted to important scientific topics. At the local level, the historic distress to the news industry has meant that major cities and regions of the country no longer have a reliable source of news about science and the environment that is tailored to the specific needs of their communities (Brumfiel, 2009).

Never well understood, but always deeply respected—There is perhaps no better example of the persistence of the deficit model than the widespread belief that the period between the launch of Sputnik in 1957 and the U. S. moon landing in 1969 was a golden age of science literacy, with an informed public pushing for large-scale government investment in science.

In contrast to this often repeated myth, public opinion surveys taken just after Sputnik indicate a public barely familiar with the most basic science concepts. In one measure, just 12% of the public understood the scientific method. On basic questions tapping knowledge of polio, fluoridation, radioactivity, and space satellites, only 1 in 6 could answer all four questions correctly (Withey, 1959). In other survey results, only 38% knew that the Moon was smaller than the Earth, and only 4% could correctly indicate the distance in miles between the Moon and the Earth (Michael, 1960). Apart from knowledge, attention to science news occurred predominantly among the 10% of American adults who held a four-year college degree (Swinehart and McLeod, 1960.)

Just after the launch of Sputnik, many Americans reported paying closer attention to the desegregation conflict in Arkansas and to the World Series than to the satellite launch and the call to arms for a Space Race (Michael, 1960). A majority of the public, in fact, did not view Sputnik as a scientific event, but rather as fitting with a larger frame of reference relative to the Cold War, describing the launch in terms of national security, international competitiveness, and falling behind the Soviet Union (Michael, 1960; Swinehart and McLeod, 1960)

By deficit model standards, these survey results reveal that the mythologized Sputnik-era America was in reality a scientifically illiterate America. The paradox then is that despite low levels of science literacy, the post-Sputnik public held science in almost universally high regard. For example, roughly 90% agreed that science was making life healthier, easier, and more comfortable, and an equal number agreed that science was contributing to societal progress (Withey, 1959). The reason for this divergence between knowledge and admiration is that science literacy, as we have reviewed, has very little to do with public perceptions. Instead, driving public opinion during the Space Race and Cold War were strong frames of social progress and international competitiveness, historically consistent messages about science that we will return to later.

Today, despite a doubling in the proportion of Americans with a college education and more science-related information available by way of the Web than at any time in media history, scores on survey questions measuring factual science knowledge have remained relatively stable for more than a decade, with Americans averaging six correct answers out of 12 true or false quiz-like items (National Science Board, 2008). Yet even with these relatively low levels of knowledge, the best available survey data suggest that science commands as much respect as it did during the decade of the Space Race.

In 2004, the National Science Foundation (NSF) brought together a team of social scientists to re-examine the organization's biannual surveys on public attitudes about science and technology. (The first author of this article served as a member of the committee advising on the project.) The NSF asked the team to redesign the survey to include a new emphasis on what the NSF termed the "cultural authority of science," particularly how the public views the role of scientific expertise in policymaking and societal decisions. The commissioned survey findings, gathered in 2006, argue against the claims of the deficit model that scientific illiteracy threatens the cultural status of science. Consider that more than 85% agree that "even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the federal government." On the specific issues of climate change, stem cell research, and food biotechnology, Americans believe scientists hold greater expertise, are less self interested, and should have greater say in decisions than industry leaders, elected officials, and/or religious leaders. Moreover, during the past 20 years, as public trust in Congress, the presidency, industry, religious institutions, and the media have plummeted; public faith in science has remained virtually unchanged. In fact, among American institutions, only the military enjoys more trust (National Science Board, 2008).

The NSF findings that show an almost unrivaled level of public trust, respect, and admiration for science and scientists are also reflected in a 2009 survey by the Pew Research Center for People & the Press. According to this survey, 84% of Americans agree that science is having a mostly positive effect on society with this strong agreement relatively consistent across every major demographic, political, and religious segment, including 74% of respondents who scored in the lower third on quiz-like questions measuring science knowledge. When asked to evaluate various professions, roughly 70% of Americans answer that scientists "contribute a lot" to society compared to 38% for journalists, 23% for lawyers, 40% for clergy, and 21% for business executives. Only members of the military (84%) and teachers (77%) rate higher in public admiration and esteem. Finally, more Americans rate advances related to science, medicine, and technology (27%) as the country's greatest achievement over the past 50 years than any other topic, including advances related to civic and equal rights (17%) and advances specific to war and peace (7%) (Pew Research Center for the People & the Press, 2009a).

As we will discuss in subsequent sections, a "miserly" public relies heavily on their trust in science and scientists as a dominant heuristic in reaching judgments about policy matters. Only on a few issues, where societal leaders effectively redefine an area of science as in conflict with something else the public deeply cares about, do perceptual gaps based on values and identity appear among the general public (Brossard and Nisbet, 2007; Ho et al., 2008). Yet even under these conditions, as is the case with climate change, scientists still appear to hold the upper hand in terms of trust (Scheufele et al., 2007). The implication is that relative to authority, deference, and respect, scientists have earned a rich bounty of perceptual capital. When controversies occur, the challenge is to understand how to use this capital to sponsor dialogue, invite differing perspectives, facilitate public participation, reach consensus when appropriate, learn from disagreement, and avoid common communication mistakes that undermine these goals.

From transmission to dialogue—Before moving to the influence of the media and strategic messaging in public engagement initiatives, it is first important to review the earliest challenges to the deficit model; challenges that sparked the use of deliberative forums and dialogue as a major new public communication tool.

Serious critiques of the deficit model first gained prominence in the early 1990s as sociologists used ethnographic approaches to study how particular social groups made sense of scientific expertise and authority. One study in particular helped set the wheels in motion for new thinking about the public uptake of scientific advice. Following the 1987 Chernobyl nuclear disaster, sociologist Bryan Wynne (1992) examined closely why English sheep farmers contested government scientist warnings about local soil and livestock contamination from Chernobyl's continent-wide fallout. Instead of narrowly blaming the conflict on the alleged ignorance of the sheep farmers, Wynne proposed that their skepticism of scientific advice was strongly filtered by feelings of distrust and alienation, feelings that were forged by local history, communication mistakes by scientists, and among farmers, a perceived threat to their way of life.

Based on his research, Wynne proposed a set of common mental rules that lay publics are likely to use in evaluating scientific advice and expertise. Later with several colleagues, Wynne further developed this framework in studies of the controversy over genetically modified crops (Marris, 2001; Marris et al., 2001). These common-sense heuristics fit closely with the conclusions from quantitative public opinion research reviewed earlier. Specifically, lay publics are likely to apply the following criteria in reaching judgments:

- Does scientific knowledge work? Do public predictions by scientists fail or prove to be true?
- Do scientists pay attention to other available knowledge when making claims? For example, in the Chernobyl case, scientists did not consult with farmers on how to best monitor grazing habits and take samples from the sheep, leading farmers to directly witness the messiness of scientists' sampling methods.
- Are scientists open to criticism? Are they willing to admit errors and oversights?
- What are the social and institutional affiliations of scientists? In other words, do they have a historical track record of trustworthiness? Similarly, do they have perceived conflicts of interest relative to their associations with industry, government, universities, or advocacy groups?
- What other issues overlap or connect to a publics' immediate perception of the scientific issue? In the Chernobyl case, a local nuclear reactor fire in 1957 preshaped suspicions of government advice and warnings. In the later case of genetically modified food, both Chernobyl and mad cow disease served as

recent events that undermined public trust in government claims about risk.

- Specific to risks, have potential long-term and irreversible consequences of science been seriously evaluated and by whom? And do regulatory authorities have sufficient powers to effectively regulate organizations and companies who wish to develop the science? Who will be held responsible in cases of unforeseen harm?

In 2000, drawing upon this emerging body of work, a UK House of Lords report urged science institutions to move beyond just a one-way transmission model of science communication toward a new focus on deliberative contexts where a variety of stakeholders could participate in a dialogue and exchange of views about science policy. Over the past decade, in the UK, Europe, and Canada there has been a wave of consensus conferences, deliberative forums, and town meetings on a number of issues. In these initiatives, recruited lay participants receive background materials in advance, provide input on the types of questions they would like addressed at the meeting, and then provide direct input on recommendations about what should be done in terms of policy. Each initiative, however, varies by how participants are asked for feedback, how much their feedback matters, and exactly when in the development of a scientific debate consultation occurs (Einsiedel, 2008).

Through these initiatives, studies find that participants not only learn directly about the technical aspects of the science involved, but perhaps more importantly, they also learn about the social, ethical, and economic implications of the scientific topic. Participants also feel more confident and efficacious about their ability to participate in science decisions, perceive relevant institutions as more responsive to their concerns, and say that they are motivated to become active on the issue if provided a future opportunity to do so (Besley et al., 2008; Powell and Kleinman, 2008). Many of these factors, of course, may be the *cause* rather than the outcome of people's participation in public forums (McLeod et al., 1999). Nonetheless, deliberative forums, if carefully organized, can shape perceptions of scientists as open to feedback and respectful of public concerns, perceptions that predict eventual acceptance and satisfaction with a policy outcome, even if the decision is contrary to an individual's original preference (Besley and McComas, 2005; Borchelt and Hudson, 2008).

These public consultation initiatives can also be conceived of as governing mechanisms that "democratize" science. Importantly, Wynne (2006) and others argue that public consultation should not occur only at the late stage when a product such as genetically modified food or nanotechnology has been introduced into the market. Instead, engagement needs to move "upstream" to when science or technology is in its formative stage, so that a diversity of stakeholders and concerned citizens can have a more meaningful say in matters of ownership, regulation, uses, applications, benefits, and risks. If the public is not allowed early and meaningful participation in decision-making, critics argue that these engagement exercises become just another form of deficit-model public relations and outreach (Wynne, 2006; Borchelt, 2008).

Similarly, Irwin (2008) concludes that not only should public engagement occur early and impact decisions, but that these initiatives should focus beyond just building consensus around an existing set of policy options. Instead, these forums should be mechanisms for expressing, identifying, and rethinking modes of governance. In this case, respectful disagreement can serve as a resource for identifying these alternatives. On nanotechnology, for example, Irwin suggests that public consultation processes in Europe are elevating the possibility of local autonomy on how nanotechnology is regulated, shifting debate away from traditional national, European, or global regimes for regulation.

Framing and public engagement—An unfortunate limitation to public dialogue initiatives is their small scale and scope. Unless intensive resources are spent on recruiting a diverse set of participants, the most likely individuals to turn out are those already opinion intense, well informed, and emotionally committed to an issue (Merkle, 1996; Goidel and Nisbet, 2006). Certainly, if a goal of public engagement is to promote mutual understanding between scientists, policymakers, and the public, then consulting with those members of the public who are the most directly affected, attentive, and active should be a priority (Wynne, 2006). Yet, in combination with these public consultation efforts, scientists and their organizations must also learn to focus on framing their messages in ways that activate participation from wider, more diverse and otherwise inattentive publics, while discovering new media platforms for reaching these nontraditional audiences.

As a conceptual term, "frames" are interpretative storylines that communicate what is at stake in a societal debate and why the issue matters (Gamson and Modigliani, 1989). At a theoretical and descriptive level, framing research offers a rich explanation for how various actors in society define science-related issues in politically strategic ways, how journalists from various beats selectively cover these issues, and how diverse publics differentially perceive, understand, and participate in these debates (Pan and Kosicki, 1993; Scheufele, 1999; Nisbet 2009b). For each group, frames help simplify complex issues by lending greater weight to certain considerations and arguments over others, translating why an issue might be a problem, who or what might be responsible, and what should be done (Ferree et al., 2002). In this manner, frames provide common points of reference and meaning between scientists, the media, and key publics (Hellsten and Nerlich, 2008).

At a psychological level, a message frame is only effective if it is relevant—or "applicable"—to a specific, existing interpretive schema acquired through socialization processes or other types of social learning. Successful framing suggests a linkage between two concepts or things, such that after exposure to a message, audiences now accept that they are connected (Scheufele and Tewksbury, 2007). For example, as we will review on climate change, by emphasizing the religious and moral dimensions of the issue, E. O. Wilson and other scientists have convinced many religious leaders that environmental sustainability is directly applicable to questions of faith. Or as we will discuss on nanotechnology, when opponents draw comparisons to asbestos, they activate public interpretations of failed government oversight and unknown risks.

At a sociological level, to make sense of political issues, citizens use as resources the frames available in media coverage, but integrate these packages with the frames forged by way of personal experience or conversations with others. Media frames might help set the terms of the debate among citizens, but rarely, if ever, do they exclusively determine public opinion. Instead, as part of a "frame contest," one interpretative package might gain influence because it resonates with popular culture or a series of events, fits with media routines or practices, and/or is heavily sponsored by elites (Gamson, 1992; Price et al., 2005).

As Wynne (1992) has argued, many members of the public hold their own applicable lay knowledge about a science-related debate that is based on personal experience, culture, or conventional wisdom. Moreover, just as in politics generally, in combination with media coverage, these lay theories enable people to reason and talk about a complex science debate in their own familiar terms and to participate in consultation exercises such as deliberative forums (Pan and Kosicki, 2005. In other words, motivated citizens—when given the opportunity—can actively participate in a "bottom-up" framing of issues. Social movements, for example, have historically used frames to mobilize members and connect groups into advocacy coalitions. Consensus conferences, deliberative forums, and town meetings are a formal mechanism for cultivating this bottom-up framing process. These initiatives can lend voice and influence to stakeholder-sponsored frames that might otherwise be absent from regulatory or political decisions on science.

Through new forms of user-centered and user-controlled digital media such as blogs, online video, and social media sites, bottom-up alternative frames may be gaining greater influence in the discursive contest that surround issues such as climate change or biotechnology. Creating, structuring, and sponsoring these new forms of participatory media may be an important mechanism for what Wynne (2006) urges is the need to "democratize" the science communication process. We will return to this trend later in the essay.

Ethics, outcomes, and generalizable meanings—Framing is an unavoidable reality of the science communication process. Indeed, it is a mistake to believe that there can be "unframed" information. Whether writing 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 (Hilgartner, 1991). Moreover, press officers and science reporters routinely negotiate story angles that favor particular themes and narratives or, at the expense of context, define news narrowly around a single scientific study (Nelkin, 1995).

When a science subject shifts from its traditional home at 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 (Nisbet et al., 2003; Nisbet and Huge, 2006). If scientists do not adapt to the rules of an increasingly fragmented media system, shifting from frames that traditionally work at the science beat to new frames that fit at other media outlets and with wider audiences, then they risk ceding their important role as communicators.

As we review in the subsequent case studies, effective framing can result in a range of outcomes. Science organizations can use framing to motivate greater interest and concern thereby expanding the audience for science, to go beyond polarized and gridlocked interpretations of an issue and provide a context for dialogue, or to nudge public support toward policies informed by science and that solve collective problems (Nisbet, 2009b). In these cases, framing can be used ethically by prioritizing dialogue and bottom-up citizen expression, by avoiding false spin or hype and remaining true to what is conventionally known about a scientific topic, and by avoiding the denigration of social groups and the advancement of partisan causes (Nisbet, 2009c). Framing should not be seen as a strategy for "selling" the public on science, but rather as a means for constructively shifting the conversation about an issue. Framing should be used to design communication contexts that promote dialogue, learning, and social connections and that allow citizens to recognize points of agreement while also understanding the roots of dissent.

Previous studies describe a deductive typology of frames that appear to reoccur across science-related policy debates. Originally identified by the sociologists William Gamson and Andre Modigliani (1989) in an examination of nuclear energy, the typology was further developed in studies of food and medical biotechnology in Europe and the United States (Dahinden, 2002; Durant et al., 1998; Nisbet and Lewenstein, 2002). In Table 1, we outline this generalizable typology, describing the latent meanings of each interpretation. These frames consistently appear in science policy debates, though as we will later see, unique issue-specific frames can also emerge. The latent meaning of any frame is often translated instantaneously by specific types of frame devices such as catchphrases, metaphors, sound bites, graphics, and allusions to history, culture, and/or literature (Ferree et al., 2002).

In the rest of this section, we briefly explain how framing applies to the communication dynamics of debates over climate change, evolution, plant biotechnology, and nanotechnology. (With the reader in mind, throughout this section and others, references to frames are italicized, and frame devices are in quotes.)

Climate change—By the end of 2007, conventional wisdom had pegged the year as a major breakthrough for mobilizing the public on climate change. As evidence, advocates pointed to the Nobel peace prize shared by Al Gore and by the scientists working on the Intergovernmental Panel on Climate Change (IPCC). Yet various poll analyses reveal that a deep partisan divide remains on the topic, with a majority of Republicans continuing to dispute the validity of the science and the urgency of the matter (Pew Research Center for the People & the Press, 2008a; McRight and Dunlap, 2008). Even among Democrats and Independents, the issue still rates as a second or third tier political priority (Pew Research Center for the People & the Press, 2009b).

What explains then the difference between the objective reality of climate change and the policy gridlock created by its perceived subjective conditions? The answer is that the issue has historically been framed in ways that reinforces partisan divisions while undermining widespread public concern. During the late 1990s, the climate-skeptic message strategy was in part devised by Republican pollster Frank Luntz. Based on dial groups and polling, Luntz recommended that the issue be framed by skeptics narrowly in terms of *scientific uncertainty* and the "unfair economic burden" to the U. S. This strategy was effectively implemented by conservative think tanks and members of Congress to defeat adoption of the Kyoto treaty and other major policy proposals (McCright and Dunlap, 2003). The strategy also led to further distortions in news coverage, as journalists applied a preferred *conflict* frame, falsely balancing competing claims (Boykoff and Boykoff, 2004).

Al Gore, many environmentalists, and even some scientists have attempted to counter the *uncertainty* and *economic development* frames with their own *Pandora's box* emphasis on a looming "climate crisis." To instantly translate their preferred interpretation, these advocates have relied on depictions of specific climate impacts including hurricane devastation, melting polar ice, and the threat to polar bears. Yet this line of communication plays directly into the hands of climate skeptics, who

TABLE 1. A typology of frames applicable to science-related policy debates.

Frame	Definition of science-related issue
Social progress	Improving quality of life, or solution to problems. Alternative interpretation as harmony with nature instead of mastery, "sustainability"
Economic development/competitiveness	Economic investment, market benefits or risks; local, national, or global competitiveness
Morality/ethics	In terms of right or wrong; respecting or crossing limits, thresholds, or boundaries
Scientific/technical uncertainty	A matter of expert understanding; what is known vs. unknown; either invokes or undermines expert consensus, calls on the authority of "sound science," falsifiability, or peer-review
Pandora's box/Frankenstein's monster/runaway science	Call for precaution in face of possible impacts or catastrophe. Out-of-control, a Frankenstein's monster, or as fatalism, i.e., action is futile, path is chosen, no turning back
Public accountability/governance	Research in the public good or serving private interests; a matter of ownership, control, and/or patenting of research, or responsible use or abuse of science in decision-making, "politicization"
Middle way/alternative path	Around finding a possible compromise position, or a third way between conflicting/polarized views or options
Conflict/strategy	As a game among elites; who's ahead or behind in winning debate; battle of personalities; or groups; (usually journalist-driven interpretation.)

accuse Gore of liberal "alarmism," putting the issue quickly back into the mental box of *scientific uncertainty* and partisanship (see Nisbet, 2009a, for overview).

Another strategy to dramatize the importance of climate change has focused on *public accountability* dimensions. Democrats and some scientists accused the George W. Bush administration of putting politics ahead of science and expertise on a number of issues, including climate change. In 2005, journalist Chris Mooney's best-selling *The Republican War on Science* helped crystallize the *public accountability* train of thought, turning the "war on science" into a partisan rallying cry. In 2007, Hillary Clinton, in a speech marking the 50th anniversary of Sputnik, promised to end the "war on science" in American politics, highlighting the prominence of this frame device. In his transition and inauguration speeches, President Barack Obama similarly invoked the *public accountability* frame promising "to restore science to its rightful place." The *public accountability* frame has mobilized many ideologically like-minded Democrats and scientists, yet continued "war on science" claims are only likely to further alienate Republicans on climate change, the very group that scientists need to engage.

Not every citizen cares about the environment or the politicization of science, yet as just reviewed, among environmental advocates and scientists, these mental points of reference continues to be the dominant emphasis. To generate widespread public support for meaningful policy action, we need new perceptual contexts, mental boxes that resonate with something a specific intended audience already values or understands.

In one leading example, various advocates have turned the traditional *economic development* frame in favor of action on climate change, redefining action not as an "unfair economic burden," but as an economic opportunity (Nordhaus and Schellenberger, 2007). This frame, instantly communicated through the sound bite of "creating green jobs," was a major emphasis by both candidates in the presidential election and is a dominant focus of the Obama administration.

A second example is offered by scientists such as E. O. Wilson (2006) who frame environmental stewardship in terms of religious *morality and ethics*, engaging evangelical audiences who might not otherwise pay attention to appeals on climate change. Al Gore's more recent We campaign also employs a heavy emphasis on the *morality/ethics* frame, replacing the *Inconvenient Truth* storyline of looming disaster with a secular call to arms for Americans to unify behind the battle against existential threat to the country. Advertisements, for example, compare the need for action on global warming to the Civil Rights movement and World War II (Nisbet, 2009a).

Finally, a unique public health frame is a promising new innovation in climate change communication. The public health frame emphasizes the potential of climate change to increase the incidence of infectious diseases, heat stroke, and other familiar health problems, especially among the elderly, children, or low income groups. The public health frame also shifts the visualization of the issue away from remote arctic regions, peoples, and animals to more socially proximate neighbors and places. In the process, the issue begins to cut across media zones, triggering coverage at local news and urban media outlets (Maibach et al., 2008).

Evolution—In January 2008, the National Academies and the Institute of Medicine jointly issued a revised edition of *Science, Evolution, and Creationism*, a report intentionally framed in a manner that would engage more effectively audiences who remain uncertain about evolution and its place in the public school curriculum. The Academies commissioned focus groups and a national survey to gauge the extent of lay citizens' understanding of the processes, nature, and limits of science. They also specifically wanted to test various frames that explained why alternatives to evolution were inappropriate for science class (Labov and Pope, 2008).

The committee had expected that a convincing storyline for the public would be a *public accountability* frame, emphasizing past legal decisions and separation of church and state. Yet the data revealed that audiences were not persuaded by this framing of the issue. Instead, the research pointed to the effectiveness of a *social progress* frame that specifically defined evolutionary science as the modern building block for advances in medicine and agriculture. The research also underscored the effectiveness of a *middle-way/compromise* frame, a message that emphasized the National Academies and other major science organizations' longstanding position that acceptance of evolution and religious faith can be fully compatible. Taking careful note of this feedback, the National Academies decided to structure and then publicize the final version of the report around these core frames (Nisbet, 2009b).

For the National Academies, political conflicts over evolution have been a lesson learned as to the importance of connecting with diverse audiences and in understanding the central role that religious identity likely plays in how the public comes to understand science. Yet what continues to be the loudest voice of science on the matter takes a decidedly different interpretation. Several authors and pundits, led by the biologist Richard Dawkins (2006), argue that the implications of evolutionary science undermine not only the validity of religion but also respect for all religious faith. Dawkins, for example, argues as a scientist that religion is comparable to a mental virus that can be explained through evolution, that religious education is a form of child abuse, that religious believers are delusional, and that in contrast, atheists are representative of a healthy, proscience mind. In making these claims, not only does Dawkins use his authority as the former Oxford University Professor of the Public Understanding of Science to denigrate various social groups, but he gives resonance to the false narrative of social conservatives that the scientific establishment has an antireligion agenda. His claims also help fuel the *conflict* frame in the news media, generating journalistic frame devices that emphasize God vs. science, or science vs. religion. The readily available heuristic for the wider public is that science—exactly as critics of evolution claim—is in fact a threat to their religious identity (Nisbet, 2009b, c).

Plant biotechnology—Framing also helps to explain why some scientific innovations are widely accepted in the United States, but might be opposed in other parts of the world. Take, for example, plant biotechnology. While a small number of environmental and consumer activists are strongly opposed to the technology, survey studies show that the wider American public continues to be relatively unaware of the issue, yet generally supportive when asked their opinion (Fink and Rodemeyer, 2007). In part, public support remains high because unlike climate change or evolution, at the policy level, there has always been very strong bipartisan support for plant biotechnology (Brossard and Nisbet, 2007).

As a consequence, the image of the issue for the wider public remains predominantly framed in *social progress* terms, focusing on more nutritious and hardier crops for the developing world, and in terms of *economic competitiveness*, with an emphasis on promoting American agricultural products abroad (Nisbet and Huge, 2006). More recently, biotechnology companies have paired this *social progress* emphasis with a *middle way* frame, defining drought and pest resistant crops relative to climate change mitigation and adaptation strategies.

The U. S. situation contrasts sharply with several European countries, where surveys show strong public opposition. These negative perceptions derive partly from the efforts of advocacy groups to frame plant biotechnology as a *Pandora's box* of unknown risks and as a matter of *public accountability*, with an emphasis on the undue influence of "big biotech." Apart from partisan cues, the technology also triggers strongly held worldviews, including feelings of anti-Americanism (and thereby opposition to U. S. biotech products) and a cultural sense that food has an intrinsic value that should remain beyond the reach of science and corporations.

Nanotechnology—One of the most recent examples of framing efforts surrounding emerging science is nanotechnology. As part of the increasingly heated debates over the potential toxic qualities of some nanomaterials, think tanks and nongovernment organizations are beginning to offer oppositional frames. The most prominent are the messages that portray nanotechnology as "the asbestos of tomorrow" (Scheufele, 2006). As a frame device, this analogy is particularly powerful because it activates two culturally shared schemas in people's minds. First, the comparison triggers a *public accountability* link to a past, well-known health controversy, specifically the absence of regulatory oversight of asbestos. Second, the phrase instantly translates the notion that emerging nanotechnologies may open a *Pandora's box* of long-term effects that will be unknown for years to come.

European corporations have been extremely sensitive to these framing efforts and have engaged in very successful preemptive campaigning. These initiatives are characterized by a consistent framing of new product releases and other marketing materials around a "nano is nature" theme. This frame device activates a *social progress* interpretation of nanotechnology as a process that is in harmony with nature, existing for thousands of years. European firms have also expanded these efforts beyond current market applications, launching preemptive campaigns to brand entire industries. The Chemie-Wirtschaftsförderungs-Gesellschaft, a German industry group, for instance, has rolled out a broad online and print campaign featuring an alternative application of the *social progress* frame, Chemie macht Zukunft [chemistry makes future]. The campaign highlights future applications of nanotechnology and their potential to improve environmental and economic conditions.

Directions forward—These cases demonstrate the need for a more scientific approach to science communication, i.e., one that is less exclusively driven by intuition, personal experience, or traditional ways of "doing communication," and more by an empirical understanding of how modern societies make sense of and participate in debates over science and emerging technologies. In this section, we detail several recommendations for new directions in public communication, paths forward derived from the research and principles reviewed.

Graduate training and new interdisciplinary degree programs—College and doctoral students majoring in the sciences should be offered courses and training in communication. These courses introduce young scientists to much of the research reviewed in this essay, focusing on the relationships between science, the media, and society, providing valuable professional know-how and skills. There is also the demand for new interdisciplinary degree programs that combine course work in communication, the sciences, policy or law, sociology, and other fields. Scientists with communication training and graduates of these new interdisciplinary programs are likely to find jobs in the news media, the high-tech industries, the government sector, or at research institutions, public affairs strategy firms, and not-for-profits. These new graduate courses and programs would be the pedagogical equivalent of the on-the-job training that the successful AAAS policy fellows program provides

Ph.D. scientists or that the Aldo Leopold fellows program offers midcareer scientists.

Some critics of our proposals have argued that scientists should stick to research and let media relations officers and science writers worry about translating the implications of that research (Holland et al., 2007). They are right: In an ideal world that's exactly what should happen. Yet in reality, scientists will be the key individuals who will give interviews, testify before Congress, or address local community forums. In addition, as senior decision-makers, many scientists are ultimately responsible for setting communication policy at scientific institutions, agencies, and organizations. These leaders need to understand how research can and should inform public communication on all issues.

Public dialogue that matters—As reviewed, public dialogue initiatives have many positive uses but also several limitations. To enhance public participation, significant resources need to be spent on sampling, recruitment, and turnout. Multiple meetings should also be held across dates and locations. In this case, success is a function of money and careful planning. Another strategy to boost public interest in these types of meetings is to pair expert testimony and deliberation with the viewing of a documentary or series of short films. These "deliberative screenings" can not only increase public turn out, but also help frame discussion and thinking in ways that might bridge polarized views. They also provide an additional outlet and repurposing for many National Science Foundation-funded films and media productions.

The scope and impact of public dialogue initiatives can also be expanded by generating local and national news attention to the event. Not only does this news attention reach a larger audience with a message that scientists are open to public input, but coverage is likely to reflect the types of frames that the meetings were organized around. For example, a recent study found that a public consultation exercise on nanotechnology generated discussion that was framed mostly in social progress terms, accenting the benefits to society (Besley et al., 2008).

A commitment to early consultation and to a genuine role for participants' recommendations can only come with the realization that sometimes a competent, informed, and engaged public might reach collective decisions that go against the self-interest of scientists. For example, at a recent public consultation exercise on nanotechnology, though the recommendations were not binding as policy, one of the outcomes was that several recruited participants decided to subsequently form their own local advocacy group to monitor the development of nanotechnology in the area (Powell and Kleinman, 2008).

Data should trump intuition—Efforts to use the media and communication campaigns to engage the public on science need to adapt to the realities of today's information environment. Many approaches to science communication and outreach still rely heavily on traditional channels, such as science television or newspapers. Recent survey data, however, suggest that we are seeing significant shifts from television (which is still the primary source of information for three quarters of respondents 65 years or older) to online sources (which are the preferred media for more than half of those under 24) (Pew Research Center for the People & the Press, 2008b). The same data also show that interest in science-related issues is highest among respondents who relied mainly on new information technologies for news, as opposed to traditional mass media channels.

Effective public communication "is not a guessing game, it is a science" (Scheufele, 2007, p. 48)—which means it is based on data. Public opinion research allows us to get a very accurate picture over time of exactly what different groups in society want to know about climate change, evolution, biotechnology, or nanotechnology, about potential implications for their daily lives, about what their concerns are, and to whom they look for answers (Scheufele, et al., 2007). Relying on systematic research to understand and communicate effectively with different publics is therefore critical to understanding how the public thinks about new technologies, what they know, and what informational channels reach them most effectively.

Quality research, of course, is expensive. Recent calls for the National Science Foundation to fund more direct research on science communication are welcome developments as is the leadership role played by the National Academies in commissioning audience research on evolution. Similarly, the National Academy of Engineering recently issued recommendations for recruiting women and minorities into careers in science and engineering, relying on empirical audience research and principles of strategic communication (Committee on Public Understanding of Engineering Messages, 2008; the second author of this article served on this committee).

Connecting to public values—Effective communication will necessitate connecting a scientific topic to something the public already values or prioritizes, conveying personal relevance. And in people's minds, these links are critical for making sense of scientific information. A number of recent studies examine how values shape the interpretation of scientific information. Findings on religiosity, for instance, show that exactly the same information can translate into very different attitudinal conclusions for highly religious respondents than for nonreligious ones (Nisbet, 2005; Nisbet and Nisbet, 2005; Nisbet and Goidel, 2007; Ho et al., 2008; Brossard et al., 2009). In other words, we may be wasting valuable time and resources by focusing our efforts on putting more and more information in front of an unaware public, without first developing a better understanding of how different groups will filter or reinterpret this information when it reaches them, given their personal value systems and beliefs. Recent research also suggests that these value-based filters may in fact differ across different cultures or national settings (Scheufele et al., 2009).

"*Going broad*"*: Beyond elite audiences*—As mentioned earlier, some critics argue that it would be unethical to take advantage of strategic communication tools to make scientific issues more relevant and accessible to a general public. But recent data on potentially widening knowledge gaps suggests that it may be unethical if we *did not use all* communication tools at our disposal to connect with hard-to-reach audiences (Scheufele and Brossard, 2008).

Many traditional approaches to public communication about science, for instance, have inadvertently favored elite audiences. In fact, some previous attempts to connect across diverse sections of the public have resulted in *widening* gaps between the already information rich and the information poor, partly from the likelihood of exposure. Almost 40% of college-educated respondents, for instance, visited a science or technology museum in 2006, compared to less than 10% for respondents with a high school education or less (National Science Board, 2008).

As a result, museum exhibits, science Web sites, traditional science documentaries, and similar outreach efforts may inherently favor elite audiences. Widening gaps between the information rich and information poor are also a function of the way issues like nanotechnology and biotechnology play out in public discourse. In their research on knowledge gaps, Phil Tichenor and his colleagues (1970) found that audiences with high socioeconomic status (SES) showed much stronger learning effects from health related information than did low-SES audiences. This effect is in part due to the fact that television shows like *NOVA* or the Science section of the *New York Times* tailor their content to highly educated audiences. As a result, learning effects for mass audiences are minimal, even if these audiences happen to tune in to *NOVA* or read an article in the *New York Times*.

What are needed then are media strategies for "going broad" with science-related content, generating attention and interest among non-elite audiences. Surveys, for example, show that local television news remains among the dominant sources of public affairs-related information for the American public (Pew Internet and American Life Project, 2006). Therefore, to reach nontraditional audiences, scientists and their organizations need to be on local television news. To do so, major national communication efforts should be closely coordinated across local media markets, with specific scientists, institutions, or organizations serving as the local angle and spokespeople. An alternative model is the example of Climate Central, a nonprofit partnership between journalists and scientists who produce climate science stories for syndication at local television outlets across the United States (Brainard, 2008).

New documentary genres and storytelling techniques are also an important mechanism for going broad. Surveys in the United States show that programming at the Discovery Channel, National Geographic, and Learning Channel constitutes the largest and most diverse audience for science-related content. More than 40% of respondents across educational levels, gender, age, religious background, and ideological orientation say that they "regularly" view these channels. In comparison, 10% or less of respondents across these groups regularly watch PBS *NOVA* or subscribe to *Scientific American*, *Discover*, *Nature*, or *Science* (Pew Internet and American Life Project, 2006). Specific to the environment, the box office success and media visibility in the United States for the 2009 major motion picture release of *Earth*, a theatrical version of a series that originally aired on the BBC and Discovery Channel, is further evidence of the wider appeal of these new documentary genres.

A recent National Academies of Science and Institute of Medicine (2008) project that pairs scientists as consultants on major motion pictures and television series is also a step in the direction of going broad and reaching new audiences. In similar fashion, an initiative led by physicists used the 2009 major motion picture release of *Angels & Demons* as a way to capitalize on the summer blockbuster's focus on particle accelerators and antimatter. The project organized local lectures in 45 locations across the United States and Canada and launched an educational Web site Angels & Demons: The Science Revealed (see website http://www.uslhc.us/Angels_Demons/index.html). Long used as a strategy for engaging the public on public health issues (Kaiser Family Foundation, 2004; Montgomery, 2007), active involvement with Hollywood in the construction of messages about science can lead to a range of outcomes including informal learning, enhanced interest and attention to science in news coverage and other media, the modeling of positive behavior related to environmental sustainability or energy use, the favorable framing of controversial issues such as the teaching of evolution in schools, or even a spike in news or policy attention to a scientific topic such as climate change. Web platforms such as the Angels & Demons site facilitate incidental exposure to science among individuals using search engines to find more information about the film.

Other important media outlets for expanding audience reach include comedy news programs such as *The Daily Show* and *The Colbert Report*. Studies have documented the ability of these programs to engage younger, harder to reach audiences about political candidates and election campaigns, shaping their political attitudes and levels of political knowledge (Feldman, 2007; Feldman and Goldthwaite-Young, 2008). On science, a recent analysis by the Pew Project on Excellence in Journalism (2008c) found that *The Daily Show* includes comparatively more attention to science and technology topics than does the mainstream press and significantly more attention to climate change. These programs also generate buzz online with heavily trafficked and forwarded clips on hot-button science topics such as evolution, genetics, climate change, or stem cell research. Additionally, both shows frequently feature scientists and science authors such as Neil deGrasse Tyson and Brian Greene as interview guests.

Given that satire and comedic news are increasingly preferred media formats for younger audiences, more research is needed on the potential for using this style of humor as a tool for public engagement on science. Little is known, for example, about the comparative effects of science information communicated in satirical form compared with the same information communicated in traditional science media. Greater understanding in this area would inform not just media strategy but also the incorporation of humor and satire into the production of documentary film, Web, and museum content.

"*Going deep*"*: Participatory, localized media*—Initiatives of a different kind should focus on building a "participatory" public media infrastructure for science and environmental information. As reviewed earlier, in a world of many media choices, on most topics, members of the public are using the Web to sample and sometimes accidentally bump into science-related content. Yet for motivated users, when an issue becomes personally or politically relevant, they are "deep diving." In coming years, this tendency will be especially the case at the local level, as citizens face an increasing need for high quality community-related information on adapting to climate change or managing the localized implications of emerging technologies such as nanotechnology. Yet despite a growing need for localized information about science and the environment, given the state of severe economic distress to the news industry, most local newspapers have cut meaningful coverage in the area. As a result, many communities lack the type of relevant news and information that is needed to adapt to environmental challenges or to reach collective choices about issues such as nanotechnology and biomedical research.

As a way to address these local-level information gaps, government agencies and private foundations should fund public television and radio organizations as community science information hubs. These initiatives would partner with universities, museums, public libraries, and other local media outlets to share digital content that is interactive and user-focused. The digital portals can feature in-depth reporting, blogs, podcasts, shared video, news aggregation, user recommendations, news games, social networking, and commenting. Museums, public libraries, and universities can also be real world contexts where citizens can contribute digital content and meet face-to-face to discuss, deliberate, and plan.

These new models for nonprofit science media are an integral part of the infrastructure that local communities need to adapt to climate change, to move forward with sustainable economic development, and to participate in the governance of nanotechnology, biotechnology, and other areas of science. A community without a quality source of science information—packaged in a way that is accessible and relevant to most members of that community—is ill prepared to make careful decisions about costs, risks, benefits, and ethics.

Science media literacy curriculum—To motivate and prepare citizens to use digital media to learn about science, share information, express their views, and coordinate activities, science organizations should partner with universities, social scientists, and journalists to develop "civic science media literacy" curricula. These modules can be formally incorporated into university, junior college, and high school science courses across the country. The modules—as required complements to textbook and laboratory content—would introduce students to quality online news sources about science, teach students about how to constructively use participatory tools such as blogs and other social media applications, educate students on how to critically evaluate evidence and claims as presented in the media, introduce students to the relationships between science and institutions as they are often covered in the news, and socialize students into enjoying and following science by way of digital media after they complete their formal science coursework. In short, this type of media literacy curriculum would not only potentially grow the audience for science media, but also impart the skills, motivation, and know-how that students need to be participatory citizens in the online and real worlds.

Opinion leader campaigns that bridge audience gaps—With so much focus on media strategy and education, it is important not to forget that perhaps the most effective strategy for connecting with difficult to reach audiences is face to face conversation and other interpersonal channels. In this matter, science organizations need to mobilize specially trained opinion leaders who can bridge the communication gap between news coverage and inattentive audiences, talking to their friends, family, and coworkers about the relevance of science-related issues such as climate change or the teaching of evolution in schools.

We know that these science opinion leaders exist and can be recruited. For more than 60 years, researchers have traced the influence of news and advertising messages in local communities, identifying a small group of opinion-leading individuals who pay close attention to public affairs and advertising, discuss what they learn from the media with a diversity of others, and appear to be more persuasive in convincing others to adopt an opinion or course of action. In this "two-step flow of information," opinion-leaders do not necessarily hold formal positions of power or prestige, but rather serve as the connective communication tissue that alerts their peers to what matters among political events, social issues, and consumer choices (Lazarsfeld et al., 1948). Over the past decade, as audiences have become more difficult to reach and less trustful of the media, this research has informed innovative communication campaigns in the areas of public health, politics, and consumer marketing. Yet despite the widespread targeting of opinion leaders in these other fields, science organizations have traditionally overlooked this important dimension of public engagement (Nisbet and Kotcher, 2009).

Several validated measurement techniques exist for identifying individuals with opinion-leader-like qualities in surveys and questionnaires (for an overview, see Scheufele and Shah, 2000). Once recruited and trained, audience-tested messages, such as those developed by the National Academies on evolution, can be matched to an opinion leader's social background and network. Moreover, when "surges" in communication and public attention are needed, such as surrounding the release of a future IPCC report or a major state legislative vote on evolution, opinion leaders can be activated with talking points to share in conversations with friends and coworkers, in emails, in blog posts, or letters to the editor (see Nisbet and Kotcher, 2009, for an overview).

Conclusion—We live in an era where most policy debates relevant to science and emerging technologies are not simply technical issues. Rather, they are collectively decided at the intersection of politics, values, and expert knowledge. Under these conditions, sophisticated public outreach and engagement are essential to overcoming perceptual gridlock on climate change, for encouraging public acceptance of the teaching of evolution in schools, for meaningfully involving the public in societal decisions about plant biotechnology and nanotechnology, or for effectively engaging with stakeholders and a wider public on almost any issue.

Yet public communication and engagement should not be conceived of as simply a way to "sell" the public on the importance of science or to persuade the public to view scientific debates as scientists and their allies do. To apply sophisticated approaches such as framing or deliberative forums to achieve these ends falls back into the trap of deficit model thinking and undermines longer term efforts at building trust, relationships, and participation across segments of the public.

Importantly, if the public feels like they are simply being marketed to, this perception is likely to only reinforce existing polarization and perceptual gridlock. Recently, for example, the strategy firm EcoAmerica used focus groups and polling to develop language intended to "re-brand" the debate over global warming, recommending that the "environment" be referred to instead as "the air we breathe, the water our children drink." Or that "cap and trade" be relabeled "cap and cash back." While EcoAmerica's research approach is in line with the audience-based communication methods we recommend in this essay, by conceiving and packaging this research as a "re-branding" and marketing campaign, they inadvertently undermine their own attempts at public engagement.

Specifically, anytime public engagement is defined, perceived, and implemented as a top-down persuasion campaign, then public trust is put at risk. When the EcoAmerica strategy memo was accidentally leaked to the media, the *New York Times* ran a front-page story "exposing" the efforts of environmental groups who in the headline were described as "Seeking to Save the Planet, With a Thesaurus" (Broder, 2009). The news report drew direct parallels to Frank Luntz's research on behalf of climate skeptics described earlier in this essay (see also Nisbet, 2009a). Perhaps worse, the event was lampooned in conservative media outlets as yet another attempt by environmentalists to "manipulate" the public.

In this essay, we reviewed what might be next for science communication and public engagement. An important paradigm shift is taking place within the scientific community that involves a movement away from a singular focus on science literacy as both the culprit and the solution to conflicts over science in society. We believe that our essay provides several important paths forward while emphasizing that effective public engagement means figuring out ways to structure and promote conversations with the public that recognize, respect, and incorporate differences in knowledge, values, perspectives, and goals.

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