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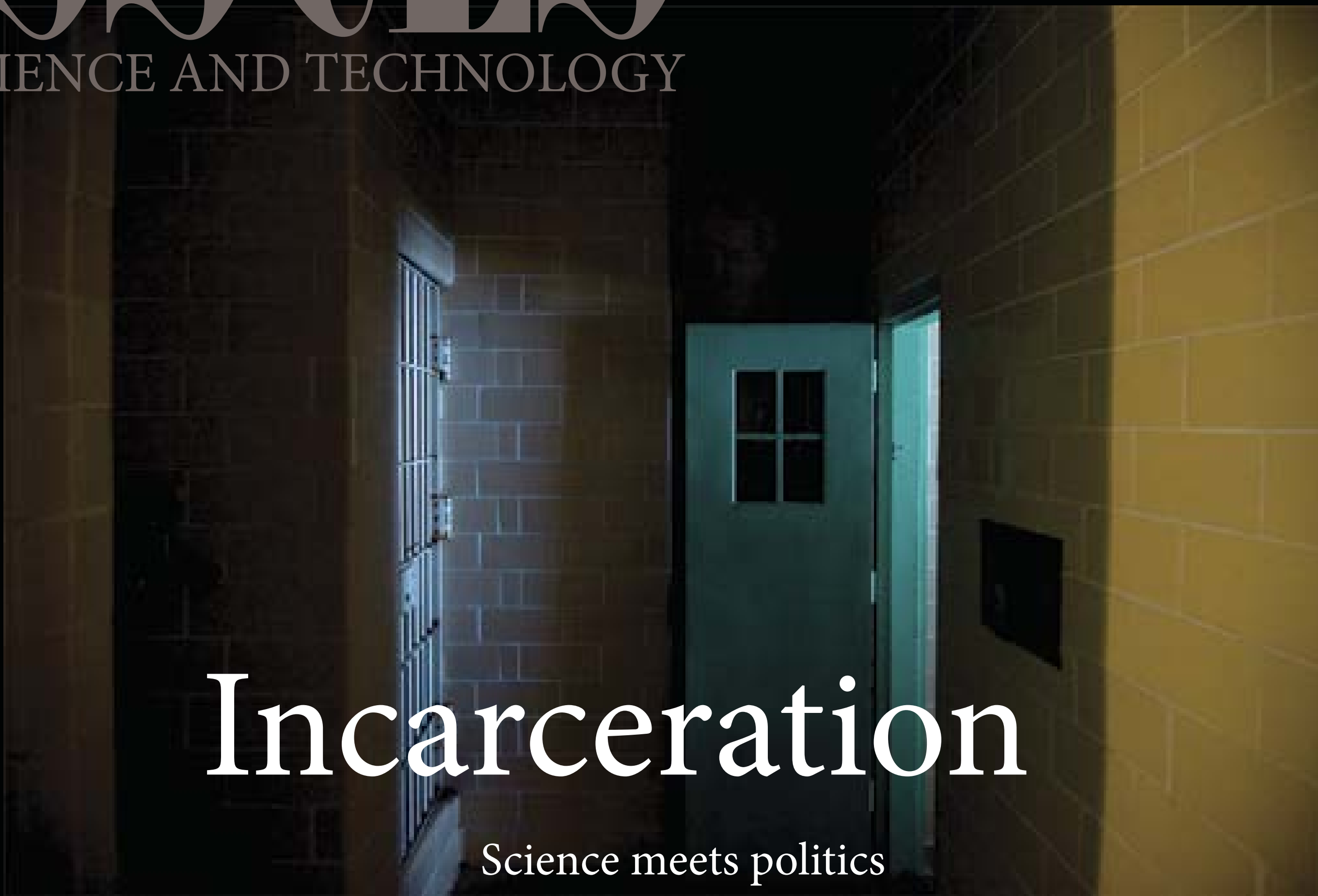

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Communicating the Value and Values of Science

Science communication, done in accord with basic principles of science, can help in advancing knowledge and improving lives. Here are some suggestions from the frontlines.

Science is communicated to the public, press, and policymakers in various ways by distinguished entities, which I have characterized elsewhere as custodians of knowledge. These include governmental institutions such as the National Aeronautics and Space Administration (NASA); intergovernmental organizations such as the Intergovernmental Panel on Climate Change, associations of scholars such as the National Academy of Sciences (NAS); and the editorial voices of major scientific journals. I regularly come in contact with these groups and the content they produce in my role as the person who signs off on the FactCheck.org postings generated by the SciCheck project, funded by the Stanton Foundation and designed to hold those engaged in public debate accountable for their uses of evidence.

In discharging that function, I'm sometimes struck by worries about what can happen when science communicators violate science's norms. When they do, they invite the audience to question whether the underlying science has done the same. And in the larger picture, when science communication forsakes the values of science, it increases the likelihood that bad science will affect the public and public policy, feed suspicion about scientists' self-interests or conspiratorial motives, and confuse the public and muddy the policy debate. By contrast, good science communicated well increases the likelihood of good public policy.

In laying out my concerns, I will focus on four "norms"—sometimes called "values"—that I believe characterize science as a way of knowing: its championing of critique and self-correction; its acknowledgement of the limits of its data and methods; its faithful accounts of evidence; and its exacting definition of key terms. In the process, I'll also cite some positive examples designed to show that, although sometimes difficult, it is possible to communicate science while also respecting these norms.

Championing a climate characterized by critique and self-correction

Before turning to a case in which science corrected expeditiously and another in which it did not, let me note that some forms of communication signal reporters about the state of knowledge about a specific topic. A consensus statement telegraphs widespread scientific agreement; retraction communicates that the published finding has been decertified. One of the reasons the press cast the false association between vaccination against measles, mumps, and rubella (commonly called MMR vaccinations) and autism as an open question for as long as it did is that despite repeated failures to replicate the bogus findings pushed by the British researcher Andrew Wakefield, and despite a press investigation that exposed his misconduct, it took the journal *The Lancet* 12 years to disavow that original 1998 article. Had Wakefield's shoddy pseudoscience been retracted in a timely fashion, reporters would have been less likely to treat it as a certified, although contested, finding. We can't know whether that change in reporting would have affected the likelihood or extent of the recent measles outbreak. But it wouldn't have hurt.

By contrast, in the case of the error-ridden study by the Japanese researcher Haruko Obokata and her colleagues, published in January 2014 in the journal *Nature*, the scientific community's ethic of self-correction functioned well. The study purportedly showed that distressing adult cells could transform them into pluripotent ones. But shortly after it appeared, scientists writing on the post-publication peer review site PubPeer began to flag problems. Within three months, Obokata's home institute found her guilty of research misconduct. Within seven months, *Nature* retracted the paper and, importantly, announced an internal review of its practices.

Acknowledging the limitations in data and methods

When scientists communicate in scholarly outlets, they disclose the limitations in their data and methods. But when communicating to policymakers and the public, the temptation exists to simplify, lest the audience interprets uncertainty as lack of underlying knowledge or becomes confused by a complex explanation. However, when science communicators downplay the limits of existing methods and data, the public has more difficulty understanding that knowledge can evolve, as did our understanding of hormone replacement therapy and the ways in which eating foods high in cholesterol affects heart health.

Another price of conveying a false sense of certainty was on display when "Snowmageddon" was a no-show in New York City in January 2015, prompting conservative talk radio host Rush Limbaugh to observe: "Now, the weather guy is apologizing and blaming his models. The same people that tell us their models [that are] 50 to a hundred years out on climate change can be trusted."

The back story? Led by forecasts of up to three feet of snow, public transportation and roads were shut down in New York City. Flights were cancelled and schools closed. But New York City received under a foot of snow. As criticism of the forecast mounted, the head of the National Weather Service noted that the weather service needed to better communicate uncertainty. I agree.

Major weather events are an opportunity to inform the public about what science knows—and also about how it knows and the limits of that knowledge. In this instance, modeling didn't fail. Rather, humans failed to communicate that models deal in likelihood, not certainty, and that different models were forecasting different boundaries for the storm. The models correctly forecast that the Northeast was going to be hit. At issue were the boundaries: For example, would New York City be within the area of highest impact or outside the edge? The latter turned out to be the case. As the *New York Times* reported, "Parts of eastern Nassau County, on Long Island, for example, got as much as 18 inches, while parts of New York City received only four."

The institutions that act as custodians of knowledge would be well served were they to ensure that error values and other relevant uncertainties are specified in all applicable communication of data. Here the social sciences provide a success story. Because scholars affiliated with the American Association of Public Opinion Research and the National Council on Public Polls promoted polling disclosure standards, most major media polls now report their margins of error. Had comparable standards been adopted in the January 2015 press release issued by NASA and the National Oceanic and Atmospheric Administration (NOAA) on the 2014 global temperature, headlines around the country probably would not have proclaimed that 2014 was the warmest year on record. And perhaps had the margin of error been featured, as it would have been in a report of an election poll, the NOAA report issued in December 2014 on that year's land and ocean surface temperature wouldn't have asserted that 2014 was "*easily* breaking the previous records," because, as a slide (labeled slide 5) in the January NASA/NOAA press packet confirmed, that was "probably" or "likely" but not incontrovertibly the case. Accepting the NASA/NOAA headline ("2014 was Warmest Year on Record") at face value and not catching the importance of slide 5 in the press packet, news accounts asserting 2014 was the warmest on record were vulnerable to critics who accurately pointed out the insignificant difference between it and two recent years.

Press skepticism about voices of authority is a healthy thing. But so, too, is press trust in the messaging of the custodians of knowledge. However, I suspect that for some reporters that trust erodes a bit when they need to issue a "clarification," as the Associated Press did when noting that its January 16, 2015 account had "reported that 2014 was the hottest year on record, according to the National Oceanic and Atmospheric Administration and NASA, but did not include the caveat that other recent years had average temperatures that were almost as high—and they all fall within a margin of error that lessens the certainty that any one of the years was the hottest."

Contrast the NOAA statement that 2014 was "easily" the warmest year or the NOAA/NASA headline labeling it as the "warmest" with a Yale Climate Connections posting by Zeke Hausfather, a senior researcher at Berkeley Earth. After noting that six groups gather temperature data (NASA; NOAA; Japan's Meteorological Agency; Berkeley Earth; the Hadley Centre in the United Kingdom; and a team comprising British researcher Kevin Cowtan and Canadian researcher Robert Way), Hausfather concluded that "In all cases, 2014 is effectively tied with 2010 and 2005 within the uncertainty of measurements."

He went on to note that "in important ways, what matters most is not which specific calendar year—2005, 2010, or 2014—is the warmest, but rather the continued long-term warming trend, particularly given the absence of an El Niño in 2014." He explained why the six groups' temperature measurements differ at times, but added, "All have quite similar results over the past 150 years, with differences primarily based on the ocean temperature series used and the method of spatially interpolating data from individual stations to areas with no station coverage." In effect, this message confirmed the existence and importance of convergent data. He also explained why 2014 is not a safe bet to be the warmest: "In both cases, 2014 is more likely than any other year to be the warmest year on record; but at the same time 2014—and this is counterintuitive—is less than a safe bet to be the warmest year on record." The reason: "The probability that 2014 is the warmest year is less than 50 percent."

Although some observers have worried that communicating scientific uncertainty risks undermining public trust or interest in science, doing so at least in some cases may actually increase both. Indeed, the researcher Jakob Jenson of Purdue University found in an experiment reported in 2008 that "both scientists and journalists were viewed as more trustworthy when news coverage of cancer research was hedged (e.g., study limitations were reported)…."

Increasing public understanding of comparative certainty could address the disjuncture between what scientists mean when they cite, for example, a 95 percent confidence level and some people's belief that if scientific knowledge is reliable, that percent would be 100. In a survey by the Associated Press in 2013, the answers of major scientists taken as a whole illustrate the kind of understanding available through comparative certainty claims: Science is as certain about anthropogenic climate change as it is that smoking is harmful to health, even as it is more certain that if you drop a stone, it will fall to earth. In short, science is certain enough about human-caused climate change to justify changing behavior.

Social scientists have long known that the analogies through which we see such phenomena as electricity can increase or impede people's understanding of the science. Electricity is understood differently through the analogy of a teeming crowd rather than flowing water. Try this test of whether it is possible to communicate through analogy what it means to say that adding greenhouse gases to the atmosphere increases the likelihood of extreme weather. The analogy comes from Australian climate researcher Steve Sherwood. Think about rolling dice. Two dice. Six sides each. One to six dots. "Adding greenhouse gases to the atmosphere loads the dice, increasing odds of … extreme weather events," Sherwood explains. In effect, it "paints an extra spot on each face of one of the dice, so that it goes from 2 to 7 instead of 1 to 6. This increases the odds of rolling 11 or 12, but also makes it possible to roll 13."

Analogies can also anchor the notion that the presence of uncertainty is not an indication that we are lacking strong theory. On the relationship between climate change and extreme weather, Danish astrophysicist Peter Thejll explains that "It is like watching a pot boil…. We understand why it boils but cannot predict where the next bubble will be." If science communication is to adhere to science's norms, it needs to find optimal ways to communicate what it knows, how it knows it, the limitations of the involved methods, and also the uncertainties surrounding its findings.

Faithfully accounting for evidence

Explaining data that run counter to the dominant scientific narrative is difficult. A case in point occurred in September 2013, when NASA images used in a FoxNews.com posting appeared to say that in 2013 Arctic sea ice had recovered. If compared only to the 2012 historic low point that Fox featured, it had—but not if you track data to 1979 when satellite monitoring began. Instead of resolving the issue, three major 2014 scientific reports compounded the problem: the American Association for the Advancement of Science's "What We Know: The Reality, Risks and Response to Climate Change"; the U.S. Global Change Research Program's "National Climate Assessment"; and "Climate Change: Evidence & Causes," a joint publication from NAS and The Royal Society. Rather than detailing possible reasons for the 2013 increase, each disregarded or downplayed it, while instead highlighting the 2012 data. In so doing, they inadvertently strengthened the hand of critics eager to assume that scientists were baffled by the 2012-13 change. One of the reports, from the NAS/Royal Society, acknowledged the 2013 data, but did so by appending a note to a chart showing the 2012 sea ice extent that stated "in 2013 Arctic summer sea ice extent rebounded somewhat…." Masked by the word "somewhat" was the fact that in mid-September 2012, the extent was 1.32 million square miles, and a year later 1.97 million square miles. To appropriate a phrase used by one of my grandchildren, that's a lot of "somewhat."

Contrast that statement with this one from Britain's Met Office, made on its website by Ann Keen, one of that group's sea ice scientists: "In 2012 we saw a record low which was likely to have been influenced by a storm which swept through the region in summer, but this year's (2013) weather conditions appear to have been less conducive to ice loss.

"We know sea ice extent is going to vary from year to year due to weather conditions and that's not at all inconsistent with the overall decline in extent. You wouldn't expect to see records broken year after year, so this 'recovery' is not unexpected.

"In fact, model simulations of sea ice suggest that as the ice gets thinner you actually get more year to year variability in extent because larger areas of the ice are more vulnerable to melting away completely over the summer."

Which is least vulnerable—the Met Office or the NAS/Royal Society—to conservative talk radio host Rush Limbaugh's assertion in March 2014 that "In fact, the Arctic has more ice now than it's had in a long, long time. It's not melting. Everything they're saying is a lie"? The answer, of course, is the statement from the Met Office.

Those who oppose the scientific consensus on climate change are often accused of cherry picking data. When custodians of scientific knowledge seem

> PRESS SKEPTICISM ABOUT VOICES OF AUTHORITY IS A HEALTHY THING.

to do the same, they not only lose the moral high ground but invite an attack on their lack of fidelity to a basic scientific norm. Seeming to downplay or ignore evidence also invites both questions about motive and accusations, including this one from Rush Limbaugh, alleging that climate scientists are trying "to scare people into supporting Big Government."

Impugning motives is a classic means of undercutting credibility. But the attack is thwarted when science communication makes plain that accounting for seemingly anomalous data, a basic scientific norm, is a driver of new knowledge that leads to refinement of theory and to a better understanding of underlying patterns and regularities. In this case, accounting for the 2013 Arctic sea ice extent is improving our understanding of the factors explaining wide variability in the context of a multidecade downward trend.

Precise, clarifying specification of key terms

Because meaning exists at the intersection of a text, a context, and a receiving audience, on matters of public importance, science communication should not only precisely and clearly define its terms but should do so in ways that make sense to a reasonable nonscientist. In other words, the language in which science is communicated needs to help the public understand the science. In the first two cases I will outline, the words and phrases in question—"eliminated," "eradicated," and "genetically modified organisms"—obscure the science. By contrast, the labels "flu associated (or related) deaths" and "global climate change" focus the public in ways that advance understanding.

My first example is an instance of what I call incomprehensible precision, a distinction between eliminate and eradicate. When the Centers for Disease Control and Prevention (CDC) said in 2000 that measles had been "eliminated" from the United States, the agency didn't mean what you and I mean when we use that word in casual conversation. Instead, it meant that there hadn't been "continuous disease transmission for 12 months or more in a specific geographic area." In effect, by "eliminated," the CDC meant "no longer endemic (constantly present) in the United States." Presumably sensing that the public might be confused by all of this, a CBS News web headline proclaimed "Measles still poses threat to U.S. despite being 'eliminated.'"

To complicate matters further, the CDC distinguishes between eradication and elimination, words that thesauruses cast as synonyms, stating that "CDC defines eradication as the permanent reduction to zero of the worldwide incidence of infection caused by a specific agent…" Proclaiming that measles had been eliminated is worrisome because the statement fails to signal the ongoing need for vaccination—a need that exists if, despite its "elimination" in one geographic locale, measles persists in some places that people travel to and from.

Where this measles example shows problematic precision, the instance to which I will turn next—genetically modified organisms (GMOs)—includes one word that is, in many instances, inaccurate and a pair of others that fail to distinguish genetically engineered crops from those that are the by-product of other forms of breeding.

People who wonder how to account for the recent Pew Research Center's finding that the public is much more wary of GMOs than are members of the American Association for the Advancement of Science might usefully reflect on the 2010 National Science Foundation Science and Engineering Indicators discovery that some members of the public think that ordinary tomatoes do not contain genes but genetically modified ones do. The person who doesn't think tomatoes have genes presumably doesn't realize that although comparatively little in the produce aisle has been bioengineered, virtually everything there has been genetically modified. Science has failed to inform the public that it is not modification of genes that distinguishes supposed-GMOs. All types of breeding—including hybridization, cross-breeding, mutagenesis, and recombinant DNA technology—involve modification and exchange of genes. The label is misleading for a second reason as well because, as the Food and Drug Administration (FDA) notes, "most foods do not contain organisms (seeds and foods like yogurt that contain microorganisms are exceptions)."

Finally, not only has virtually all of the produce in the grocery store at some point in time been genetically modified, but so, too, have the ancestors of the grocer and the customer perusing the pears. As a recent article in *Genome Biology* shows, some (albeit a relatively small number) of the approximately 20,000 genes in humans today were acquired through horizontal gene transfer—in other words, from other species. Among them are genes that produce antioxidants and enhance our innate immune responses. We are all GMOs, as it turns out. Yet some among our society of GMOs remain fearful of anything identified as a genetically modified organism and think that all GMOs should be labeled.

To begin the process of drawing clarity out of confusion, it will be necessary to craft a label that captures what is distinctive about the process and product. "Recombinant deoxyribonucleic acid (rDNA) technology (rDNA-t)" may work in technical discussions among scientists, but probably not with the public. At the risk of using an acronym that confuses crops that are genetically engineered with a golf tournament, my candidate for purpose of starting the discussion is Precise Genetic Adaptation (PGA). "Precise" because, unlike mutagenesis, the modification at issue here does not affect the broader genome. "Genetic" because genes are the focus of the change. "Adaptation" because that is the intended outcome. One might then characterize the newly FDA approved "Innate" potato, a trademarked creation of the Simplot company, as a Precisely Genetically Adapted potato.

Effective scientific labels invite questions whose answers will increase the audience's understanding of the relevant science. Use of the terms "adaptation" or "adapted" invites the questions: How was it adapted? And adapted to do what? The answers should explain how genes can be added, edited, or suppressed through bioengineering and point out the reasons for doing so, which include increasing resistance (to drought, temperature, salinity, pests, pesticides, or pathogens); or enhancing nutritional value (Golden Rice) or suppressing a problematic characteristic (the Innate potato, which is claimed to reduce bruising and the production of carcinogens when cooked); or reducing the reproductive capacities of a disease carrier (the transgenic mosquito).

With these distinctions in place, those concerned about the recent report by an agency within the World Health Organization suggesting that the commonly used weed-killing chemical glyphosate may be carcinogenic could engage in debate about the effects of widespread use of glyphosate-resistant corn and soy beans and not have the audience assume that that specific concern applies to crops genetically engineered to be pest resistant or to suppress a possible carcinogenic property.

By contrast to the muddled debate over GMOs, science has moved toward a clearer conceptual phrase by shifting from "global warming" to "global climate change." The alternative works because saying "global climate change" concentrates attention on phenomena—such as rising sea levels, changed precipitation patterns, and more extreme weather—that probably will have a greater effect on most of us than the increased temperature itself.

Where perceptions of whether global warming is occurring are affected by the temperature on the day of the survey, the tie between the experience of extreme weather and climate change doesn't suffer the same problem. In other words, a focus on "climate change" can help the public understand why, even as the globe overall warms, some areas may experience cooling. In 2014, for example, although much of the western United States was warmer than average, temperatures in the East were cooler.

Not only does it better signal relevant phenomena, but the "global climate change" frame provides a ready response to the stock line of attack against "global warming," expressed by Rush Limbaugh and Senator James Inhofe (R-Oklahoma), chairman of the Standing Committee on Environment and Public Works. After the "Snowmageddon" melted down, Limbaugh noted: "You've got people out there saying that this major ice and snowstorm has been brought about by global warming, and they apparently have no irony whatsoever that they're blaming global warming for massive winter storms." Senator Inhofe visualized the same line of argument with a picture of an igloo and an actual snowball. Where Limbaugh's major ice and snow storm and Inhofe's igloo seem to some to undercut the existence of "warming," each could comfortably raise the questions: "Is such extreme weather now more likely than in the past? If so, is climate change a probable cause?"

My next example draws together all four of the norms on which I've focused. First, some background. From 2003 to 2010, the CDC used a 2003 estimate of 36,000 flu deaths as the yearly toll taken by the flu. In 2010, a reporter for National Public Radio recalled, "When we've asked the Centers for Disease Control and Prevention for updated figures, they told us 36,000 was the best they had."

Because it was derived from flu seasons in the 1990s when the particularly lethal H3N2 strain was circulating, that number overestimated the deaths in the first decade of the 21st century. "Why did the CDC exaggerate the number of flu-associated deaths and seem to attribute the deaths to flu itself rather than attendant illnesses?" asked critics. In a polarized political environment, antagonists answer the question "why" with suggestions that scientists are self-interested. In the case of climate science, the ascribed motive involves funding and alleges that scientists who buck the dominant narrative will lose federal grant support and find their work closed out of major scholarly journals. In the case of the flu death numbers, some critics alleged that the CDC was in league with the pharmaceutical companies that profit from the vaccines.

The CDC's vulnerability to these attacks was reduced when in 2010 it changed its message to read: "Flu seasons are unpredictable and can be severe. Over a period of 30 years, between 1976 and 2006, estimates of flu-associated deaths in the United States range from a low of about 3,000 to a high of about 49,000 people." The definition is precise. Not "flu-caused" but "flu-associated," terms the CDC defines by explaining that flu was a "likely" contributor "but not necessarily the primary cause of death." The word "estimates" is used and a range specified. The limits of the CDC's knowledge are articulated. The fact that the flu season is unpredictable is reported. The CDC site also accounts for the available data by providing links to the science justifying the answers.

This CDC message honors science's disclosive, accountability, and definitional norms better than it did when it seemed to say that the flu exacted a quota of approximately 36,000 deaths year in and year out. In this change we see a dramatically altered relationship between the CDC and its intended audience.

As confirmed in a study published in 1982 by John T. Cacioppo, Richard E. Petty, and Joseph A.

Sidera, messages are capable of priming a salient self-schema, an identity, in their audience. Specifically, people who are induced to think of themselves as religious evaluate messages differently than do those who self-schematize as legally oriented. In this current CDC message, we see a first persona—the speaker implied by the cues in the message—who not only trusts the audience but respects its intelligence. The voice here is modest but authoritative. It tells the audience not only what science knows but what it doesn't know and why. The second persona in this message—the implied audience—is interested enough to navigate nuance and committed to understanding what and how the CDC knows. The trust engendered by these two personae should increase the likelihood that the audience will embrace the CDC statement that says: "The best way to prevent the flu is by getting vaccinated each year."

Science communication needs to find optimal ways to communicate what it knows, how it knows it, the limitations of the involved methods, and also the uncertainties surrounding its findings.

No hole in ozone hole story

To this point I have suggested that when science communication fails to champion a climate characterized by critique and self-correction, as in the Wakefield case, it increases the public's vulnerability to flawed science. When science communication fails to acknowledge the limitations in its data and methods, as it did when it failed to communicate the uncertainties in its predictions of "Snowmageddon," it opens modeling in general and modeling of both weather and climate in particular to critique. When it fails to feature the level of certainty with which it is asserting that 2014 is the warmest year, it risks press trust and fuels the attack that alleges that climate science has an unacknowledged ideologically-driven agenda. When it fails to account for evidence, as it did in the case of the 2013 Arctic sea ice extent increase, it invites questions about motive that can feed suspicions about self-interest or conspiratorial intent. And when science communication fails to carefully select and define key terms, as it did by conventionalizing discussion of "genetically modified organisms" and saying the measles had been "eliminated," it confuses the public and muddies the policy debate.

Having noted exemplary and problematic instances of science communication, let me end with a story about the value of science both done and communicated well.

Science came to understand the causes of ozone depletion in the atmosphere through a process of critique and self-correction. After discovering that the ozone layer was thinning in the Antarctic, scientists looked for possible causes: Volcanic eruptions. The workings of solar electrons and protons. Supersonic transport. Natural variability. None accounted for the loss. Ultimately, the hypothesis that ozone-destroying chlorine atoms were a key culprit was advanced and chlorofluorocarbons (CFCs) identified as one likely source.

The public and policymakers came to understand the problem through a well-specified analogy (the ozone layer is the Earth's sunscreen), a metaphor (the "ozone hole"), and an iconic image that capsulized the phenomenon. The notion that the ozone layer is the Earth's sunscreen is particularly apt because it points to the fact that ozone absorbs ultraviolet rays from the sun. At the same time, the analogy invokes the widely shared experience of suffering sunburn in the absence of sufficient sunscreen. Where the ozone hole metaphor mistakenly suggests a stratospheric space devoid of ozone, this personalized sunscreen analogy lends itself to the accurate conclusion that the ozone layer has thinned, a phenomenon analogous to wearing too fine a coat of sunscreen. Finally, the analogy shows the relationship between humans and the ozone layer. The Earth's sunscreen is our protector.

In addition to sharing an iconic image and a compelling analogy, scientists offered a carefully specified estimate that tied nicely to the sunscreen analogy: "[F]or each 1 percent decline in ozone levels, humans will suffer as much as a 2 to 3 percent increase in the incidence of certain skin cancers."

The story of protecting the ozone layer reminds us that within recent memory, well-communicated science resulted in Republicans and Democrats in the United States, as well as nations around the globe, working together for the collective good of the planet and its inhabitants. The Senate unanimously ratified the Montreal Protocol phasing out ozone-depleting substances. The Protocol was adopted by 196 states and the European Union. And when President Ronald Reagan signed it in 1988, he explicitly praised the role science played in this historic achievement.

The narrative is instructive for other reasons as well, among them its caution about unintended consequences. It was, after all, scientists who synthesized CFCs as a seemingly safe replacement for ammonia as a refrigerant. But it is also a story about the accuracy of scientific forecast. With the Montreal Protocol in effect, NASA reported in 2014 that Antarctic "[s]atellite and ground-based measurements show that chlorine levels are declining…." And in 2015, the Environmental Protection Agency estimated that the fully implemented Montreal Protocol "is expected to avoid… approximately 1.6 million skin cancer deaths… in the United States for cohort groups in birth years 1890-2100."

When science embodies its integrity-protective norms, scientists increase the likelihood that the knowledge is durable. The results have changed our understanding of ourselves and our world. Whereas some ancients envisioned the sky as a roof supported by giant pillars, we see it now as billions of expanding galaxies, discoveries built on the ingenuity and engineering required to imagine and create the telescope. When science communicators hew to science's norms, they not only signal that the underlying science is sound but also increase the likelihood that the public will embrace science's findings. Without public trust in science, we would not have tap water that we trust or widespread smallpox, measles, and pneumonia vaccination. The confidence that institutional leaders place in science has improved jurisprudence in the form of cautions to juries about the unreliability of eyewitness testimony. Millions will experience greater economic security in their later years because, acting on the findings of behavioral economists, their employers initiated "opt out" retirement savings structures for their employees. Put simply, trust in science matters.

In sum, let me note that the million-plus people who otherwise would have died of skin cancer may not know that they were the ones saved by implementation of the Montreal Protocol. But if science communication does its job in telling the story of science as a way of knowing, they—and other members of the public—will be more likely to realize that implementing sound science has not only enhanced understanding of ourselves and our world but has also improved our lives. Science's capacity to do so is magnified when scientists and science communicators honor science's norms by specifying intended meanings, engaging seemingly uncongenial evidence, remaining acutely conscious of the limits of their methods and data, and championing a culture of critique and self-correction. The resulting sound science, communicated well, increases the likelihood of good public policy.

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Recommended reading

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