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D I A L O G U E

The Ethics of Communicating Scientific Uncertainty

Summary

Scientific uncertainty is inevitable in many public policy debates, especially in the environmental and public health arena. Scientists, lawyers, and media professionals develop and communicate the data, information, and analysis that inform public decisionmaking. But each of these professions regards and communicates scientific uncertainty differently, in part due to varying professional norms and ethical standards. On September 12, 2014, the Environmental Law Institute hosted a webinar to examine how the fields of science, law, and journalism each address scientific uncertainty, and how core professional norms shape the way they communicate it. Below, we present a transcript of the event, which has been edited for style, clarity, and space considerations.

Jay Austin (moderator) is a Senior Attorney at ELI.
George Gray is Professor at George Washington University's Department of Environmental and Occupational Health and Director of the Center for Risk Science and Public Health.
Jim Hilbert is Professor at William Mitchell College of Law in St. Paul, MN, and Co-Director of the Expert Witness Training Academy.
David Poulson is Senior Associate Director of the Knight Center for Environmental Journalism at Michigan State University.

Jay Austin: I'd like to welcome everyone to this ELI dialogue on the ethics of communicating scientific uncertainty. My name is Jay Austin. I'm a senior attorney at ELI, and I'll be moderating today. This dialogue is a companion to a workshop[1] that ELI hosted in Washington, D.C., in September 2014. Both events were organized with support from the National Science Foundation's Paleoclimate Program.[2] The listening audience today is drawn both from participants in the workshop and from ELI's broader network of law and policy mavens.

The goal of the two events is to bring together three disparate groups—scientists, lawyers, and journalists—to discuss the topic of uncertainty and, more specifically, to compare notes on how each of these professions communicates about scientific uncertainty within their professions, between the various professions, and to a larger audience including the general public.

We're hoping to talk about the norms and standards that guide each of these groups and to try to reach a better or common understanding of how they approach complex scientific topics. That includes big topics like climate change with all the attendant uncertainty, but also reaches into essentially every area of environmental and public health policy where decisions are being made based on uncertain or incomplete information.

That's a general summary of our scope, and I think our speakers will help refine it. We've got an extremely distinguished panel of experts and teachers to get us started. In the order you'll be hearing from them, we have George Gray, a professor at George Washington University's Department of Environmental and Occupational Health and also director of the Center for Risk Science and Public Health. Jim Hilbert is a professor at the William Mitchell College of Law in St. Paul, Minnesota, and co-director of the Expert Witness Training Academy there. And David Poulson is senior associate director of the Knight Center for Environmental Journalism at Michigan State University.

I've asked each of these folks to talk from the perspective of a longtime practitioner of their respective professions and to introduce the rest of us to what it means to think about uncertainty the way that a scientist or lawyer or journalist does. After they've finished their presentations, there should be some time left for questions.

George Gray: I'm going to talk about how users of science think about uncertainty. When I say "users," I'm focusing on the risk assessment process, which is where individual acts of science done in a laboratory or out in the field or making measurements are brought together to help inform decisions that we're going to make as a society. The norm is full disclosure, and I'll show you some examples of that as we go along.

I want to start with a reminder that uncertainty is everywhere. Sometimes, it's not acknowledged, but it's revealed. For example, what if you had a concern about cell phones and brain cancer? You could look at the U.S. Food and Drug Administration's (FDA's) fact sheet, where the agency

1. Visit Environmental Law Institute, Ethics of Communicating Scientific Uncertainty, http://www.eli.org/scientific-uncertainty.
2. For more information, visit the National Science Foundation's website at http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=12727.

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has reviewed the data and concluded that they don't see an increased health risk due to radio frequency energy, a form of electromagnetic radiation emitted by cell phones. That's the FDA's point of view.

But you could dig a little deeper and look at something from the International Agency for Research on Cancer (IARC), part of the World Health Organization. IARC, after reviewing all the data, says wait, we think cell phones are possibly carcinogenic to humans. That conclusion is based on their review of the same evidence that the FDA looked at, exactly the same evidence. Similarly, we can look to the National Cancer Institute (NCI). They reviewed the same data and produced a fact sheet at almost the same time as did FDA and IARC, and NCI takes the position that they see no evidence for potential risks of brain cancer from cell phone radiation. They claim that there is no evidence from studies of animal cells or humans that radio frequency energy could be causing adverse effects.

Now I ask, how does something like this discrepancy happen? Are there differences in the science? I will tell you that all of those fact sheets came out within months of each other. The agencies were looking at exactly the same data, so maybe it's a difference in the interpretation of science. That is an important source of uncertainty: The same groups looking at the same data can sometimes make different judgments. Those judgments might be about the relevance of evidence. They might be about the acceptability of risk. So, there is uncertainty in our interpretations of science. These interpretations, this bringing together of references, is what we want to do in much of public health and environmental decisionmaking.

So, the important thing to remember is that risk really does mean there's uncertainty. If you knew something was going to happen, we wouldn't say it's risky. We would say it's preordained or something like that; it's just going to happen. In risk assessment, we see ordinary use of science. We see uncertainty about causal relationships. We've just looked at one example: whether cell phones can cause brain cancer. Sometimes, we have debates about the likelihood that something is going to happen. If you use your phone, how much would you have to use it in order to have something bad happen?

Sometimes, it's about the consequences. This might be the case in the climate change debate. Are we talking about sea-level rise of millimeters, centimeters, or meters? And the consequences of each of those sea-level rises is different. We're making predictions about those; we're uncertain about them.

One of the things that we see in the processing of science in the risk assessment world is that there are norms. There are choices that are made for how we're going to deal with that uncertainty. On the one hand, I think of science as the place where facts are found and information is developed. It is positive. It tells us "what is." On the other hand, we have policy. That's where society tries to decide the normative question of how things should be. We want to use that science information to help us understand how things should be, and what we might need to change to make more likely what we want them to be. The problem is that science does not have that ability to tell us. We have many acts of science that have to be put together, and even then they don't tell us how the world should be.

In the middle, we have what I call science policy. This is a term that originated with the National Academy of Sciences (NAS) 30 years ago when they were looking at some of these questions in what is known as the Red Book. These are choices or decisions that are made about how to deal with uncertainty when we're taking science and putting it into policy.

When science is put into policy, there are norms about how it should be done, and that brings us to the so-called Red Book, actually titled *Risk Assessment in the Federal Government: Managing the Process*.[3] It resulted from the U.S. Department of Agriculture (USDA), FDA, and the U.S. Environmental Protection Agency (EPA) going to NAS in 1983 and saying: "We want to do and use risk analysis as a way to help us make decisions. Help us think about it. Get a bunch of big brains together and help us think about it."

Well, one of the things that NAS said in 1983 is that when you do these assessments, when you take the data and characterize the risk at the end, you've kind of got the answer that you're going to use to help you make decisions. What you should do is have a description of the nature and magnitude of the risk, but you also need to talk about the attendant uncertainty. This has been recognized as part of our science processing world almost as long as we've been doing it.

Another piece of background is a memorandum issued by the Office of Science and Technology Policy together with the Office of Information and Regulatory Affairs within the Office of Management and Budget in the Executive Office of the President.[4] The memorandum presented a series of principles for risk analysis and was distributed to the entire federal government. The idea was to advise agencies that these are the goals they should be trying to meet when they're doing their risk analyses.

The memorandum was issued 30 years after the Red Book, and it's still reminding us that what's necessary is to be transparent and clear about the uncertainties in risk assessment. You need to state them explicitly. You have to talk about where they are. You have to talk about whether those uncertainties actually influence how big you think the risk is. If I use a different way of approaching my problem, do I think this risk will be bigger or smaller?

So, the norms in science and the norms in risk assessment are to get the information out there, to talk about the

3. Risk Assessment in the Federal Government: Managing the Process (National Academy of Sciences, 1983).
4. Memorandum from Susan E. Dudley, Office of Information & Regulatory Affairs, and Sharon L. Hays, Office of Science & Technology Policy, on Updated Principles for Risk Analysis (Sept. 19, 2007), *available at* http://www.whitehouse.gov/sites/default/files/omb/assets/regulatory_matters_pdf/m07-24.pdf.

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uncertainties, and to make them explicit. If we look at how we do that, we realize how hard it is.

One more report, issued in 2013 by the Institute of Medicine at NAS,[5] was focused specifically on how we make environmental decisions in the face of uncertainty. One of the things it says is that we've got to be clear about what those uncertainties are. In this case, it was prepared for EPA, where EPA puts together what they call decision documents or when they communicate with the public. They need to tell people what uncertainties are in the assessment and how they're going to be addressed, how they affect the decision at hand. The Agency has to include an explicit statement that uncertainty is inherent in science.

So, this is a group of scientists being, I think, kind of aspirational. We want to always remind people that there's uncertainty in science, including the science that is behind EPA decisions. My point here is that the norm is to get the information on uncertainty out there, be explicit, tell people about it. If it matters in the decision that an agency is going to make, then the agency must tell people about that.

Next, I want to talk about how we describe uncertainty, how we characterize it. That's one of the real challenges in moving science into decisionmaking. I'm going to talk about three different ways that we can see uncertainty described: with words, with words that have quantitative implications, and entirely with numbers.

Let's start with the first way of describing uncertainty: with words. An example of this is the system used by IARC. One of the things the agency does is gather all of the available data and numerous experts and make judgments about the likelihood that specific substances (for example, industrial chemicals, pharmaceuticals, or natural products) are going to be carcinogenic to people. Now, when IARC looks at the data, they're essentially trying to make the causal inference that we talked about: What are the things that are uncertain in assessing risks?

Because the data don't always completely support a finding that something is carcinogenic or is not, IARC has words that they use to tell us how much faith we can put in there being a causal relationship. Group 1 in the chart in this slide (see Figure 1) includes things where the agency says they believe they can causally establish that this exposure, this particular chemical, this particular pharmaceutical does indeed cause cancer in people. Those are things that they call carcinogenic to humans.

But then you get into the second group, Group 2A, where they say these things have less evidence, but they're *probably* carcinogenic. And then there's Group 2B, where IARC has even less evidence and says that the substances are *possibly* carcinogenic to humans. So, the agency is trying to express to us the uncertainty that is present in making that causal relationship, but they're doing it with words. The question is, do these words actually convey what IARC hopes they will?

Figure 1: Using Words

e.g., IARC Carcinogenicity

- Group 1: Carcinogenic to humans
- Group 2A: Probably carcinogenic to humans
- Group 2B: Possibly carcinogenic to humans
- Group 3: Not classifiable
- Group 4: Probably not carcinogenic to humans

Question: Do the words mean the same thing to everyone?

Center for Risk Science and Public Health

Let's look at the second way of presenting the information: with words that have quantitative implications. There have been studies finding that some people think "probable" is more likely than "possible," while others think "possible" is more likely than "probable." So, these words may not have the meanings that people want. In the world of climate change, the International Panel on Climate Change (IPCC) said: When we use words, what we're going to do is tell you exactly what we mean by that. So, if you look, for example, at things on the next slide (see Figure 2) that they say are "very likely," that means when they make a specific statement—and these are very specific statements, things like "sea-level rise by the year 2100 on the East Coast of the United States will be greater than one meter." If IPCC says that's very likely, it means they believe that the evidence they've accumulated suggests that it's 90% likely; there's only about a 1-in-10 chance that they'll turn out to be wrong about it, but they're not saying they know it for sure.

Figure 2: Defining Words

IPCC Working Group 1 definitions: "refers to a probabilistic assessment of some well defined outcome having occurred or occuring in the future"

• Virtually certain:	>99% probability (1:100)
• Extremely likely:	>95% (1:20)
• Very likely:	>90% (1:10)
• Likely:	>66% (1:3)
• More likely than not:	>50%
• Unlikely:	<33%
• Very unlikely:	<10%
• Exceptionally unlikely:	<1%

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IPCC has different gradations of uncertainty built into their words when they're trying to describe possible results ranging from "more likely than not," where it's essentially a slightly better than 50-50 chance, to "virtually certain." Bear in mind that "virtually certain" still isn't 100% certain; IPCC is still acknowledging that there's uncertainty

5. Committee on Decision Making Under Uncertainty, Environmental Decisions in the Face of Uncertainty (National Academy Press 2013), *available at* http://www.nap.edu/catalog/12568/environmental-decisions-in-the-face-of-uncertainty.

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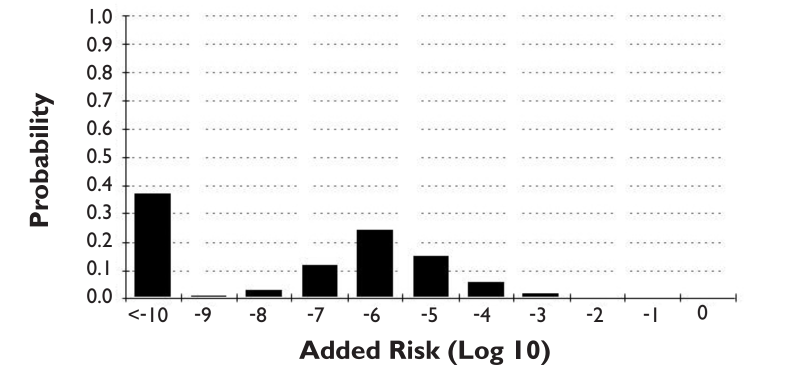
and there's a chance they could be wrong. So, here we see an attempt to be more explicit in describing uncertainty.

Now, that's hard to communicate. Take the example of a news story done by Seth Borenstein, who is a very good science reporter from the *Associated Press*. I spent a lot of time on the phone with him talking about what scientists mean when they say it's "highly likely," so it's a 95% chance that it's there. What does that mean? I believe our discussion specifically concerned the question of the human contribution to increases in global mean temperature over the last 50 years, and the query was what it means to be 95% sure that humans have contributed to global temperature increases.

Figure 3: Lifetime Cancer Risk From Drinking Water With 100 ppb of Chloroform



Source: J.S. Evans et al., *Use of Probabilistic Expert Judgment in Distributional Analysis of Carcinogenic Potency*, 20 Reg. Toxicology & Pharmacology 15-36 (1994). *Center for Risk Science and Public Health*

Seth's news story[6] even breaks it up. One of the things he said is, "What are some other things in science that have a similar level of certainty?" We in science don't describe our uncertainty in this way in very many other contexts, but someone else told him that, yes, this is more certain than scientists' certainty that vitamin supplements are good for you. But it still ends up getting twisted around. The number isn't 100%; it's 95%. And for some non-scientists, that's just not good enough. Some climate change deniers have looked at 95% certainty figures and scoffed. After all, people wouldn't get on a plane that had only a 95% certainty of landing safely. So, here's one example of how difficult it is to convey uncertainty in a situation. In the situation of climate change, it's rather contentious.

The third method of describing uncertainty, and one that's even harder to communicate, is doing it entirely in numbers. That happens in many contexts in engineering, in math, or when decisionmakers are thinking about space shots. But it hasn't been done very much in public health.

Take the example of a project I was involved in where we tried to estimate quantitatively all the sources of uncertainty in estimating the cancer risk that might come from drinking water that contains chloroform. Chloroform is a disinfectant byproduct that forms when we treat water with chlorine to kill microbes that make you sick. But chloroform has evidence of potentially being a carcinogen. This graph (see Figure 3) has the risk on the X axis and the likelihood that that's going to occur on the Y axis. I can guess that most people have almost no intuition about what the graph is telling us. It's a very complete description of uncertainty. Putting that into words would be harder for Seth than working with the IPCC's report.

One other thing we also have to keep in mind is something that worries me because I think describing uncertainty is really important. Paul Slovic, who is considered one of the fathers of risk perception research, and Branden Johnson did a study[7] in which they asked members of the public about the presentation of uncertainty in risk assessments. They found that if a regulatory agency discussed the uncertainty in risk assessments, some people thought that was good and signaled that the agency is honest, but many others thought that it signaled agency incompetence. There's a large part of the world that equates an admission of uncertainty with incompetence. In other words, they believe that if you're uncertain, it means you're not very good at doing what you're doing. If you were good at it, they say, you'd be able to tell me with certainty. That is a problematic mindset that I don't know how we'll overcome.

To wrap up my comments, what I want to make very clear is that we're always dealing with a state of uncertainty. Sometimes uncertainties are large enough that we would make a different decision, depending on which scientific interpretation we go with. Science requires that we disclose this uncertainty. The norm of science is to disclose uncertainty, and ideally to disclose the magnitude of that uncertainty. But when we do that, it puts us in, I think, a very difficult situation. Communicating that information is really, really hard.

Jim Hilbert: Listening to George's presentation, I'm reminded how different the cultures of law and science are, because I'm going to give a background (for the scientists and journalists, who may not be well-versed in these matters) of an oversimplified, brief example of how one lawyer, at least, views scientific uncertainty. I apologize in advance to lawyers for the shortcuts I might take, but I want to try to explain a few different dimensions that inform how the legal system thinks and interacts with scientific uncertainty.

First, with respect to the objectives of the legal system, the legal system has its own set of values. As Justice Stephen Breyer put it: "[A] court proceeding, such as a trial, is

6. Seth Borenstein, Associated Press, *What 95% Certainty of Warming Means to Scientists* (Sept. 24, 2013), http://bigstory.ap.org/article/what-95-certainty-warming-means-scientists.

7. Branden Johnson & Paul Slovic, *Presenting Uncertainty in Health Risk Assessment: Initial Studies of Its Effects on Risk Perception and Trust*, 15 Risk Analysis 485 (1995), *available at* http://www.glerl.noaa.gov/seagrant/ClimateChangeWhiteboard/Resources/Uncertainty/Mac1/Johnson95.pdf.

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not simply a search for dispassionate truth. The law must be fair."[8] Lawyers are not focused on the factual truth in the scientific sense so much as other professions or groups of people are because that is rarely our sole concern. Looking at four different legal values—fairness, justice, finality, and predictability—we see that the values overlap and interconnect. Let me explain what I mean.

The concepts of fairness and justice are deeply complex. We could spend a considerable amount of time working through how they are discrete and how they're defined, but let me provide a more operational definition that simplifies how they are tied together. This may sound a bit ambitious and maybe even grandiose, but in the end, the legal system needs to be sufficiently objective and equitable (at least in appearance) so that society will abide by its rules and decisions. Ultimately, the rule of law is about a system of order. We need a structure for resolving disputes that society can accept. It's far from perfect, of course, but it is sufficiently fair and just.

Finality is particularly important for our discussion today, because again this relates to the notion of order. We generally don't have the luxury of pursuing curiosity and refining our understanding over generations. We cannot have unending conflict. Legal disputes must have closure within a relatively short period. We have procedures such as appeals that can extend the time frame, and the law does change from time to time, but for individual legal disputes, we must provide some degree of closure. A related value is predictability. Lawyers are deeply rule-bound. This extends to the procedures for resolving disputes. We have an enormous number of complex rules in place so that we can, to a certain degree, understand what we're supposed to do and what behavior is acceptable. It's also importantly seen in our processes for resolving legal disputes, which I'm going to explain in a few minutes. So, scientific validity in the sense of being the factual truth is a relevant part of the legal system's values, but it's certainly not our main focus.

Let me clarify one thing before moving on. As a former civil rights plaintiff's lawyer, I'm sharing these concepts as the underlying values toward which our system ideally strives. These concepts are not necessarily the current features of our legal system, only ideals. Our legal system is not absolutely fair and we do not achieve finality in a very timely manner, but I do think that to some extent we lawyers hold these values as our guiding principles. I think the values relate in part to how we view scientific uncertainty. So, the way we strive for the values through culture and professional norms is important in this context.

But first of all, let me make sure that we're clear about the definition. We structure our legal system as an adversarial process—maybe this is a natural development from the nature of disputes. Oversimplifying a bit, we generally have two sides and our system provides an impartial referee—a judge—and in most cases a jury of peers who decide who wins the dispute. We've developed an important workaround of the structure in that the vast majority of disputes rarely get to trial. Nonetheless, the adversarial nature of the system is still intact. Despite the fact that we do settle most cases out of court, the litigation process is still very much embedded in our culture. Our adversary system requires each attorney to make the best case possible for their side, which may, as I will explain, involve not only promoting the position of their client, but challenging the arguments put forth by the other side.

So, we also may be talking about the word uncertainty. Lawyers and scientists and journalists—we may all say the same thing, but I get the sense that we are referring to very different meanings. With respect to scientific uncertainty, I think lawyers generally share the everyday meaning of uncertainty, similar to what George just said. It's unfortunate, but I think lawyers generally think of uncertainty a bit like the "incompetence" quote he shared. I feel that people tend to infer that scientists do not know *anything* about a topic just because they don't know *everything* about it.

The way this plays out is that scientists work carefully to avoid misleading incompleteness, for example. Whereas, on the other hand, I don't think we lawyers have that same problem. In fact, I believe we're comfortable with incompleteness. So, as scientists continue to question things and to explore, we lawyers on the other hand like to exploit that. I suspect we often manufacture the perception that minor differences mean more than they really should, and we try to magnify that and make uncertainty a negative.

I know this may be surprising given what I said and given what you know about lawyers, but lawyers actually do have rules of ethics. We do have obligations of professional responsibility. There are two rules that are important for our discussion, and they're somewhat at odds with each other, with one seeming to be a little more dominant. Let me explain that. Under our ethical rules, a lawyer has an obligation to present the client's case with persuasive force. That obligation, however, has a certain limit. Our duty to zealously represent, to be a strong advocate, is qualified by what we call our duty of candor to the tribunal. It's important to understand that the threshold for that duty of candor is a fairly minimal ethical standard. It means that we can't present evidence that is either known by us to be false or reasonably believed to be false. So, the bar is pretty low.

When these two rules of ethics play against each other, we as advocates in an adversarial system push to resolve any doubts in favor of our client's account. We offer interpretations of events that serve our client's position and do the best we can to present our client's version. We're comfortable doing so because we believe that the other side is going to do the same thing. The approach is viewed more as an adversarial struggle than it is some kind of objective, transparent effort to find the truth.

We do this in part because of the standards we have in our court systems, in legal burdens of proof. Most people are probably familiar with the standard in criminal cases of "beyond a reasonable doubt." I think nonlawyers are often surprised by the lower threshold required in civil cases,

8. Stephen Breyer, *Science in the Courtroom*, Issues in Sci. & Tech. (online) (Summer 2000), http://www.issues.org/16.4/breyer.htm.

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the standard of "preponderance of the evidence." Even in a criminal case, "beyond a reasonable doubt" does not mean certainty. In a civil case, what we mean by "preponderance of the evidence" is "more likely than not." So, if the scale is tipped just a bit on one side, that's enough in a civil case.

Figure 4: Judge as Gatekeeper

Researchers surveyed 400 state trial court judges in all 50 states. The survey results suggest that "many judges may not be fully prepared to deal with the amount, diversity and complexity of the science presented in their courtrooms" and that "many judges did not recognize their lack of understanding."

(S. Gatowski et al. 2001)

Figure 7-7

Understanding of *Daubert* guidelines for admitting scientific evidence: 2001

Number of judges

	Clearly understands	Understanding questionable	Clearly does not understand
Falsifiability	23	140	237
Error rate	15	40	344
Peer review and publication	284	39	77
General acceptance	328	10	62

Source: S. Gatowski et al., *Asking the Gatekeepers: A National Survey of Judges on Judging Expert Evidence in a Post-*Daubert *World*, 25 J. Law & Hum. Behav. 433-58 (2001).

Science & Enginering Indicators—2004

We are looking at things in terms of a level of uncertainty and incompleteness that may be surprising given what's at stake in so many of these cases. The way that we structure how our trials, our legal processes, proceed is also indicative. Take the rules of evidence, for example. In order for scientific evidence to come into the proceeding, we rely on experts. We rely on real people. The vast majority of cases involve some degree of scientific evidence, and accordingly most of our cases have experts such as doctors or engineers involved. That scientific evidence (nearly all of it, anyway) is made part of the trial through actual expert testimony. The part I think is interesting is that the experts are chosen by one side or the other. This is where things get a little murky.

We have a formal standard that suggests that experts are meant to be impartial. Their duty is to assist the court in understanding complicated matters. But in practice, the reality is, as you'd expect, experts are perceived as, and become, a much more partisan part of the trial than that aspiration of impartiality. Most other countries have experts assigned or chosen by the court. In the United States, the parties pick the experts. Keeping in mind our ethical obligation to robustly advocate for our clients, we often pick experts that are most favorable to our client's position. We do not necessarily disregard the quality of the experts or the quality of the science, but I think our paramount concern is whether the position of the expert supports our client's case. That's an important standard to point out.

Talking about expert scientific testimony, we do have some standards in place to preserve a certain level of quality. We refer to the case of *Daubert*.[9] There are some other cases that matter in other states, but the principal standard that most people are familiar with is the U.S. Supreme Court's *Daubert* standard. It's complicated, but essentially it boils down to: Experts must qualify as experts in order to be allowed to testify, and their expert opinion must be relevant and valid and reliable.

So, the Court has itself set up a structure where we have certain checks on the use of proper scientific evidence in the legal process. The first check is the lawyers themselves. We have an ethical obligation not to present false evidence. That's a pretty low standard, but nonetheless we are essentially the first line of defense against false evidence. That said, we have, you could argue, a pretty strong incentive to cherry-pick (to some extent) what is good for our side and to avoid or even undermine what might be good for the other side.

We have a jury system. We have a fact finder, somebody who makes a decision at the end of the proceeding based on what they have heard in terms of the science. The fact finder is presented evidence through this adversarial system where the science that is presented to them is essentially mediated through lawyers. And, importantly, we have judges as well. I want to mention this quote from the *Daubert* case, because I think it explains our philosophy in terms of how we balance this reality: "Vigorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof are the traditional and appropriate means of attacking shaky but admissible evidence."[10]

That's how the judicial system handles uncertainty: by cross-examination, presentation of contrary evidence, and the parties' burden of proof. In the *Daubert* case, the Supreme Court is saying that that's essentially the check on the system. We're certainly going to make sure that the experts who come in are qualified. They've got to have the background. The opposing side is given a chance to exclude the scientific experts or exclude portions of their testimony based on aspects that may not be expert opinion.

The opinion that the experts are going to give must be relevant to the case and it must be valid and reliable, and that's a fairly complex determination. But the Court is not as interested in excluding evidence; instead, it's being careful. The *Daubert* standard was meant to be in some respects a liberal standard, so that the process of the adversarial system would work out any issues or trouble we might have with the science.

With that structure, with *Daubert* and with other expert testimony standards, we've essentially made the trial judge the gatekeeper of scientific information. Judges are highly learned. They are extremely qualified to be judges. But as

9. Daubert v. Merrell Dow Pharmaceuticals, 509 U.S. 579, 23 ELR 20979 (U.S. June 28, 1993).

10. 509 U.S. at 596.

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one study[11] in the table shown on the slide here suggests (see Figure 4) (and I think it aligns with lawyers' sensibility of what kind of background most judges have), it's not clear yet that judges have what we might expect as sufficient scientific literacy to be in that position.

This study is interesting. It asks about some of the terms that come up in the *Daubert* test. If you look at issues like scientific "peer review" and "general acceptance," those were terms that were familiar to the 400 state trial court judges who were surveyed. They knew what peer review meant in a general sense. They understood general acceptance in a general sense. But the terms "falsifiability" and "error rate"—those they did not understand. The study suggests that, although we have entrusted a lot of oversight to our trial judges on what is appropriate science for each case, the level of scientific literacy among judges is probably inconsistent at best.

To summarize my comments: From my lawyer perspective, uncertainty, scientific uncertainty in particular, is primarily a tool for advocates to challenge the science of the other side, almost as a weapon in the adversarial battle between two parties in a legal dispute.

David Poulson: This dialogue gives fascinating, different perspectives on the question of uncertainty. I collected a couple of really good quotes from the prior presenters.

What I want to talk about are some of the unique challenges that journalists face in trying to communicate uncertainty. I have to confess that ever since I was invited to participate in this dialogue, there's been a phrase going through my head: "A lawyer, a scientist, and a journalist walk into a bar. . . ." I'm going to take my best shot at completing the rest of it.

What I would suggest is that the lawyer walks in and orders three different bottles of the bar's best whiskey. He reads the label slowly and carefully, he peers deeply into each of the liquids. Then finally he selects one and orders a drink. The bartender is a little exasperated and says, "Are you *certain*?" And the lawyer says, "Just a minute." He gets up, he leaves the bar. Then he brings in the bartender from down the street and says, "This independent expert verifies my choice." The first bartender sighs and pours the drink.

Then the bartender turns to the scientist. The scientist orders three empty shot glasses and pours into them a little from each of the bottles that the lawyer had asked to have brought over to the table. The scientist takes out of his own pocket a bottle and puts a drop of liquid from it into each glass. And when one turns purple, he points to it and says, "I'll drink from that one." The exasperated bartender says, "Are you *certain*?" The scientist says, "Well, science tells me that I am."

So, the bartender sighs and pours the drink. He turns to the journalist and asks, "What do you want?" "Well," says the journalist, "I'm *certainly* thirsty. Give me a drink!"

Okay, so the question that I've been asked to address is: What are journalistic norms for communicating uncertainty? In many ways, that's a tough one. There are professional journalism societies and news organizations that have codes of ethics. I can tell you that my university's journalism school will kick you out of the program and out of the university for certain infractions of its ethics code. But there's not a universal code of behavior, and certainly not an agency that's going to yank your legs if you violated the code. It has a lot to do with our First Amendment rights.

But there's something else going on right now that's perhaps more significant. Journalism is undergoing a significant upheaval and redefinition. We won't get into that here. But it's difficult to name norms that are large enough to encompass the way everyone practices journalism. I'll give you an example here: Rush Limbaugh.

We can argue about whether this guy is a journalist, and he'd argue that he is something better than a journalist. But Rush and others like him certainly are taking up a lot of the time and attention that people have for consuming media. They speak with great authority to people who long to be told what to think, and they have the ability to persuade. This may take precedence over a pretense at accuracy. Nonetheless, a George Mason University study[12] showed that Rush Limbaugh has devoted more time to the arcane science of climate models than many mainstream media folks have. I'm not saying it's quality time. I'm saying it's more time.

While this is going on, and while it seems as if anyone can now claim to be a journalist, the longtime best source of original professional informed reporting is in significant decline. There are simply fewer journalists, particularly on specialty beats like the environment. In fact, most of them may be in this audience.

That said, we can agree on at least three aspirational norms. "Fair" and "accurate" are the easy ones. They may be difficult to implement, but they're easy to understand. The tricky aspirational norm is the third one, "engagement." That's a burden journalists bear that lawyers and scientists don't share. Judges *have* to read lawyers' briefs. Journal editors and fellow scientists *have* to review the scientist's studies. But the journalists lack the luxury of very informed audiences who are paid to read what they write (although I guess I just learned that maybe judges are not as scientifically literate as perhaps I hoped they were).

Journalists must convince their audiences, who may well be clueless, to voluntarily consume what they produce. They must write the story that demands to be read, and sometimes that makes it difficult to handle uncertainty. I will give you some examples of engagement strategies. I don't mean to give you Journalism 101, but I want to touch base with at least these three concepts: "short," "simple,"

11. Sophia I. Gatowski et al., Asking the Gatekeepers: *A National Survey of Judges on Judging Expert Evidence in a Post-*Daubert *World*, 25 J. L. & Hum. Behav. 433 (2001).

12. Karen Akerlof et al., *Communication of Climate Projections in US Media Amid Politicization of Model Science*, 2 Nature Climate Change 648 (2012), *available at* http://www.nature.com/nclimate/journal/v2/n9/full/nclimate1542.html.

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and "conflict." There are certainly many others. The first two, shorter and simpler, are often dismissed and misrepresented by others as "dumbing it down." But in defense of journalists, I will tell you that it takes incredibly smart people to write complex things simply.

Let's look at the challenges of writing short, starting with this sentence: "'The planet is warmer,' said the study."

I'm going to take you into the construction of a tiny piece of a news story. This is an example of the bloat of a short sentence. It starts as a nice and easy read, but many critics would argue that it is much too simple. For one thing, what kind of study are we talking about?

So, we'll clarify it: "'The planet is warmer,' said the scientific study."

Ah, it's a *scientific* study. Well, that tells us marginally a little more. But what is a scientific study?

So, let's add some additional clarification here: "'The planet is warmer,' said the peer-reviewed scientific study."

Yes, now we've hit that gold standard the scientists are always pushing us to pursue, the gold standard of peer review. We've just satisfied the scientist, but now we've got the journalist back in the picture. The journalist is worried. He wonders if anyone knows what "peer-reviewed" means.

So, we add this perspective to the sentence: "'The planet is warmer,' said the peer-reviewed scientific study. Peer review means that other scientists independently verified the quality of the study's methodology prior to its publication."

Now, we're into an explanation of peer review. And the news story begins to bog down.

Suppose the journalist writes this: "'The planet is warmer,' said the study, which was not peer-reviewed. That means that other scientists did not independently verify the quality of the study's methodology prior to its publication."

Ah, the story is not peer-reviewed. Does that make the news story useless? Maybe the journalist shouldn't be writing the article at all. (This is what the reader is thinking.) But aren't there good studies that are not peer-reviewed, and conversely poor studies that are peer-reviewed? Shouldn't we explain the discrepancy? Isn't there a big debate over it? But wait, do readers really care about this debate? And most importantly, have they quit reading as we explore that issue? So, we can see that how much detail to go into on this point may be just one of many such points where journalists must weigh what to explain throughout the construction of a news story.

So, simplifying is powerful communication, but it's tricky when it comes to expressing uncertainty. The Union of Concerned Scientists produced a graphic[13] to show how various emissions scenarios will affect the climate of my state, Michigan. It's meant to be a simple communications tool, but it's a little messy. For the sake of sanity, just focus on the example that indicates how Michigan's climate could someday be like Oklahoma's climate is today if one particular scenario were to bear out.

I saw a presentation where a scientist presented this graphic to a group of journalists, pitching it as an effective communication strategy, but then he had to back off a bit. He immediately told the journalists that, well, this is just a little too simplistic because it doesn't really take into account areas where he sees no variability or extreme weather. He was comfortable presenting it to a bunch of journalists because he could explain its uncertainty, but when the journalists pressed him by saying "We want to use this in our news story," he had second thoughts about them reproducing it for their readers, simply because he couldn't explain all these caveats to individual readers. He couldn't show up to explain them.

Another example is the famous "hockey stick" curve, a graphic that is frequently disseminated to both scientific and lay audiences by the United Nations Environment Programme.[14] Scientists love it because it's chockfull of information. It shows variability and data produced as proxy, real, and projected measurement. It indicates multiple climate change models and the variation within each. It illustrates uncertainty within a general trend. You can spend a lot of time analyzing this graphic. Yet, when researchers at my university, Michigan State University, asked general readers to estimate temperature change over time from this graphic, only 40% got it right and most of them greatly underestimated the amount of change.

So, the researchers reduced the cognitive overload and developed a simpler version of the graphic (see Figure 5). This time, 64% of people surveyed got it right. Now, 64% isn't great, but it's better than 40%. Those folks who got it right spent a lot less time figuring it out. But many scientists will call this very simple graphic deceptive because it fails to show variation, or uncertainty, in multiple models. Yet, the researchers in the study argue that the complex graphic is actually much more deceptive because no one understands it.

Lastly, I want to touch on "conflict" as creating problems with reporting uncertainty. Conflict is often associated with newsworthiness. It certainly can generate engagement with readers. In fact, we encourage journalists to explore points of disagreement in all their news stories. But this is where journalists get beat up with that old "false balance" argument in reporting climate change.

In a survey we did at Michigan State maybe four or five years ago, 92% of the journalists we surveyed, who self-identified as at least sometimes reporting on the environment, agreed that there's scientific consensus on climate change. But—and this is what drives people nuts about journalists who persist in reporting what the skeptics have to say—in the survey of those exact same journalists, over one-third still thought that the skeptics' view should appear somewhere in their stories. There's a caveat here because they might believe that the skeptics' view should appear

13. See slide 45 from the PowerPoint presentation, available at http://www.eli.org/ethics-of-uncertainty.

14. Philippe Rekacewicz, UNEP/GRID-Arendal, *Variations of the Earth's Surface Temperature: Year 1000 to 2010*, *in* Vital Climate Change Graphics Update (2005), *available at* http://www.grida.no/graphicslib/detail/temperature-trends-and-projections_5870.

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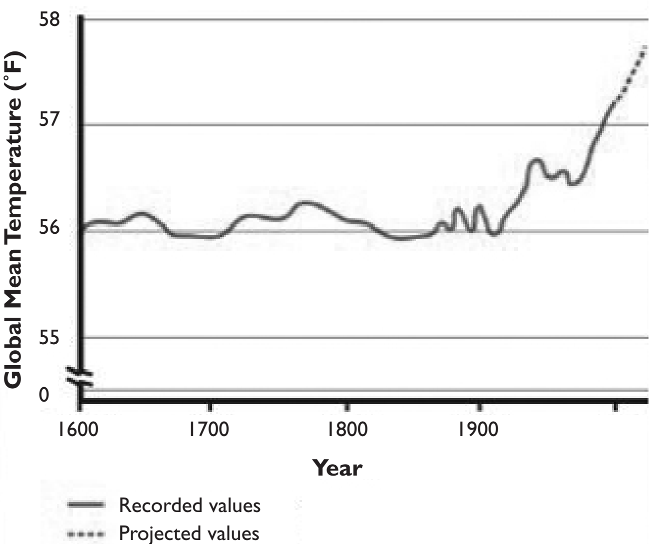
Figure 5: 400 Years of Climate Change



Source: Gregory Ruetenik et al., *Analyzing Visual Representations of Climate Change*, 43 Abstracts With Programs 571 (Geological Society of America 2011).

for no other reason than to provide an opportunity for the journalists to explain why the skeptics are wrong.

Why does this happen? In a survey, we asked reporters what is the single greatest obstacle they have in covering climate change, and far and away, it's lack of time. Lack of time can lead to something that a colleague of mine calls "dead-rat journalism." When you lack time to critically analyze competing claims, particularly in a field with which you're unfamiliar, you tend to downstream the critical thinking to the readers. Remember that the dwindling supply of journalists are asked to be experts in many topics that they cover. My colleague says a story is dropped off at the doorstep like a dead rat that just lies there without any context. Readers are left to weigh multiple perspectives themselves. The journalist in essence has written a but/however story. So and so says this, and so and so says that. *But* so and so says this, *however* so and so says that. The reporter is saying in essence: "I don't know who to believe, readers, so you figure it out."

Critics, I believe, have made too much of this observation in climate change reporting. We're not nearly as bad in doing that as some people seem to insist. A lot of smart journalists report excellent context. They are aware that balance is not the goal of a news story, especially when it gets in the way of truth. Balance is not the same as fairness or accuracy.

I have a geologist friend who posed this challenge: The earth is round. Who do you talk to for "the other side" of this story? My reply is, well, there is no other side of the story. She says, oh yes there is: The International Flat Earth Society. And then she asked me: When are you journalists going to start treating climate skeptics like the flat-earthers? My answer is: not soon. And here are my reasons for that.

Journalists who lack the expertise and the time to develop a story may have to compensate for that lack more often than they'd like to. They cover a political candidate one night, a court ruling the next night, and climate change the next. Sometimes, they have little choice but to attribute information to a source and leave it up to the reader to weigh its credibility. Sometimes, but not all the time.

Of course, climate-change skeptics also are part of a high-profile political story. They're noisy; how can they be ignored? This is not just a science story.

Lastly, there's what I call the Rachel Carson argument. This is an argument that applies less to climate change, where the consensus is so overwhelming, than it does to many other stories, but it goes something like this: When Rachel Carson raised an alarm about pesticides, she was attacked as a lightweight who did not know what she was talking about. She wasn't considered a real scientist because, after all, she was just a woman. The only thing Rachel Carson had going for her was that she was eventually proven to be right. Journalists are afraid of ignoring the minority view because they know that someday it might be right. Journalists will certainly report consensus as they pursue truth, but many don't find consensus particularly comforting.

At their best, when allowed to, journalists can handle uncertainty very well. They investigate and weigh arguments. They report the bias of those making the arguments. They're smart enough to find out who is financing the research. They can lead readers to truth, or at least to the recognition that the truth is complex. But they have to do it while engaging people with the unpopular pastime of wrestling with uncertainty. If they don't do that, it's not journalism.

Jay Austin: We've got about 20 minutes for questions. I'd like to start by asking the panel members a question very similar to something Dave touched on. I agree with Dave that it probably is a topic for an entirely separate dialogue, but nonetheless I would ask folks to tackle it here.

The question is how technology, and specifically the Internet and social media technology, have affected how your profession deals with uncertainty. On the one hand, the Internet was largely created to improve and disseminate scientific communication. On the other hand, as Dave points out, it's been hugely disruptive to traditional models of journalism, and for that matter, publishing as a whole. I think that law and courtroom practice are (so far) possibly the least directly affected or the most insulated from this revolution. But even there, it seems that public perceptions of legal issues are being altered by the technology, or that in some sense we're seeing accelerated reactions to law and policy problems as they arise in real time in the court of public opinion, which I think at least indirectly has some effect on what happens in legal fora. I'd like each of you to give your take on what the pros and cons have been of this technological revolution or the net effect of it for you and your colleagues' work, and how it affects how you communicate scientific uncertainty.

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George Gray: That's a very provocative question. The technological revolution has good news and bad news. One of the things that's clearly happened with the growth of technology—not necessarily the Internet, but just computing power and such—is that tools were developed to allow scientists to characterize uncertainty, and to model it, and to display it in a much richer way and much more quickly and get a lot more complexity into it.

So, let's do a better job of understanding where uncertainty comes from and why it matters. My concern with the way that it's received in the world is that I think the Internet has a tendency to encourage echo chambers to seek out people who think like them. What tends to happen is that where there are sources of uncertainty and alternatives and interpretations, you get communities built around each one and you never talk across them, and people don't understand how or whether science can help resolve these, and instead it simply becomes an opportunity to whip everyone up into a foaming froth and not advance things as much as one would like to see.

Jim Hilbert: I'd like to echo George's first point. Courtroom technology has improved so dramatically in the last generation that scientists who are testifying as experts are able to use that technology, as they are doing in the regular world, in a much richer format to help them make their points. I think that's a positive.

I worry that people now have greater access to information that's unfiltered and they may think they know something about something. They may rely less on experts. Fact finders like juries (or maybe even judges in some limited cases) who have done their own research on a topic on the Internet and think they know something, they may be likely to fall into one of those echo chambers that George mentioned. Then those fact finders, for reasons that are still to be defined, rely more on what they've read on the Internet than on what they might hear from an expert in courtroom testimony. That can be a problem in a legal process where we're using experts to try to translate complex scientific information.

The last piece, and I think this is very good news, is that technology has connected people and given them a chance to organize around issues where the law and a legal forum can help. They can say maybe it was the release of the chemicals that caused X, Y, and Z to occur, because now through the Internet people are able to see similar patterns or situations in other places. They're able to connect with organizations or attorneys who do this kind of work in a way that 20, 30, 40 years ago was much, much harder. I do think that's a real positive.

David Poulson: Yes. And I'll say that, separate from the whole economic business model, in terms of journalism, it's both good and bad. I would hope that it weighs more toward the good. What was really exciting to journalists initially was the concept of including links in stories. You could write a news story that attempted to explain, boil down a court decision or boil down a scientific study, and basically say to readers: "Hey, if you don't believe my take on this, here's a link to the study. Read it yourself." That's an exciting development because it allows greater depth than we would have otherwise. The only caveat is that there's some thought that, well, that's fine you've got links, but readers never follow them. It takes a motivated reader to go after the information in the links, but at least we can offer that to them.

And then the engagement piece, talking about the development of multimedia and different ways of explaining complex issues to the public. It's nice to have more tools in the toolbox. Interactivity: We can hear back from our readers; we can carry on a conversation. That can be exciting because our readers can plug a hole in our story. A reader can raise a question that we didn't raise before, and we can even respond. We can say: "You know, I never really thought about that, that's an interesting point. And by the way, I talked to so and so who has something relevant to say about what you raised." Of course, on the other extreme, we have those ranting comments at the end of newspaper stories where we don't think we're really changing anybody's mind. Readers have pretty much made up their mind and there's not a lot we can do about that.

The issue of focus is intriguing, too, because there is excitement when we can really concentrate on a topic like the environment. But then you end up kind of developing a ghetto of maybe environmental people who are really interested in talking about the environment, when the great unwashed out there should be exposed to those issues, but they aren't. Your old broadsheet newspaper used to expose you to a lot of subjects, including subjects that you didn't know you were interested in.

Jay Austin: An audience question for Dr. Gray. Does Dr. Gray see any particular constraints to how scientists discuss uncertainty that derive from their ethical code? Doesn't the scientific method also have a kind of adversarial approach in that it requires scientists to challenge each other in their work?

George Gray: That's a great question because it is sort of like an adversarial system in that findings are put out there. Findings go through peer review, which is a process of intense scrutiny. Then people may decide to challenge. They may try to replicate a finding and not be able to do it, and that leads to conflict and challenge. But I think when it comes to questions where we're trying to use science, rather than focusing on an individual act of science or a particular study or a particular data-gathering effort, we're looking at the synthesizing efforts.

Getting the uncertainty out is the thing that most people really think is important. It's essentially laying out the scientific evidence in a systematic and clear way so that people really use that information. Often, these are people in regulatory agencies and maybe in the courts who are

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going to make important decisions for people's lives and really have an understanding of the state of knowledge. Sometimes, that involves conflicting data. It's not at all unusual to find one study that says a certain chemical is harmful, and another that says we looked everywhere and found absolutely no signs of harm. That's important for someone to know. It makes that chemical different from one where every single study concludes that this is something to be worried about.

So, I think there is a difference between people doing specific scientific investigations and situations where we bring, usually through something like risk assessment, a large body of science together where we're trying to say what our state of knowledge is today.

Jay Austin: Question from Seth Borenstein largely directed to George, but I believe, Dave, you might be able to weigh in from a journalistic perspective as well. Seth asks, "What about a combination of the uncertainty communications that George Gray uses? I like the IPCC method, but I then added comparison for context. Is the best way to communicate scientific uncertainty by comparing it to other similar uncertainty factors? And is that a good solution?"

George Gray: I think that that attempt in Seth's article was a really good one. It's somehow putting it into context. The problem is there are very few other parts there—or if it's science, do we actually do that well? I forget what I gave him as a comparison, but there are many things where you could say there are certain uncertainties as the example there. Vitamins are good for you. Everybody accepts it. But there's a chance they're not. I mean, think how often we've had eggs turn out to be good for you, then bad for you. Or salt. There is real uncertainty in science.

Something that I think is interesting, and this goes back to the very first question, is that there may be graphical ways to help people understand. It's different from the probability distribution on my slide. The world of medical decisionmaking thinks a lot—because of the ethics of informed consent—about how you can help people understand the uncertain risks that come as a side effect with a drug or as a complication with a surgical procedure or with what might happen if you become part of a medical study. Using different kinds of visual techniques might help people understand probability and uncertainty. That might be a place where we could combine or take advantage of these new technologies to mix in words and pictures to convey uncertainty more clearly.

David Poulson: I have nothing to add other than to say: "Go, Seth!" I mean, that was great stuff. It sticks in my mind as something I've used in class and certainly should be part of a journalist's toolbox. I thought that was a great way of conveying uncertainty.

Jay Austin: We're at the end of the questions. Panelists, are there any final comments you care to make to sum up, or comments on the presentations of your co-panelists?

Jim Hilbert: I have a comment with respect to the last question. It occurred to me that as we communicate about uncertainty, in the legal context, we have to be really careful about which audience we're talking to. When lawyers counsel scientists on how to communicate their science to policymakers who have some expertise, that's one audience. But if it's in a courtroom and it's to a jury with different levels of sophistication in terms of scientific literacy, you have to be very, very careful about that. In fact, some lawyers who frequently work with experts will tell them things like: "Pretend you're talking to an eighth-grader or a sixth-grader. Think about how this enormously complex concept can be communicated in a way that the jury is going to understand." What's lost in that translation is really interesting, I think.

Jay Austin: Thanks, Jim. Seeing no final questions or comments, I'd like to express great gratitude to our panel, from all of us at ELI and from our colleagues at the National Science Foundation's Paleoclimate Program. Thank you all.