Communicating Scientific Uncertainty: A Lawyer's Perspective

by Michael Traynor

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Summary

Scientific uncertainty is both inevitable and the source of communication challenges: science, law, and journalism each have different views of and uses for uncertainty. When dealing with uncertainty on policy issues such as climate change, these differing perspectives can lead to misunderstanding, controversy, and gridlock. The author offers his reflections on the legal process and legal ethics as applied to issues of scientific uncertainty. He concludes that lawyers can strengthen their ability to serve clients and the public if they enhance their understanding of scientific uncertainty and obstacles to communication and learn ways to communicate more effectively.

I. Introduction

Humans instinctively want certainty. The world, however, is uncertain. Communicating intelligently is an everyday challenge. The challenge is daunting when the subject is technical, when statistical correlation may be confused with causation, and when there are asymmetries among communicating parties. At any time, wide variations in skills, knowledge, information, experience, cultural identification, and beliefs may impede effective communication.[1] And over time, even a message that once successfully reached an audience may lose reliability; for example, peer-reviewed scientific studies published by respected journals that cannot be replicated.[2]

Recognizing that there will be different views, I aim simply to provide the perspective of one lawyer who has attempted to grapple, in practice for many years and through the American Law Institute (ALI),[3] with various

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1. ELI has recently launched a new website on the ethics of communicating scientific uncertainty, *available at* http://www.eli.org/scientific-uncertainty (last visited Jan. 1, 2015).
2. *See, e.g.*, Editorial, *Announcement: Reducing Our Irreproducibility*, 496 Nature 398 (2013); Editorial, *Error Prone*, 487 Nature 406 (2012); Editorial, *Further Confirmation Needed*, 30 Nature Biology 806 (2012); Bruce Booth, *Science Being Studied: Replication, Publication, and Resource Allocation*, Forbes, Nov. 8, 2013 (also discussing the Reproducibility Initiative); George Johnson, *New Truths That Only One Can See*, N.Y. Times, Jan. 20, 2014. On recent efforts to improve reproducibility, see, e.g., Editorial, *Journals Unite for Reproducibility*, 515 Nature 7 (2014); Jonathan W. Schooler, *Metascience Could Rescue the "Replication Crisis,"* 515 Nature 9 (2014).
3.

> The American Law Institute was founded in 1923 in response to concerns that the body of American common law was both uncertain and complex. . . . The ALI addresses uncertainty in the law by developing restatements of legal subjects for use by courts and lawyers applying existing law. . . . The ALI also examines and analyzes legal areas in need of reform. . . .

American Law Institute, Annual Report 2013-2014, at 4 (2014). The annual report and other information about the ALI and its projects are available at http://www.ali.org (last visited Jan. 1, 2015).

issues of uncertainty and communication. My main point is simple: Lawyers can strengthen their ability to serve clients and the public if they enhance their understanding of scientific uncertainty and obstacles to communication and learn ways to communicate more effectively. In addition, this Article considers, among other matters, the ethical obligations of a lawyer in this regard, including the obligations to be competent and to exercise independent judgment.

This Article is not intended, however, to propose law reform measures or changes in ethical duties. It is not intended to be exhaustive. It does not address important recent movements such as the People's Climate March.[4] It focuses primarily on the fundamental challenge to scientists, journalists, and, particularly, lawyers of communicating uncertainty in the context of climate change. It also highlights an assortment of other issues for comparison or contrast and provides a few selected references to subjects that are addressed in significant and substantial detail by other scholars.

Uncertainty exists in many fields. Economics, medicine, national security, and poker are examples, to name just four in addition to science, journalism, and law. Uncertainty is inevitable.[5] Uncertainty also "is a way to manage scientific ethos and provide grounds for the public to participate in scientific controversies."[6] In the ensuing pages, I discuss uncertainty in concept and context (Part II), illustrate the legal system's various ways of coping with uncertainty through standards, rules, ethical requirements, and counseling norms (Part III), describe obstacles to communicating about scientific uncertainty among professions and to the public (Part IV), and conclude with some positive examples of effective communication (Part V).

II. Uncertainty in Concept and Context

A. *Various Concepts and Definitions of Uncertainty*

Definitions of uncertainty often refer to probability, which depends heavily on data from the past and estimates for the future. Moreover, various existing matters are not yet discovered and various future effects are not predictable. There are many concepts and definitions of uncertainty.

The Working Group on Mitigation of Climate Change for the Intergovernmental Panel on Climate Change (IPCC) states, for example, that "'Uncertainty' denotes a cognitive state of incomplete knowledge that results from a lack of information and/or a disagreement about what is known or even knowable."[7] The Guidance Note for IPCC lead authors uses qualitative terms such as "likely" or "unlikely" and provides corresponding quantitative probability percentages (a probability distribution) in a Likelihood Scale.[8]

The U.S. Climate Change Program in a 2009 report discusses sources and types of uncertainty, the importance of quantifying uncertainty, cognitive challenges in estimating uncertainty, statistical methods and models, methods for estimating uncertainty, propagation and analysis of uncertainty, making decisions in the face of uncertainty, communicating uncertainty, and guidance for researchers.[9]

A recent RAND report describes the concept of "deep uncertainty" as occurring "when the parties to a decision

4. My good friend and Earthjustice colleague Edwin Matthews recently wrote about the People's Climate March and the thousands of similar gatherings in many cities around the world. *See* Edwin Matthews, *People March for Climate Change—And Democracy*, Litchfield Cnty. Times, Sept. 23, 2014 ("[F]or success we depend urgently on our leaders to pay attention and lead and on our governments to implement bold collective action to change our direction."), *available at* http://www.countytimes.com/articles/2014/09/23/opinion/doc5421b7388e9e0046648945.txt?viewmode=fullstory (last visited Jan. 1, 2015). In a documentary film, *The Race to Save the World*, Joe and Harry Gantz are currently filming the growing involvement of individuals in the climate change movement and the impact that climate change has on their lives.

5. In the preliminary description of error analysis in his leading text, John R. Taylor states: "In science, the word *error* does not carry the usual connotations of the terms *mistake* or *blunder.* Error in a scientific measurement means the inevitable uncertainty that attends all measurements." John R. Taylor, An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements 3 (2d ed. 1997).

> Error analysis is the study and evaluation of uncertainty in measurement. Experience has shown that no measurement, however carefully made, can be completely free of uncertainties. Because the whole structure and application of science depends on measurements, the ability to evaluate these uncertainties and keep them to a minimum is crucially important.

Id. See also Ifan G. Hughes & Thomas P.A. Hase, Measurements and Their Uncertainties: A Practical Guide to Modern Error Analysis 7 (2010) ("A crucial part of any experiment is to measure and quantify the uncertainties in measurement. . . . A precise measurement has a small relative uncertainty").

6. Andrew C. Revkin, *How Rachel Carson Spurred Chemical Concerns by Highlighting Uncertainty*, N.Y. Times, Sept. 12, 2012, *quoting* Kenny Walker & Lynda Walsh, "*No One Yet Knows What the Ultimate Consequences May Be"—How Rachel Carson Transformed Scientific Uncertainty Into a Site for Public Participation in* Silent Spring, 26 J. Bus. & Tech. Commc'n 3 (2012). Andrew Revkin also quotes a "valuable capping thought" from Kenny Walker:

> If you can be accurate yet still use uncertainty to frame the impact, you're not only trustworthy, you're interesting, and you effectively shape the terms of debate. We've all got to stop ignoring uncertainty, and instead learn to manage it. Fifty years later, I think that's one of the primary lessons of "Silent Spring."

See Kenny Walker, "*Without Evidence, There Is No Answer": Uncertainty and Scientific Ethos in the Silent Spring[s] of Rachel Carson*, 2 J. Envtl. Human. 101, 114 (2013).

7. Intergovernmental Panel on Climate Change (IPCC), Working Group III, Mitigation of Climate Change, Integrated Risk and Uncertainty: Assessment of Climate Change Program Policies 6 (2014).

8. *See* IPCC Guidance Note for Lead Authors of the Fifth Assessment Report on Consistent Treatment of Uncertainties 3 (2010):

Term	Likelihood of Outcome
Virtually certain	99-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	3 to 66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

For a critical analysis of the IPCC Guidance Note, see Carolina E. Adler & Gertrude Hirsch Hadorn, *The IPCC and Treatment of Uncertainties: Topics and Sources of Dissensus*, 5 WIREs Climate Change 663-76 (Sept./Oct. 2014). *See also infra* note 38.

9. U.S. Climate Change Science Program, Best Practice Approaches for Characterizing, Communicating, and Incorporating Scientific Uncertainty in Climate Decision Making (2009).

do not know—or agree on—the best model for relating actions to consequences or to the likelihood of future events."[10] Roger Cooke, of Resources for the Future, in an important discussion paper defines and contrasts "deep and shallow uncertainty," "with regard to messaging the uncertainty about climate change."[11]

According to Leonard Smith and Nicholas Stern, writing about uncertainty and climate policy:

> Policy-making is often focused on cases where there is confidence that major changes are likely to occur, while there is very limited ability to quantify the impacts of those changes for people. There are at least four relevant varieties of uncertainty in this case . . . and they are not mutually exclusive: imprecision, ambiguity, intractability and indeterminacy.[12]

George Marshall, founder of the Climate Outreach and Information Network based in Oxford, England, states that uncertainty is "likely to be a major reason why people ignore climate change,"[13] and goes on to note: "The main source of public uncertainty, though, relates to the widespread perception that scientists are themselves divided on the issue."[14]

Leendert van Bree and Jeroen van der Slujs describe an "uncertainty typology," stating that:

> There is a distinction between various sources of uncertainty: decision uncertainty (*e.g.* related to human decisions that determine future GHG and aerosol particle emissions), natural variability (*e.g.* related to the internal variability of the climate system), and scientific uncertainty (*e.g.* related to data gaps, incomplete understanding or insufficient computing power of climate and climate impact models).[15]

In addition to variations among concepts of uncertainty, there are human considerations and frailties. For example, we use shortcuts to make decisions.[16] We are not good judges of probability. We are not rational utility maximizers. We may not perceive or appreciate probability distributions. We routinely overestimate some outcomes, whether great ones such as winning the lottery or bad ones such as becoming infected with the Ebola virus, as compared to more mundane causes of death, disease, or injury such as the flu or traffic accidents. We routinely underestimate some outcomes such as climate disaster. We may be more likely to misjudge probability if we are far removed from risk or when our individual behavior (as distinguished from collective behavior) may have only an infinitesimal

10. RAND, Research Highlights, Making Good Decisions Without Predictions: Robust Decision Making for Planning Under Deep Uncertainty, *available at* http://www.rand.org/pubs/research_briefs/RB9701.html (last visited Jan. 1, 2015). *See also* Paul K. Davis, *Lessons From RAND's Work on Planning Under Uncertainty for National Security* (2012), *available at* http://www.rand.org/pubs/technical_reports/TR1249.html (last visited Jan. 1, 2015):

    > It may be helpful to start with definitions and because risk and uncertainty are tightly bound in common language to introduce them together. Uncertainty: A primitive concept meaning a state of limited knowledge or of indecision. It is useful to distinguish between normal uncertainty and deep uncertainty. The former applies when we understand a phenomenon and how to value outcomes. Under this condition we can address uncertainty with standard versions of sensitivity analysis or probabilistic analysis . . . . Deep uncertainty is the condition where we do not know with confidence the model by which to describe the phenomenon of interest, the relevant probability distributions, or how to value the outcomes. Risk: the potential for something adverse to happen. The extent of risk depends on the likelihood of bad developments and the consequences if they occur. . . . A first step in dealing with uncertainty is confronting its existence, ubiquity, and magnitude. A second step is dealing with it when informing assessments and decisions.

    Id. at 3.

11. Roger M. Cooke, *Deep and Shallow Uncertainty in Messaging Climate Change* (Resources for the Future, Discussion Paper RFF DP 14-11, Apr. 2014):

    > Deep and shallow uncertainty are defined and contrasted with regard to messaging the uncertainty about climate change. Deep uncertainty is often traced back to the writings of Frank Knight, where in fact it simply meant subjective probability. Although Knight envisioned a scientifically grounded quantification of subjective uncertainty, deep uncertainty is frequently invoked to disable uncertainty quantification, with attendant problems in communicating and propagating uncertainty through chains of reasoning. These issues, together with science-based uncertainty quantification, are illustrated with recent applications to ice sheet dynamics. The issues of performance assessment and validation are addressed.

12. Leonard A. Smith & Nicholas Stern, *Uncertainty in Science and Its Role in Climate Policy*, 369 Phil. Trans. R. Soc. 1, 4 (2011).

13. George Marshall, *Don't Even Think About It: Why Our Brains Are Wired to Ignore Climate Change* 72 (2014), http://www.climatedenial.org (last visited Jan. 1, 2015):

    > In experiments, uncertainty about future outcomes is one of the key factors that lead people to act in their own short-term self interest. Policy makers and campaigners on all sides understand very well the importance of uncertainty in regard to action. This is why the U.N. Framework Convention on Climate Change expressly states, in its third principle, that a 'lack of full scientific certainty should not be used as a reason for postponing measures' to minimize the causes of climate change. And this is why President George W. Bush excused his inaction on the issue by saying that 'no one can say with any certainty what constitutes a dangerous level of warming, and, therefore, what level must be avoided.

    Marshall also encourages readers to visit http://www.climateconviction.org (last visited Jan. 1, 2015).

14. *Id.*

15. Leendert van Bree & Jeroen van der Sluijs, *Background on Uncertainty Assessment Supporting Climate Adaption Decision-Making*, *in* Adapting to an Uncertain Climate: Lessons From Practice 23 (Tiago Capela Lourenço et al. eds., 2014) ("Decision-making on adaptation under climate uncertainty also involves effective communication and appreciation between science, society, and policy. Such communication and appreciation is often hampered by misunderstandings about the phenomenon of uncertainty in the science and the fundamental limits to climate change and impact predictions."). Selected additional references include Exec. Office of the President, Memorandum for Heads of Executive Departments and Agencies, M-07-24, Updated Principles for Risk Analysis (Sept. 19, 2007); Anna M. Michalak et al., U.S. Carbon Cycle Science Program, U.S. Carbon Cycle Science Plan (2011) (discussing dealing with uncertainty, providing clear explanations, addressing decisionmaker needs, communication, and dissemination, interdisciplinary and international collaboration, and enforcement); T.N. Palmer & P.J. Hardaker, *Handling Uncertainty in Science*, 369 Phil. Trans. R. Soc. A2011 (Oct. 31, 2011); Royal Society, Special Issue on "Handling Uncertainty in Science" (2011); Ryan P. Steen & Sara A. Leverette, *Oceans and Ice: Scientific Uncertainty in the Regulation of Protected Species*, Nat. Resources & Env't 1 (Summer 2013).

16. *See, e.g.*, Gerd Gigerenzer & Wolfgang Gaissmaier, *Heuristic Decision Making*, 62 Ann. Rev. Psychol. 451, 454 (2011) ("A heuristic is a strategy that ignores part of the information, with the goal of making decisions more quickly, frugally, and/or accurately than more complex methods."); Lisa Rosenbaum, *Communicating Uncertainty: Ebola, Public Health, and the Scientific Process*, 372 New Eng. J. Med. 7 (2015); Amos Tversky & Daniel Kahneman, *Judgment Under Uncertainty: Heuristics and Biases*, 185 Science 1124 (Sept. 27, 1974), *reprinted as* Appendix A, Daniel Kahneman, Thinking, Fast and Slow 419-32 (2011).

effect.[17] In addition, we have cultural biases that may tilt our views in one direction or another.

B. *Uncertainty in Different Contexts and Relationships*

A scientist may consider that "all scientific knowledge is uncertain" and that "this experience with doubt and uncertainty is important."[18] A tobacco or fossil-fuel industry executive may think that "doubt is our product since it is the best means of competing with the 'body of fact' that exists in the mind of the general public" and is "the means of establishing a controversy."[19] Such a "merchant of doubt"[20] also relies on inside information.

For example, as Frank Knight noted in his classic work *Risk, Uncertainty, and Profit*:

> Those in control of the policies of a business are almost inevitably in a better position to foresee its future earnings than are outsiders, and it is difficult to prevent their taking advantage of this position to the detriment of their efficiency as managers of productive operations. The "corporation problem" arises largely out of this situation.[21]

The effectiveness of communications about uncertainty also turns on the relationships among the communicating parties and their underlying attitudes. A recent study by Dr. Gretta Pecl and her colleagues at the Institute for Marine and Antarctic Studies at the University of Tasmania[22] shows that most rock lobster fishers in Tasmania view climate change as not occurring or as representing natural changes or cycles; are reasonably confident in their ability to adapt; and are more concerned with business or other immediate pressures.[23]

Based on a conversation with Dr. Carla Guenther, Senior Scientist at the Penobscot East Resource Center in Stonington, Maine,[24] I understand that lobstermen in Maine may have comparable perceptions and adaptive approaches. Dr. Guenther also suggests considering the contrasting and instructive example of a lobsterman communicating with his personal physician about a diagnosis of cancer and attendant risks. There are differences that ought to enhance the effectiveness of the communication about risk and uncertainty in the physician-patient context including: the trusted relationship; the perceived competence, authority, and professional and ethical responsibility of the physician; the one-on-one nature of the communications; the physician-patient privilege; the personal severity, immediacy, and impact of the risk on the fisherman; and the possibility of surgical, pharmaceutical, and other remedial or palliative relief and attendant requirements for informed consent.

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17. The "black swan" and "perfect storm" issues also bear mention. *See, e.g.*, Elisabeth Paté-Cornell, *On "Black Swans" and "Perfect Storms": Risk Analysis and Management When Statistics Are Not Enough*, 32 Risk Analysis 1822-33 (2013) ("'Perfect storms' involve mostly *aleatory* uncertainties (randomness) in conjunctions of rare but known events. 'Black swans' represent the ultimate *epistemic* uncertainty or lack of fundamental knowledge . . . where not only the distribution of a parameter is unknown, but in the extreme, the very existence of the phenomenon itself.").
18. For example, Richard Feynman has said that scientists
    > are used to dealing with doubt and uncertainty. All scientific knowledge is uncertain. This experience with doubt and uncertainty is important. I believe that it is of very great value, and one that extends beyond the sciences. I believe that to solve any problem that has never been solved before, you have to leave the door to the unknown ajar. You have to permit the possibility that you do not have it exactly right. Otherwise, if you have made up your mind already, you might not solve it.

    Richard P. Feynman, *The Uncertainty of Science*, *in* The Meaning of It All: Thoughts of a Citizen Scientist 26-27 (1998)*; see also* James Gleick, Genius: The Life and Times of Richard Feynman 371 (1992) ("He believed in the primacy of doubt, not as a blemish on our ability to know, but as the essence of knowing.").
19. Tobacco industry documents available online at http://tobaccodocuments.org/bw/332506.html (last visited Nov. 14, 2014) and http://legacy.library.ucsf.edu/tid/jpm19j00 (last visited Jan. 2, 2015) reveal the following interesting thinking:
    > Doubt is our product since it is the best means of competing with the "body of fact" that exists in the mind of the general public. It is also the means of establishing a controversy. Within the business we recognize that a controversy exists. However, with the general public the consensus is that cigarettes are in some way harmful to the health. If we are successful in establishing a controversy at the public level, then there is an opportunity to put across the real facts about smoking and health. Doubt is also the limit of our "product." Unfortunately, we cannot take a position directly opposing the anti-cigarette forces and say that cigarettes are a contributor to public health. No information that we have supports such a claim.

    Brown & Williamson, Smoking and Health Proposal, B&W Doc. No. 332506. Bates Number 521054740-521054748 (in University of California, San Francisco, Legacy Tobacco Documents Library. *See also* David Michaels & Celeste Monforton, *Manufacturing Uncertainty: Contested Science and the Protection of the Public's Health and* Environment, 95 Am. J. Pub. Health S39-48 (2005); Stephanie Tai, *Uncertainty About Uncertainty: The Impact of Judicial Decisions on Assessing Scientific Uncertainty*, 11 U. Pa. J. Const. L. 671 (2009).
20. *See* Naomi Oreskes & Erik M. Conway, *Doubt Is Our Product*, *in* Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues From Tobacco Smoke to Global Warming 10-35 (2010).
21. Frank H. Knight, Risk, Uncertainty, and Profit 35 (1921).
22. University of Tasmania, Institute for Marine & Antarctic Studies, http://www.imas.utas.edu.au/ (last visited Jan. 1, 2015).
23. *See* Melissa Nursey-Bray et al., *Communicating Climate Change: Climate Change Risk Perceptions and Rock Lobster Fishers, Tasmania*, 36 Marine Pol'y 753, 755 (2012):
    > The risk perception study provided a contrast to the scientific evidence for past, present and future climate impacts on rock lobster and the fishery. . . . First, in relation to climate change, 18 of the 22 (just under 80%) fishers viewed climate change as either not occurring or as representing natural changes or cycles. Second, fisher descriptions of observed changes in their fishing areas over time revealed clear synergies with scientific observations. Third, interviews demonstrated that fishers considered climate change as a secondary risk to their businesses given the ongoing regulatory environment, issues around successional planning and debt within the industry. Finally, fishers seemed to feel that the industry was naturally volatile and fishers had adaptive capacity, which mediated in large part any concern over climate change.

    The study was initiated by the Institute for Marine and Antarctic Studies at the University of Tasmania, which is also the national host for Redmap, http://www.redmap.org.au (last visited Jan. 1, 2015), and a leader of the developing Global Marine Hotspots Network. *See also* Gretta Pecl et al., The East Coast Tasmanian Rock Lobster Fishery: Vulnerability to Climate Change Impacts and Adaptation Response Options, Report to the Department of Climate Change, Australia (2009), *available at* http://www.climatechange.gov.au/sites/climatechange/files/documents/03_2013/rock-lobser-report.pdf (last visited Jan. 2, 2015). With regard to regulation of fisheries in U.S. federal waters, see Sarah M. Kutil, *Scientific Certainty Thresholds in Fisheries Management: A Response to Climate Change*, 41 Envtl. L. 233 (2011).
24. Penobscot East Resource Center, http://www.penobscoteast.org (last visited Jan. 1, 2015).

The example of the physician-patient communication is instructive not only to show differences from general communications about climate change, but also in another and disturbing way: Even with the differences, a recent study states that "Currently, patient-centered communications and shared decision making in oncology are suboptimal."[25] If communications in this one-on-one trusted context are suboptimal, is it any wonder that more general communications to the public or to particular groups about climate change often fail? As Dan Kahan, professor of law and professor of psychology at Yale Law School, states: "The failure of widely accessible, compelling science to quiet persistent cultural controversy over the basic facts of climate change is the most spectacular science communication failure of our day."[26]

The psychology of communicating uncertainty is important to understand and study.[27] The Cultural Cognition Project at Yale Law School is engaged in critical studies and projects.[28] The Annenberg Public Policy Center, under the direction of Kathleen Hall Jamieson, recently opened a new area of study, the Science of Science Communication, to investigate how scientific evidence can be more effectively conveyed to the public.[29]

Whether a communication is calm and reasoned or strident and opinionated makes a difference. In a 2011 article, I said, "Even though the challenge was urgent, most people were not yet persuaded. Apocalyptic words were not effective to cause people preoccupied with varied stresses to pay attention to climate change and may even have fostered alienation, denial, and hostility."[30] Communications about scientific uncertainty can become polarized and political, with zealous protestations and apocalyptic warnings on one side and self-serving justifications and denials on the other. Both are barriers not only to effective communication and understanding, but also to reasoned discussion and possible intermediate approaches.

III. Illustrative Legal Standards, Rules, Ethical Requirements, and Counseling Norms

As the following discussion demonstrates, lawyers are experts at proceduralizing and compartmentalizing difficult problems. The legal system facilitates private ordering as well as the resolution of the disputes that come within it. Its main purpose is not the pursuit of scientific "truth."

In general, courts, legislatures, and the legal profession attempt in various ways to address and communicate uncertainty, risk, unreliability, and incomplete information in a changing environment. They must do so within a system that has various objectives. In abbreviated summary, the objectives include: determining responsibility and resolving adversarial litigation with finality and transparency; enabling transactions to be concluded with an enforceable contract; ensuring the participants and the public a reasonable measure of fairness, acceptability, and predictability; facilitating settlements; and allocating decisionmaking authority to competent institutions and processes, including, as the case may be, legislative bodies, administrative agencies, elected executives, courts, and private ordering.[31] Full development of these very different intellectual and institutional tasks and their many intersections with the uncertainties of science is beyond the scope of this Article.

In the climate change context, both the U.S. Congress and the state legislatures have allocated decisionmaking authority primarily to themselves and administrative agencies. At the federal level, the main agency is the U.S. Environmental Protection Agency (EPA); at the state level, the main agency may be the one governing air quality—for example, the California Air Resources Board. In broad

25. *See Patient-Centered Communications and Shared Decision Making*, *in* Delivering High-Quality Cancer Care: Charting a New Course for a System in Crisis (Laura Levit et al. eds., 2013); *see also* Lyn Paget et al., *Patient-Clinician Communication—Basic Principles and Expectations* (Discussion Paper at Inst. of Medicine Roundtable on Value & Science Driven Health Care, June 2011).

26. Dan M. Kahan, *Climate Science Communication and the Measurement Problem*, http://ssrn.com/abstract=2459057 (last visited Jan. 1, 2015) ("The source of the climate-change controversy and like disputes is the contamination of education and politics with forms of cultural status competition that make it impossible for diverse citizens to express their reason as *both* collective-knowledge acquirers and cultural-identity providers at the same time."). *See also* Paul Voosen, *Striving for Climate Change: To Get Beyond Debates Over Science, Dan Kahan Seeks Their Roots*, Chron. Higher Educ., Nov. 3, 2014.

27. *See* Ctr. for Research on Envtl. Decisions, The Psychology of Climate Change Communication: A Guide for Journalists, Educators, Political Aides, and the Interested Public (2009). *See also* Robert Jay Lifton, *The Climate Swerve*, N.Y. Times, Aug. 23, 2014 ("Americans appear undergoing a significant psychological shift in our relation to global warming"); John C. Dolores & Richard E. Redding, *The Effects of Different Forms of Risk Communication on Judicial Decision Making*, 8 Int'l J. Forensic Mental Health 142 (2009); Harry Collins, Are We All Scientific Experts Now? 80-91 (2014) (discussing "citizen skeptics" and "Climategate"); Judith Curry, *Interview on Science Communications* (Aug. 27, 2014), *available at* http://judithcurry.com/2014/08/27/jc-interview-on-science-communications (last visited Jan. 1, 2015); Nat'l Research Council, Comm. on Communicating Toxicogenomics Information to Nonexperts: A Workshop Summary (2005).

28. *See* Cultural Recognition Project at Yale Law School, http://www.culturalcognition.net; *see also* Dan M. Kahan et al., *The Polarizing Impact of Science Literacy and Numeracy of Perceived Climate Change Risks*, 2 Nature Climate Change 732-35 (2012); Dan M. Kahan et al., *The Tragedy of the Risk-Perception Commons: Culture Conflict, Rationality Conflict, and Climate Change* (Cultural Cognition Project, Working Paper No. 89 (2011); (preliminary draft subject to revision, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1871503 (last visited Jan. 1, 2015); Dan Kahan, *How "Cognitive" Adaptation Relates to Mitigating a Polluted Science Communication Environment* (Nov. 4, 2014), *available at* http://www.culturalcognition.net/blog/2014/11/4/how-cognitive-adaptation-relates-to-mitigating-a-polluted-sc.html (last visited Jan. 1, 2015); Jane Brody, *Emotion Is Not the Best Medicine*, N.Y. Times, Nov. 4, 2014 (referring to research by Dan Kahan that "indicates that people pick and choose evidence that reinforces the sense of who they are and the groups they belong to").

29. Annenberg Pub. Pol'y Ctr., General News, Oct 16, 2014, *available at* http://www.annenbergpublicpolicycenter.org/annenberg-public-policy-center-to-study-science-of-science-communication (last visited Jan. 1, 2015) ("The new area will look at the failure to dispel public controversy over such issues as climate change, vaccinations, and genetically modified organisms despite the presence of valid, compelling and widely accessible scientific evidence.").

30. Michael Traynor, *Note to the Next Generation*, 28 Envtl. F. 42, 45 (2011).

31. *See, e.g.*, Stephen Breyer, Making Our Democracy Work: A Judge's View 106-20 (2011) (discussing executive discretion, administrative action, and comparative expertise); Stephen Breyer, *Introduction*, Federal Judicial Center Reference Manual on Scientific Evidence (3d ed. 2011).

terms, legislative and administrative rulemaking involves science that is applicable to "legislative facts," while scientific fact-finding in court tends to involve "adjudicative facts."[32] In general (and again in broad terms), legislative and administrative rulemaking sets standards for the future, while judicial decisionmaking and administrative adjudication resolve existing controversies.[33]

On climate change, a prominent example of a judicial decision that addresses the fundamental issue of decisionmaking authority is *Massachusetts v. EPA*.[34] The U.S. Supreme Court held that Congress had validly granted EPA authority to promulgate regulations regarding air pollution caused by greenhouse gas emissions and that EPA had a responsibility to exercise its authority.[35] Court cases involving climate change are just beginning to develop.[36] Additional examples of ways in which our legal system copes with uncertainty include the following:

A. Standards of Proof

Varying standards of proof bear on the level of tolerable uncertainty; for example "beyond a reasonable doubt," "clear and convincing," and "preponderance of the evidence." Such standards are related to the interests at stake, whether life and liberty, or compensatory damages or other monetary relief such as restitution of unjust enrichment, or punitive damages. As Prof. David Faigman observes, the difference in standards

> relates to the classic problem in science policy of balancing sensitivity and specificity. This concern relates to the problem of balancing the likelihood of making false positive errors versus the prospect of making false negative errors. In criminal cases, the concern is with making false positive errors, thus resulting in a high burden of proof—and increasing the number of false negatives as a result.[37]

Apart from criminal cases and in substantive application, the standards of proof described above are not necessarily either the same as or different from standards that may be used in other fields such as the Likelihood Scale used by the IPCC.[38]

B. Deference to Juries and Other Initial Finders of Fact

The law gives great deference to juries, trial courts in nonjury cases, and administrative agencies that determine disputed facts. One way the legal system deals with uncertainty is to treat much of it as presenting factual issues to be resolved at the initial stage of adjudication. For example, our system gives such issues to a jury, trial judge, or administrative agency to resolve. That delegation is accompanied by legal guidance such as jury instructions, the sometimes difficult distinction between "questions of fact," "questions of law," and "mixed" questions, and limitations on the scope of review by an appellate court.[39] The combination of uncertainty, deference to juries and other initial finders of fact, and the assessment by litigating parties of the risks involved often leads to settlement rather than trial. Uncertainty can thus foster dispute resolution and conserve resources.

C. Admission of Scientific Evidence

The courts serve as gatekeepers to the admission of evidence, including scientific evidence. There are cases and

32. *See, e.g.*, Kenneth Culp Davis, *An Approach to Problems of Evidence in the Administrative Process*, 55 Harv. L. Rev. 364, 402-10 (1942); and *The Principle Requiring a Trial for Disputed Adjudicative Facts*, *in* Administrative Law Text §7.03 160 (3d ed. 1972); Robert E. Keeton, *Legislative Facts and Similar Things: Deciding Disputed Premise Facts*, 73 Minn. L. Rev. 1 (1988).
33. It bears noting that in resolving a controversy, an adjudicative body such as a court may need to deal with past events (did the toxic substance cause the plaintiff's cancer?), present facts (is the defendant competent to be tried?) and future concerns (is the defendant in a criminal case likely to be violent or does the defendant in a civil case need to be enjoined from continuing misappropriation or other misconduct?).
34. 549 U.S. 497, 37 ELR 20075 (2007). It is beyond the scope of this Article to address in any depth the various issues surrounding the communication of scientific uncertainty in contexts that range across kinds of science (such as research, clinical, physical, and behavioral) and legal contexts (legislative, executive, and judicial—both criminal and civil).
35. *Massachusetts*, 549 U.S. at 534:
    > Nor can EPA avoid its statutory obligation by noting the uncertainty surrounding various features of climate change and concluding that it would therefore be better not to regulate at this time. . . . If the scientific uncertainty is so profound that it precludes EPA from making a reasoned judgment as to whether greenhouse gases contribute to global warming, EPA must say so.
36. *See* Emily Hammond & David L. Markell, *Civil Remedies*, *in* Global Climate Change and the Law (Michael B. Gerrard & Jody Freeman eds., 2014) (discussing possible litigation over common-law causes of action); Michael B. Gerrard et al., Sabin Center for Climate Change Law, *US Climate Case Chart*, http://web.law.columbia.edu/climate-change/resources/us-climate-change-litigation-chart (last visited Jan. 3, 2015); *Non-US Climate Change Litigation Chart*, http://web.law.columbia.edu/climate-change/resources/non-us-climate-change-litigation-chart (last visited Jan. 3, 2015).
37. Message from David Faigman, Professor, Hastings College of Law, to the author (Nov. 7, 2014).
38. For the Likelihood Scale, see IPCC Guidance Note, *supra* note 8, at 3. Likelihood ratios used in epidemiology, for example, may come to a court regularly under standards of proof such as preponderance of the evidence. With regard to the IPCC's Likelihood Scale, it bears noting that the degrees of likelihood do not represent a universal standard. Such terms may be defined differently by legislatures and courts in different contexts. Consider, for example, the following definition in the California Sexually Violent Predator Act, Cal. Welf. & Inst. Code §6600(a)(1):
    > "Sexually violent predator" means a person who has been convicted of a sexually violent offense against one or more victims and who has a diagnosed mental disorder that makes the person a danger to the health and safety of others in that it is likely that he or she will engage in sexually violent criminal behavior.

    In *People v. Superior Court (Ghilotti)*, 44 P.3d 949, 964-66 (Cal. 2002), the California Supreme Court held that the term "likely" did not mean a probability greater than 50%; however, courts in other states may interpret the term in their statutes to contemplate probabilities greater than 50%. *See, e.g.*, John M. Fabian, Kansas v. Hendricks, Crane, *and Beyond: "Mental Abnormality," and "Sexual Dangerousness": Volitional vs. Emotional Abnormality and the Debate Between Community Safety and Civil Liberties*, 29 Wm. Mitchell L. Rev. 1367, 1437-40 (2003) (discussing *Ghilotti*); Nicole Yellen, *The California Sexually Violent Predator Act and the Failure to Mentally Evaluate Child Molesters*, 33 Golden Gate U. L. Rev. 295, 312-13 (2003). (I thank Professor Faigman for this example and for the reference to likelihood ratios in epidemiology.)
39. *See, e.g.*, Fed. R. Civ. Proc. 52(a)(6) (the clearly erroneous standard of review applies to findings of fact by trial courts); *see also* U.S. Court of Appeals for the Ninth Circuit, *Guide on Standards of Review* (Rev. May 2012), *available at* http://www.ca9.uscourts.gov/content/view.php?pk_id=0000000368 (last visited Jan. 2, 2015).

guides to this much-discussed topic, which will just be noted here.[40] "In short, scientists generalize while courts particularize," as Professor Faigman and his colleagues state in an important recent article.[41]

D. Temporary Restraining Orders and Preliminary Injunctions

A proceeding in which a party seeks a temporary restraining order or a preliminary injunction presents particular challenges in the context of uncertainty. By definition, such a proceeding occurs at or near the beginning of a case, before and while the facts and record are being developed and are uncertain. The court is asked to take or deny action that can be crucial and often decisive in the face of an insufficient record and substantial uncertainty.[42] The lawyer seeking such extraordinary relief should not exaggerate the claimed "emergency" or "irreparable harm" and the lawyer opposing it should not belittle it. They should both help the court understand the factual context and frame an order that addresses what action, if any, is needed for the situation.[43]

E. Constitutional Rights and Duties

Various constitutional provisions bear on the issue of communicating scientific uncertainty.[44] For example, thanks to the First Amendment, scientists, lawyers, journalists, and others enjoy substantial freedom to express their views. Pursuant to the Due Process Clauses of the Fifth and Fourteenth Amendments, prosecutors must disclose to defendants exculpatory and mitigating evidence (a rule known as the *Brady* doctrine).[45] The Sixth Amendment provides a defendant in a criminal prosecution the right to counsel (a right that encompasses issues relating to counsel competency), the right to trial by an impartial jury, and the right to have compulsory process for obtaining witnesses in the defendant's favor. The Seventh Amendment right to jury trial in civil cases may give rise to issues of presentation of scientific evidence to a lay panel, the allocation of responsibility between judge and jury, and the safeguarding of juror findings from reexamination. Under the Eighth Amendment's prohibition on cruel and unusual punishments, there are potential expert testimony issues regarding corrections and punishment as well as the competency and capacity of the defendant. Under the Fourteenth Amendment, particularly its guaranty of equal protection of the laws, scientific and behavioral evidence may bear on issues of unconstitutional discrimination.

F. Criminal Law

In addition to constitutional rights and obligations, in criminal law, there are issues involving prosecutorial use of forensic evidence and exoneration by DNA evidence. The uncertainty that a defendant and counsel confront in considering a plea, sentence bargain, or defense and trial is aggravated by prosecutors' disregard of their constitutional and ethical obligations to disclose exonerating or mitigating evidence.[46]

G. Toxic Torts

The ALI, before publishing the *Restatement (Third) of Torts: Liability for Physical and Emotional Harm* in 2005, engaged in its traditional thorough process of drafting by expert reporters, review by expert advisers, and intensive discussions by the governing council and members.

40. *See, e.g.*, Daubert v. Merrell Dow Pharms., Inc., 509 U.S. 579, 23 ELR 20979 (1993); Federal Judicial Ctr., Reference Manual on Scientific Evidence (3d ed. 2011); *see generally* David L. Faigman et al., Modern Scientific Evidence: The Law and Science of Expert Testimony (2014); Paul C. Gianelli & Ed Imwinkelreid, Scientific Evidence (5th ed. 2013); Cynthia H. Cwik, Jules Epstein, and Carol Henderson (eds.), Scientific Evidence Review, Admissibility and the Use of Expert Evidence in the Courtroom, Monograph No. 9 (2013); Jack B. Weinstein, *Science and the Challenges of Expert Testimony in the Courtroom*, 77 Or. L. Rev. 1005 (1998).
41. David L. Faigman et al., *Group to Individual (G2i) Inference in Scientific Expert Testimony*, 81 U. Chi. L. Rev. 417 (2014).
42. *See, e.g.*, John Leubsdorf, *The Standard for Preliminary Injunctions*, 91 Harv. L. Rev. 525 (1978).
43. When I taught Remedies at the University of California at Berkeley (Boalt Hall) from 1982 to 1989, I would develop these points in a class devoted to temporary restraining orders and preliminary injunctions, and invite Judge Thelton Henderson of the U.S. District Court for the Northern District of California as a speaker. He would contribute his experience and views about the ethical, legal, and practical issues—bringing the point home with a comment that when it came to lawyers who went over the line or got chalk on their shoes, "We talk about you in the lunchroom."
44. The intersection of constitutional law with scientific issues presents major and ongoing issues of great public concern, such as capital punishment, abortion, and discrimination. For extensive treatment of the evidentiary and fact-finding issues, see David L. Faigman, Constitutional Fictions: A Unified Theory of Constitutional Facts (2008); David L. Faigman, *Fact-Finding in Constitutional Cases*, *in* How Law Knows 156 (Austin Sarat et al. eds., 2007).
45. Brady v. Maryland, 373 U.S. 83 (1963).
46. A recent example of wrongful conviction and imprisonment due to "proof" by "science" and eventual exoneration by science—i.e., DNA evidence that led to the actual murderer and to a confession by him that he acted alone—involves the 2008 exonerations in Mississippi of Kennedy Brewer and Levon Brooks. To obtain the convictions eventually held wrongful, the prosecutor had used a forensic pathologist who was not board-certified in forensic pathology and was known to conduct approximately six times more autopsies per year than the professional standard (1,200-1,800 autopsies annually instead of 250), and a forensic odontologist to testify to so-called matching bite marks. The two defendants were ultimately exonerated thanks to effective work by the Mississippi Innocence Project. K.C. Meckfessel-Taylor, a friend who formerly worked at the Project, informs me that the case is not unique, that convictions and incarcerations resulting from bias and the manipulation of "science" are commonplace in Mississippi. She raises the question: "How can we use science to advance justice while acknowledging that scientific theories may be based, to some extent, on proof but are not inherently Truth?" *See, e.g.*, Press Release, Mississippi Innocence Project, *Two Innocent Men Cleared Today in Separate Murder Cases in Mississippi, 15 Years After Wrongful Convictions* (Feb. 15, 2008); Angela J. Davis, *Mississippi Innocence and the Prosecutor's Guilt*, 25 Geo. J. Leg. Ethics 989 (2012) (reviewing a film about the wrongful convictions of Brewer and Brooks); Radley Balko, *The Bite-Marks Men: Mississippi's Criminal Forensic Disaster* (Feb. 20, 2008), *available at* http://www.slate.com/articles/news_and_politics/jurisprudence/2008/02/the_bitemarks_men.html (last visited Dec. 29, 2014). The problem of convicting people on the basis of "scientific evidence" and later exonerating them on the basis of DNA evidence and related issues is constructively addressed by Judge Harry T. Edwards, *The National Academy of Sciences Report on Forensic Sciences: What It Means for the Bench and Bar*, 51 Jurimetrics 1 (2010). *See also* Susan Haack, *Of Truth in Science and Law*, 73 Brook. L. Rev. 985 (2008).

With regard to the difficult issues of toxic torts and causation, ALI representatives also met with scientists, primarily epidemiologists, at the National Academy of Sciences. The Restatement contains extensive comment on the subject.[47]

Under the Restatement, "the plaintiff has the burden to prove that the defendant's tortious conduct was a factual cause of the plaintiff's harm."[48] The Restatement follows the general requirement that "the law demands proof by a preponderance of the evidence in civil cases."[49] With regard to expert testimony, it does not require that an expert testify to "reasonable medical or scientific certainty." Indeed, it rightly criticizes any such requirement.[50] Such criticism is an important advance toward addressing the major challenge of translating science for legal decisionmaking.[51]

H. Products Liability

A central problem in the law of products liability[52] concerns design defects and attendant issues of uncertainty, risk assessment, and communication both to client manufacturers and by them to dealers and customers and, in the case of human pharmaceuticals, by manufacturers to doctors as "learned intermediaries." Attention is necessary to the questions whether a risk can be prevented or mitigated by design; and, if it cannot be prevented, whether and to what extent risk can be further reduced by warnings or user instructions or both. Overwarning is counterproductive.

I. Contracts and Certainty

Parties who are negotiating a contract involving scientific subject matter (or any matter) should keep in mind the fundamental requirement that the terms of a contract must be "reasonably certain."[53] "The terms of a contract are reasonably certain if they provide a basis for determining the existence of a breach and for giving an appropriate remedy."[54] In suitable cases, parties may use contracts to attempt to address or mitigate uncertainty about the future. Contract negotiation requires intelligent determination whether a range of negotiable solutions is available and, if so, skill in negotiating a solution within that range.[55]

J. The Procedural Context

The procedural context also bears on the issues. Cases involving high-voltage power lines and electromagnetic radiation offer an example: A person with a cancerous brain tumor who is seeking compensation in a court case might not be able to establish causation. A property owner, however, might be able to obtain property tax or eminent domain relief because psychological perceptions of risk have diminished the property's market value. On the other hand, a public utility might have difficulty overturning an administrative decision that the power lines must be sited a certain distance away from a residential area; courts are reluctant to substitute judicial judgment for administrative agency discretion, and they provide leeway for administrative agencies to determine safe distances (and other matters) if they are otherwise within legal boundaries.[56]

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47. *See* 1 Restatement (Third) of Torts: Liability for Physical and Emotional Harm §28 cmt. *c*. (2005).
48. *Id.* §28(a).
49. *Id.* cmt. *e*.
50. *Id.*

> [S]ome courts have employed a requirement that an expert testify that an opinion is held to a "reasonable degree of medical [or scientific] certainty" for it to be admissible. This phrase implies a standard different from the preponderance requirement, suggests reliance on medical or scientific standards for proof, and seems to impose a high threshold for the opinion to be admissible. . . . Requiring an expert to state that an opinion is held to a medical or scientific certainty is problematic because the medical and scientific communities have no such "reasonable certainty" standard. Thus for an expert to understand this standard, meaning must be provided by the attorney who hired the expert, by the expert's imagination, or by some other source outside the legal system. . . . Moreover, the reasonable-certainty standard provides no assurance of the quality of the expert's qualifications, expertise, investigation, methodology, or reasoning. Thus, this Section adopts the same preponderance standard that is universally applied in civil cases. Direct and cross-examination can be employed to flesh out the degree of certainty with which an expert's opinion is held and to identify opinions that are speculative and therefore inadmissible.

51. Comment *e* also states that "[e]xperts must hold their opinions with some degree of certainty for them to be admissible." *Id.* The Reporters' Notes to Comment *e* cite cases rejecting the "reasonable medical or scientific certainty" requirement in favor of a preponderance of the evidence test. The concept of an expert testifying with reference to the applicable standard governing the burden of proof itself bears continuing attention. Recent scholarship is helpful in distinguishing between expert testimony to provide "framework" evidence such as general scientific findings and expert testimony to provide "diagnostic" evidence to address the case at hand. *See* Faigman et al., *supra* note 41, at 421-24. Notably, Faigman says that "compared to framework testimony, diagnostic testimony is more likely to be suspect in terms of validity, at the same time its particularized nature and better 'fit' is more likely to influence the fact finder's determination in the case at hand." *Id.* at 471-72. Part of the continuing overall challenge in translating science for legal use involves the related question of whether the expert's requisite degree of certainty should be decided by the judge at the threshold level of admissibility or left to the adversarial process of cross-examination and rebuttal experts, for example, and to the jury.
52. *See generally* Restatement (Third) of Torts: Products Liability (1998).
53. Restatement (Second) of Contracts §33(1) (1981).
54. *Id.* §33(2).
55. *See generally* Thomas C. Schelling, The Strategy of Conflict (1960). Schelling has also expressed important views about uncertainty and climate change. *See, e.g.*, Thomas Schelling, *Interview With Conor Clarke*, The Atlantic (July 13-14, 2009), *available at* http://www.theatlantic.com/politics/archive/2009/07/an-interview-with-thomas-schelling-part-one/21199/, and http://www.theatlantic.com/politics/archive/2009/07/an-interview-with-thomas-schellintg-part-two/21273/ (last visited Dec. 29, 2014); Thomas Schelling, *Uncertainty and Action on Climate Change*, Project Syndicate, Jan. 7, 2008:

> As more becomes known about climate change—for example, the role of clouds and oceans—more uncertainties emerge. Nevertheless, the greenhouse "theory," as it is sometimes disparagingly been called, has been established beyond responsible doubt. There is uncertainty about the quantitative parameters, and there can be doubt about whether the warming of recent decades is entirely due to the "greenhouse effect." But the basics of global warming are not in scientific dispute.

Reaching common understanding of such "basics" seems roughly akin to the establishment of a range of negotiation, and reaching agreement on a possible approach seems roughly akin to negotiating a solution within the range although multiple parties are involved.

56. *See, e.g.*, Edward Gerjuoy, *Electromagnetic Fields, Biology, and Law*, 35 Jurimetrics J. 55 (1994); *Round Table Discussion: Science, Environment, and the Law*, 21 Ecology L.Q. 343-44 (1994) (remarks by Alex Kozinski,

The Special Challenge of Neonicotinoids and Honeybees

Pesticides are the subject of statutes and regulations, administrative proceedings, court litigation, and extensive commentary. Relatively new nicotine-like insecticides called neonicotinoids (neonics for short) are the subject of intense controversy. They are blamed for causing or contributing to honeybee colony collapse disorder. They are also credited with causing or contributing to improved agriculture and being less harmful than preexisting insecticides. Neonicotinoids have provoked complex scientific, policy, and legal issues involving causation, uncertainty, the precautionary principle, the proportionality principle, and various remedial approaches, including regulation and the development of good practices in the industry with or without regulation.[a]

Among the important differences on these issues between Europe and the United States are those analyzed by a comparative scholar, Alberto Alemanno, who discusses differing perspectives between "scientific insufficiency" and "scientific uncertainty."[b] It is not my purpose here to address substantively the various statutes, regulations, administrative proceedings, and court cases that are relevant to neonicotinoids or express a view on them. Instead, I wish to comment briefly on the communication issue.

Instead of polarizing accusations and zealous protests on the one hand or self-serving commendations and denials on the other, the subject is one for cordial exchanges of views; precision and comprehension in the gathering, analysis, reporting, and use of data; and consideration of the questions whether sensible intermediate approaches, including legal ones, are available between prohibition and unregulated use. Such approaches could involve targeted administrative regulations, guidelines, or advisories as well as the application of good integrated pest management practices. For example, adjustments can be made regarding the timing and mode of application of the appropriate neonicotinoid. Regulators should monitor pesticide usage, study adverse effects reports, and make prompt adjustments when appropriate. For instance, simple mechanical solutions to minimize the creation of toxic dust during the planting of treated seed have been demonstrated to mitigate the main complaint regarding neonics. There may also be approaches from other jurisdictions that should be considered.

a. My brother Joe Traynor is a soil technologist and bee broker. His company, Scientific Ag Co., provides honeybees for almond growers and others, and he publishes a frequently quoted periodic beekeeper newsletter. *See, e.g.*, Simon Agnew, *The Almond and the Bee: A Global Biological Process Begins With Joe Traynor and His Brokering of Bees for California's Most Valuable Horticultural Export*, S.F. Chron., Oct. 12, 2007, *available at* http://www.sfgate.com/magazine/article/The-Almond-and-the-Bee-2518870.php (last visited Jan. 1, 2015). I have been in regular communications with him and Randy Oliver, who maintains an informative website at http://scientificbeekeeping.com (last visited Jan. 1, 2015), and seeks to bring the best information as well as common sense to this complex challenge. So does Susan Kegley, President of the Pesticide Research Institute, with whom I have also spoken; her Institute is undertaking important analyses of neonicotinoids, pest management, and related issues. *See* https://www.pesticideresearch.com/site (last visited Jan. 2. 2015).

b. *See* Alberto Alemanno, *The Science, Law, and Policy of Neonicotinoids and Bees: A New Test Case for the Precautionary Principle*, 4 Eur. J. Risk Reg. 191 (2013).

K. *Ethical Rules*

Ethical rules also bear on a lawyer's responsibilities to communicate with clients, courts, and others, while continuing to serve as an advocate. The American Bar Association (ABA) Model Rules of Professional Conduct are followed substantially or with variations in most U.S. jurisdictions.[57] The Model Rules were recently updated with the ABA's approval of recommendations from its Commission on Ethics 20/20 that was created to examine the impact of globalization and technology on the legal profession. They apply primarily to individual lawyers, although in a very few jurisdictions, they also apply to law firms. They bear directly or indirectly on a lawyer's competent understanding and communication of uncertainty and advice to clients about handling risk.[58]

A fundamental Model Rule concerns competence: **"A lawyer shall provide competent representation to a client. Competent representation requires the legal knowledge, skill, thoroughness and preparation reasonably necessary for the representation."**[59] In addition to this black letter rule, the Model Rules provide comments. For example, Comment [8] provides: "To maintain the requisite knowledge and skill, a lawyer should keep abreast of changes in the law and its practice, including

moderator). On the precautionary principle, see note 76, *infra*.

57. American Bar Association (ABA), Model Rules of Prof'l Conduct (2014).

58. In addition to the Model Rules specifically quoted and discussed in the text, also relevant are Model Rules concerning the scope of representation and consultation with client (R.1.2); diligence and promptness (R.1.3); communication (R.1.4); confidentiality (R.1.6); conflict of interest and attendant appreciation of risk and informed consent issues (Rs.1.7, 1.8); client with diminished capacity (R.1.14); evaluation for use by third persons (R.2.3); lawyer as third-party neutral and communication of difference from role as representing a client (R.2.4); meritorious claims and contentions (R.3.1); fairness to opposing party and counsel, including duties re evidence (R.3.4); impartiality and decorum and prohibition against unauthorized ex parte communications (R.3.5); trial publicity (R.3.6); lawyer as witness (R.3.7); advocate in nonadjudicative proceedings (R.3.9); truthfulness in statements to others (R.4.1); communication with person represented by counsel (R.4.2); dealing with unrepresented person (R.4.3); responsibilities of partners, managers, and supervisory lawyers (R.5.1); responsibilities regarding nonlawyer assistance (R.5.3); professional independence (R.5.4); unauthorized practice of law (R.5.5); responsibilities regarding law-related services (R.5.7); communications concerning a lawyer's services (R.7.1); advertising (R.7.2); solicitation of clients (R.7.3); communication of fields of practice and specialization (R.7.4); reporting professional misconduct (R.8.3); and misconduct, including dishonesty, fraud, deceit, or misrepresentation (R.8.4).

59. Model Rules of Prof'l Conduct R.1.1 (black letter in original here and in related citations).

the benefits and risks associated with relevant technology, engage in continuing study and education and comply with all continuing legal education requirements to which the lawyer is subject."[60]

The Model Rules require that **"In representing a client, a lawyer shall exercise independent professional judgment and render candid advice. In rendering advice, a lawyer may refer not only to law but to other considerations such as moral, economic, social and political factors, that may be relevant to the client's situation."**[61] Under Comment [4], "Where consultation with a professional in another field is itself something a competent lawyer would recommend, the lawyer should make such a recommendation. At the same time, a lawyer's advice at its best often consists of recommending a course of action in the face of conflicting recommendations of experts."

The Model Rules require candor to the tribunal.[62] On the specific subject of offering evidence, they provide that: **"A lawyer shall not knowingly . . . offer evidence that the lawyer knows to be false. If a lawyer, the lawyer's client, or a witness called by the lawyer, has offered material evidence and the lawyer comes to know of its falsity, the lawyer shall take reasonable remedial measures, including, if necessary, disclosure to the tribunal. A lawyer may refuse to offer evidence, other than the testimony of a defendant in a criminal matter, that the lawyer reasonably believes is false. . . ."**[63]

The Model Rules also impose specific obligations on prosecutors with regard to forensic evidence and disclosure of exculpatory and mitigating evidence.[64]

The ABA Committee on Ethics and Professional Responsibility has recently issued a formal opinion on the managerial and supervisory obligations of prosecutors.[65] It takes into account "the frequency of prosecutorial misconduct nationwide documented by, *inter alia*, opinions in criminal cases and disciplinary proceedings in the last fifteen years" that "reveal numerous violations of *Brady* (which are also violations of Rule 3.8), and show other examples of misconduct, e.g., prosecutors using false evidence or failing to correct false statements to the court, prosecutors engaged in other improper courtroom conduct, and prosecutors engaging in conduct that would violate" other rules.

L. The Lawyer as Counselor

One of the critical roles of a lawyer is to counsel clients about uncertainty in various contexts.[66] For example, clients want to understand the uncertainties and risks involved in litigation in court or before governmental agencies or in negotiating a contract or a regulatory compliance program.[67] They also need sound advice in carrying on their daily and business affairs and in making disclosures under applicable laws or voluntary standards.

The U.S. Securities and Exchange Commission (SEC) has published an interpretive release to guide U.S. public companies on disclosure requirements related to climate change.[68] Columbia University's Sabin Center for Climate Change Law has noted that the SEC guidance "follows several years of activity by state attorneys general, institutional investors, environmental groups, and others to clarify the climate change disclosure requirements of public companies."[69] Four subjects may trigger disclosure obligations: (1) impact of legislation and regulation; (2) impact of international accords; (3) indirect consequences of regulation or business trends; and (4) physical impacts of climate change such as the increased severity of weather phenomena and sea-level rise.[70]

The Sabin Center notes that prior to the SEC's guidance, several organizations have provided monitoring and tracking of voluntary and state-mandated disclosures regarding greenhouse gas emissions and climate-related risks. These include the Climate Registry, the Carbon Disclosure Project, and the Global Reporting Initiative.[71] The nonprofit organization known as CERES is among the leaders in the evolution of sustainability reporting.[72] It provides a web-

60. *See, e.g.*, Gail Bingham et al., *Effective Representation of Clients in Environmental Dispute Resolution*, 27 Pace Envtl. L. Rev. 61 (2009).
61. Model Rules of Prof'l Conduct R.2.1.
62. Model Rules of Prof'l Conduct R.3.3.
63. Model Rules of Prof'l Conduct R.3.3(a), subd. (3). Comment [8] provides that:

    > The prohibition against offering false evidence only applies if the lawyer knows that the evidence is false. A lawyer's reasonable belief that evidence is false does not preclude its presentation to the trier of fact. A lawyer's knowledge that evidence is false, however, can be inferred from the circumstances. *See* Rule 1.0(f) ["a person's knowledge may be inferred from circumstances"]. Thus, although a lawyer should resolve doubts about the veracity of testimony or other evidence in favor of the client, the lawyer cannot ignore an obvious falsehood.

    See, e.g., David S. Caudill, *Lawyers Judging Experts: Oversimplifying Science and Undervaluing Advocacy to Construct an Ethical Duty?*, 38 Pepp. L. Rev. 675, 684-89 (2011).
64. Model Rules of Prof'l Conduct R.3.8: **"The prosecutor in a criminal case shall: . . . (d) make timely disclosure to the defense of all evidence or information known to the prosecutor that tends to negate the guilt of the accused or mitigates the offense, and, in connection with sentencing, disclose to the defense and to the tribunal all unprivileged mitigating information known to the prosecutor, except when the prosecutor is relieved of this responsibility by a protective order of the tribunal . . . ."**
65. ABA Comm. on Ethics & Prof'l Responsibility, Formal Op. 467, at 7 (2014).
66. This section draws from a number of constructive suggestions about the lawyer's role as counselor made by Leslie Carothers. I have separately addressed the ethical, business, and other pressures on lawyers. *See* Michael Traynor, *The Pursuit of Happiness*, 52 Vand. L. Rev. 1025 (1999).
67. The ALI recently initiated a new project entitled Principles of the Law, Compliance, Enforcement, and Risk Management for Corporations, Nonprofits, and Other Organizations. *See* ALI, Press Release, *The American Law Institute Announces Four New Projects* (Nov. 17, 2014), *available at* http://www.ali.org/email/pr-14-17.html (last visited Jan. 3, 2015).
68. U.S. Securities & Exch. Comm'n (SEC), Commission Guidance Regarding Disclosures Related to Climate Change, 75 Fed. Reg. 6290, 6295 (2010), *available at* http://www.sec.gov/rules/interp/2010/33-9106fr.pdf (last visited Jan. 1, 2015). *See also* Sudhir Lay Burgaard, *Time to Issue a New Climate Disclosure Guidance*, 29 Nat. Resources & Env't 56 (Fall 2014).
69. Sabin Ctr. for Climate Change Law, Climate Change Securities Disclosures Res. Ctr., http://web.law.columbia.edu/climate-change/resources/climate-change-securities-disclsoures-resource-center (last visited Jan 1, 2015).
70. *Id.*
71. *Id.* The Sabin Center provides an extensive listing of references.
72. *See* http://www.ceres.org/company-network/how-we-work-with-companies/disclosure (last visited Dec. 29, 2014). *See also* Sara Gossman, *Reflecting Risk: Chemical Disclosure and Hydraulic Fracturing*, 48 Georgia L. Rev.

based tool for SEC climate disclosure search of various company filings.[73]

Lawyers are increasingly involved in counseling with their clients about making disclosures and preparing necessary filings not only under the federal securities laws, but under other applicable laws and standards.[74] In their counseling role, lawyers must weigh all the relevant facts and legal issues, not merely the ones that favor the client's desired outcome.[75] Uncertainty in the science may help justify either action or inaction. Lawyers can counsel their clients to follow the precautionary principle.[76] They can recommend that a decision to proceed with a product or activity be accompanied with physical safeguards as well as warnings and instructions to users. They can urge that uncertainty and the risk of imposing large costs or burdens on another party should preclude action. They can encourage clients to undertake a thorough risk management program, including liability insurance and contractual indemnities where available.[77] In counseling with clients, lawyers should also be attuned to their ethical obligations. The lawyer's role can also include advocacy *with* the client as well as *for* the client. Such advocacy can help the client attain its goals in the long term as well as the short term.

IV. Obstacles to Communicating About Scientific Uncertainty

Two major obstacles to communication are inherent in the present human condition: innumeracy; and hard-wired behavioral preferences. In addition, there are specific obstacles in such contexts as the following:

A. Between Scientist and Lawyer or Scientist and Tribunal

The different standards of proof or truth, knowledge, and authority to make a decision in the face of some degree of uncertainty provide a challenge and sometimes an obstacle to effective communication. As Deborah M. Hussey Freeland puts it: "Expert witnesses speak science to law."[78] The language and professional disciplines are different.

B. Between Lawyer and Journalist

On climate change and similar issues involving law and science, the lawyer needs to understand the journalist's need to meet deadlines and to communicate accurately, succinctly, and clearly. The journalist[79] needs to understand that the lawyer may be acting as an advocate for a client and must abide by ethical rules including confidentiality.

Based on my personal experience with various media, both lawyer and journalist need to understand the opportunities and limitations of the particular media they are using. For example, print journalists and, in some cases, radio journalists, and TV talk show hosts or interviewers may provide an opportunity to explore a subject in a conversational, rational, and give-and-take way that enhances public understanding. On the other hand, a lawyer-advocate being interviewed for a headline news item on a program that will likely air only a snippet or soundbite has to be especially careful not to have a single remark or clause taken out of context, particularly in a way that might undermine or be misconstrued against his client's cause.

C. Between Scientist and Journalist

On the key subject of climate change, the U.S. Climate Change Program offers useful comments, for example:

> Uncertainty offers the opportunity for various interests to confuse and divert the public discourse in what may

83, 101-11, 137-44 (2013) (disclosure and the challenge of uncertainty, and reenvisioning chemical disclosure).

73. *See* http://www.ceres.org/resources/tools/sec-climate-disclosure/sec-climate-disclosure (last visited Dec. 29, 2014).

74. *See* Matthew Morreale, *Corporate Disclosure Considerations Related to Climate Change*, *in* Global Climate Change and the Law (Michael B. Gerrard & Jody Freeman eds., 2d ed. 2014) (reviewing federal securities laws, EPA's Mandatory Reporting Rule, the Federal Trade Commission Act and Green Guides, Financial Accounting Standard Board accounting standards, voluntary reporting and emerging standards, and trends in litigation and enforcement.

75. Leslie Carothers, Note to ELI Staff and Mike Traynor (Oct. 1, 2014) (on file with author).

76. The basic precautionary principle is: "When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm." World Comm'n on Ethics of Scientific Knowledge & Tech. The Precautionary Principle, 14 (2005), *available at* http://unesdoc.unesco.org/images/0013/001395/139578e.pdf (last visited Dec. 29, 2014).

"Morally unacceptable harm refers to harms to humans or the environment that is: threatening to human life or health, or serious and effectively irreversible, or inequitable to present or future generations, or imposed without adequate consideration of the human rights of those affected." *Id.* "If the idea of precaution is to make headway, then private industry has to take on co-responsibilty for precautionary management." *Id.* at 41. The U.N. Framework Convention on Climate Change (UNFCCC) states:

> The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate adverse effects. Where there are threats of serious or irreparable damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost.

UNFCCC, art. 3, subd. 3, May 29, 1992, S. Treaty Doc. No. 102-38, 1771 U.N.T.S. 107, *available at* http://unfccc.int/resource/docs/convkp/conveng.pdf (last visited Jan. 1, 2015). On the precautionary principle, the necessary quantum of proof to find an endangerment to public health and the environment under the Clean Air Act, and the limitations on our ability to make objective decisions, see Leslie Carothers, *Upholding EPA Regulation of Greenhouse Gases: The Precautionary Principle Redux*, 41 Ecol. L.Q. 683 (2014).

77. *See, e.g.*, Frank B. Friedman & James K. Vines, *Teach the Business Case*, 31 Envtl. F. 34 (Nov./Dec. 2014) (discussing the advisability of an environment, health, and safety system).

78. *See* Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 Geo. Int'l Envtl. L. Rev. 289-90 (2013):

> Expert witnesses speak science to law. When scientists testify in court, they speak from one language into another, one profession into another, one discipline into another, one culture into another. To inform the fact-finder effectively, and to treat the witness and the judicial process fairly, lawyers need to understand the legal and scientific significance of how expert witnesses speak science.

See also Faigman et al., *supra* note 41.

79. The term "journalist" is used here in a broad sense to include bloggers and social media commentators about scientific uncertainty as well as traditional media journalists. This Article notes but does not address the phenomenon of expanding various communications through social media.

> already be a very difficult scientific process of seeking improved insight and understanding. In addition, many reporters are not in a position to make their own independent assessment of the likely accuracy of scientific statements. They have a tendency to seek conflict and report "on the one hand, on the other hand," doing so in just a few words and with very short deadlines. . . . [Given] "strong peer pressure . . . against becoming a visible scientist who communicates with the media and the public," . . . combined with an environment in which there is high probability that many statements a scientist makes about uncertainties will immediately be seized on by advocates in an ongoing public debate, it is perhaps understandable that many scientists choose to just keep their heads down, do their research, and limit their communications to publication in scientific journals and presentations at professional scientific meetings.[80]

D. *Between Scientists and the Public*

Scientists and physicians (as well as lawyers) often find it difficult to communicate effectively with the public. There are and have been some notable scientific and medical communicators; for example, Freeman Dyson, Richard Feynman, Atul Gawande, Jerome Groopman, Oliver Sacks, and Emilio Segrè. The front pages of magazines such as *Science* and *Nature* also report scientific developments in a comprehensible way.[81] Unsung heroes include those high-school and middle-school science teachers who not only enable their students to comprehend science, but also elicit their enthusiastic interest.

It is understandable that scientists wish to set forth their findings and supporting data in a way that will be appreciated by other scientists and policymakers. Sometimes, however, they might include attention to the separate issue of science communication to the public. For example, the IPCC's Synthesis Report, *Climate Change 2014*, contains a number of critical findings and explanatory diagrams, including stark observations about changes in our climate system.[82] In its section on policy approaches for adaptation and mitigation, it does not, however, call out for special treatment of the communication issue. Instead, it merely states that "examples of information programmes include labeling programs that can help consumers make better-informed decisions."[83] It is therefore also understandable that such reports can foster interpretations that are both amusing and simplistic, such as Tom Toles' cartoon depicting various country representatives at a table labeled "New U.N. Climate Report, in Brief" where the server arrives with a smoking platter saying "Your goose is cooked."[84] Scientists might consider using more examples that are readily understandable to lay readers. For example, in discussing the IPCC's report, Martin Wolf asks rhetorically:

> What would you feel if someone justified his decision to overtake on corners with the argument that one could not be certain a car was coming in the opposite direction? You would think he was playing Russian roulette. Why would anybody think that makes sense in dealing with the only habitable planet we know of? Under uncertainty, the rational path is to insure against extreme outcomes.[85]

E. *Partisan Political Divisions as a Barrier to Communication*

In the United States, the problem of communication within and across disciplinary areas is aggravated by partisan political divisions. A recent Pew Research Center report includes a comparison of partisan differences in views of the following global threats: Iran's nuclear program; China's emergence as a world power; the conflict between Israelis and Palestinians; Islamic extremist groups such as al Qaeda; the Islamic militant group in Iraq and Syria known as ISIS; North Korea's nuclear program; growing tension between Russia and its neighbors; the rapid spread of infectious diseases from country to country; and global climate change. On global climate change, only 25% of surveyed Republicans say it is a "major threat" to the United States, while 68% of Democrats and 44% of Independents say that it is, with a Republican-Democratic difference of -43. To illustrate how wide this division is, the next greatest difference was +18, with 74% of Republicans saying Iran's nuclear program is a "major threat" versus 56% of Democrats and 54% of Independents describing it as such.[86]

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80. U.S. Climate Change Science Program, Best Practice Approaches in Characterizing, Communicating, and Incorporating Scientific Uncertainty in Climate Decision Making 69-70 (2009). On the ethical issues facing reporters and the "false balance" problem, see, e.g., Bud Ward, *Journalism Ethics and Climate Change Reporting in a Period of Intense Media Uncertainty*, Ethics in Sci. & Envtl. Pol. (2009). *See also* Seth Borenstein, *What 95% Certainty of Warming Means to Scientists*, Associated Press, Sept. 24, 2013.
81. Many years ago, I attended a captivating series of lectures by Dr. Segrè on the history of the atomic nucleus. Held at the University of California at Berkeley, the audience grew with each lecture. Currently, the university's Department of Astronomy, for example, presents occasional programs to lay audiences on subjects as mysterious as black holes and extra-solar planets.
82. IPCC, Fifth Assessment Synthesis Report, Climate Change 2014. For example, in its Summary for Policy Makers, *available at* http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_SPMcorr1.pdf (last visited Jan. 1, 2015), the IPCC states (p. 1): "1. Observed Changes and their Causes. Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems. . . . Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen."
83. *Id.* §4.4.
84. Thomas Toles, *Your Goose Is Cooked*, Wash. Post, Nov. 4, 2014. For a different perspective, see Judith Curry, *The Global Warming Statistical Meltdown*, Wall St. J., Oct. 10, 2014 (concluding that "This slower rate of warming—relative to climate model projections—means there is less urgency to phase out greenhouse gas emissions now, and more time to find ways to decarbonizes the economy affordably. It also allows us the flexibility to revise our policies as further information becomes available.").
85. Martin Wolf, *An Unethical Bet in the Climate Casino*, Fin. Times, Nov. 12, 2014.
86. *See* Pew Research Ctr., As New Dangers Loom, More Think the U.S. Does "Too Little" to Solve World Problems (2014); Judith Curry, JC Interview on Science Communications (Aug. 27, 2014), *supra* note 27 ("Climate science has become hotly politicized, with many scientists playing an adversary role."). I note but do not attempt to develop the

The Pew Report was published prior to the recent midterm elections that resulted in a Republican majority in the U.S. Senate and increased the number of Republican members in the U.S. House of Representatives. It remains to be seen whether the newly constituted Congress will address the challenges of climate change effectively. On the one hand, those challenges could provide an opportunity for intelligent bipartisan cooperation; on the other hand, the challenges could create even greater division and acrimony than the country has already experienced. I expect there will be many difficulties, including efforts to undermine EPA and environmental laws. I also expect that the possibilities for cooperative approaches might be enhanced if issues are framed in nondivisive ways to elicit the support of varied constituents, including (where possible) the business and defense communities with respect to fundamental issues of common concern such as national security, jobs, health, safety, and the protection of families and children.[87]

F. Competing Cultural Groups

Important studies of cultural cognition are revealing the critical effect that identification with a particular community has on science communication. As Prof. Dan Kahan at Yale Law School states:

> The "beliefs" individuals form about a societal risk such as climate change are not of a piece; rather they reflect the distinct clusters of inferences that individuals draw as they engage information for two distinct ends: to gain access to the collective knowledge furnished by science, and to enjoy the sense of identity enabled by membership in a community defined by particular cultural commitments.[88]

In a recent blog, he notes:

> Essentially, the science communication environment has become polluted with antagonistic cultural meanings that transform "positions" on global warming into badges of membership in & loyalty to competing cultural groups. These meanings effectively *disable* the faculties that diverse citizens use, very successfully most of the time, to align their own decision-making (personal & collective) with the best available evidence.[89]

V. Positive Examples of Communicating About Uncertainty

Communicating about uncertainty should not be just a one-sided or one-way matter. It can and often should involve both the communicator and the recipient interactively. A recent example concerns climate change and its effect on fisheries along the 60,000 miles of Australian coastline. "Redmap," the Range Extension Database and Mapping Project, involves fishermen, scientists, and others in keeping current an online map of how species distributions may be changing in response to climate and related information. The project engages fishers, divers, and the broader community in the building of the knowledge base and creates a sense of public ownership of the information generated, facilitating shared understanding.[90]

The Institute for Marine and Antarctic Studies at the University of Tasmania and others are centrally involved in this project. They are also developing a Global Marine Hotspots Network, a communication network involving scientists, resource managers, and other stakeholders from rapidly warming regions. A key idea of the network is that "Research, development, management and communication can all be delivered faster and with greater certainty through a coordinated network across global hotspots."[91]

Another positive example is the Southeast Florida Science Communication Initiative, which involves a team of social scientists and media professionals. Its "goals are to generate data and other information that the Florida agencies and ultimately other individuals and groups can use and improve effective science communication in the interest of collective decision-making."[92] The Center for Research on Environmental Decisions published in 2009 a useful guide for scientists, educators, and others on the

separate question whether and to what extent gender discrimination is a barrier to effective communication within and across disciplines. *See, e.g.*, Mary Beard, *The Public Voice of Women*, 36 London Rev. Books 11, Mar. 20, 2014, *available at* http://www.lrb.co.uk/v36/n06/mary-beard/the-public-voice-of-women (last visited Jan. 1, 2015); Matt Shipman, *Gender Bias in Researcher-to-Researcher Communication*, http://www.scilogs.com/communication_breakdown/gender-bias-study-2013/ (last visited Jan. 1, 2015).

87. Although it does not involve climate change, it bears noting that the Green Science Policy Institute, with the help of Earthjustice, contributed scientific expertise and policy support to change California's requirements governing furniture flammability. The purpose is to increase fire safety without harmful flame retardants. The Institute is a leader in providing scientific information for policy changes to prevent the use of tens of millions of pounds of harmful flame retardants in consumer products. *See* http://greenscience-policy.org (last visited Jan. 1, 2015). *See also* Eve Gartner, *America to Benefit From Flame Retardant Victories* (Sept. 4, 2014), *available at* http://www.earthjustice.org/blog/2014-september/america-to-benefit-from-flame-retardant-victories (last visited Jan. 1, 2015).

88. *See* Kahan, *supra* note 26, p. 1.

89. Dan Kahan, *How *Cognitive* Adaptation Relates to Mitigating a Polluted Science Communication Environment* (Nov. 4, 2014), *supra* note 28.

90. Range Extension Database & Mapping Project (Redmap), http://www.redmap.org.au (last visited Jan. 1, 2015).

91. Stewart Frusher et al., *A Global Network of Marine Hotspots* (Oct. 2011), *available at* http://www.imas.utas.edu.au/__data/assets/pdf_file/0011/257834/A4_Global_Hotpots_Oct2011.pdf (last visited Jan. 3, 2015). *See also* Gretta T. Pecl et al., *Ocean Warming Hotspots Provide Early Warning Laboratories for Climate Change Impacts*, 24 Rev. Fish. Biol. Fisheries 409 (2014) (emphasizing "the need for trans-disciplinary and participatory approaches to effectively engage stakeholders"); Alistair J. Hobday & Gretta T. Pecl, *Identification of Global Marine Hotspots: Sentinels for Change and Vanguards for Adaptation Action*, 24 Rev. Fish Biol. Fisheries 415, 423 (2014) ("Developing a network of scientists, resource managers and policy makers working in global marine hotspots, where information is integrated and synthesized, contrasted and compared across locations provides, us, globally, with critical learning opportunities to address the immediate and future challenges of climate change.").

92. *See* Katie Carpenter, Cultural Cognition Project, *The Southeast Florida Science Communication Initiative* (Feb. 21, 2013), http://www.broward.org/NaturalResources/ClimateChange/Documents/YaleCultural%20CognitionProjectPresentation.pdf (last visited Jan. 1, 2015); Dan Kahan, *What SE Florida Can Teach Us About the *Political* Science of Climate Change* (June 27, 2014), http://www.culturalcognition.net/blog/2014/6/27/what-se-florida-can-teach-us-about-the-political-science-of.html (last visited Jan. 1, 2015).

psychology of climate change communication.[93] Its recommendations include encouraging group participation.[94]

Two additional approaches that merit attention are suggested by Professor Kahan:

> One method, examined in depth by Geoffrey Cohen, is to present information in a manner that affirms rather than threatens people's values. . . . The second technique for mitigating public conflict over scientific evidence is to make sure that sound information is vouched for by a diverse set of experts. . . . We need to learn more about how to present information in forms that are agreeable to culturally diverse groups, and how to structure debate so that it avoids cultural polarization. If we want democratic policy-making to be backed by the best available science, we need a theory of risk communication that takes full account of the effects of culture on our decision-making.[95]

Presenting crucial information to the public in a culturally cognizant and credible way does not mean presenting it in a weak or pandering way. Americans are a resilient and savvy people. They can be told, for example, who benefits economically from climate change doubt. Show them the money.[96] As we improve our communications, we need to pay attention also to improving our instrumentation, measurement, and public reporting of greenhouse gas emissions. Better data should lead to better communications as well as citizen use of the data. We should also consider making more effective use of third-party verification methods to ensure accuracy while reducing administrative burdens on regulators.[97] A simple example is to advance from an antiquated era in which cows are visually counted to determine methane emissions to a 21st century era in which advanced and available technologies are used.

Lastly, it is important not to exaggerate uncertainty or besiege people with doomsday stories. Whether the subject is climate change or honeybees, the public will be best served by rational discussion and exploration of pragmatic approaches.

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93. Ctr. for Research on Envtl. Decisions, The Psychology of Climate Change Communications: A Guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public (2009).
94. *Id.* at 33-36.
95. Dan Kahan, *Fixing the Communications Failure*, 463 Nature 296-97 (2010), *citing* Geoffrey L. Cohen et al., *When Beliefs Yield to Evidence: Reducing Biased Evaluation by Affirming the Self*, 26 Pers. Soc. Psychol. Bull. 1151-64 (2000), and Geoffrey L. Cohen et al., *Bridging the Partisan Divide: Self-Affirmation Reduces Ideological Closed-Mindedness and Inflexibility in Negotiation*, 93 J. Pers. Soc. Psychol. Bull. 415-30 (2007); *see also* Dan Kahan, *How "Cognitive" Adaptation Relates to Mitigating a Polluted Science Communication Environment* (Nov. 4, 2014), *supra* note 28:

    > We need a science communication *mitigation* strategy. We need to staunch the 'us-vs-them sources of pollution, which emanate from both sides. We need to *detoxify* that environment, so that reasoning people & their representatives don't face the sorts of conditions that in fact make it perfectly rational for them to form climate-change positions that express who they are instead of what they know.

96. In a famous scene in the movie *Jerry Maguire*, the wide receiver played by Cuba Gooding Jr. tells the agent played by Tom Cruise: "Show me the money." Unless they are deceived by "merchants of doubt," Americans should be able to understand bluntly described economic motivations separated from political and cultural rhetoric. *See also* notes 19-20, *supra*; James Parker-Flynn, *The Fraudulent Misrepresentation of Climate Science*, 43 ELR 11098, 11103-04 (Dec. 2013) (discussing "who funds misinformation"); *Follow the Money*, Wikipedia, *available at* http://en.wikipedia.org/wiki/Follow_the_money (last visited Jan. 1, 2015) ("*Follow the money* is a catchphrase popularized by the 1976 drama-documentary motion picture *All the President's Men*, which suggests a money trail or corruption scheme within high (often political) office").
97. *See* Herbert J. Weisberg, Willful Ignorance: The Mismeasure of Uncertainty 363-64 (2014):

    > Choosing a culture of science in which independent validation becomes a primary criterion for scientific acceptance will help to regain public trust. . . . In a world of cheap and plentiful data, it should become feasible to institutionalize some forms of routine independent validation. Eventually, methods and standards for replication of study results will evolve. Proper validation will become an essential component of research activity.

    See also Cynthia Giles, Assistant Administrator, U.S. EPA Office of Enforcement and Compliance, *Next Generation Compliance*, Envtl. F. 22 (Sept./Oct. 2013); and appendix of annotations and references, including third-party verification, http://www2.epa.gov/sites/production/files/2014-10/documents/giles-next-gen-article-forum-eli-sept-oct-2013-appendix.pdf (last visited Jan. 2, 2015).