Law & Science: Toward a Unified Field

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Abstract

To be relevant to the real world and to have a reasonable chance of producing fair outcomes, legal and political decisionmaking must take science into account. Scholars have been aware of this for over fifty years. The need for law to be informed by rigorous science is compelling, as we must make collective decisions that impact our sustainability and our humanity on a global scale. However, the field of Law & Science remains as fragmented now as it was a half-century ago. We have yet to find a reliable way to establish coherent interdisciplinary interaction that enables science to inform legal decisionmaking across a variety of disciplinary fields and cultural contexts.

Approaching the problems of interdisciplinary interaction that vex Law & Science as instances of cross-cultural communication, this paper proposes that while the lawyer and the scientist need not be fully conversant in each other's languages to work together, lawyers can do much to ensure that science is properly used to inform the law by understanding what scientists think they are doing, and who they think they are. As expert negotiators, lawyers can develop genuine respect for scientists' values, methods and goals, promoting effective interdisciplinary collaboration and producing well informed decisions that merit public trust.

I. Introduction

We learn about challenges to the sustainability of our material and cultural customs through the physical and social sciences. These sciences help us to see and connect the dots that reveal phenomena such as: climate change; the sources and effects of air, water, soil, light and noise pollution; and security threats flowing from scientific research that promises a higher quality of life but could be misdirected to cause significant harm. Our understanding of these challenges can help us to rethink our customs to create a healthier, more sustainable world.

We learn about challenges to our concepts of what it means to be human through the physical and social sciences as well, as we develop new abilities and disabilities resulting from developments such as: communication and information technologies that create highly detailed, durable records of personal information that are accessible to governments, businesses and a global public; medical research and technologies in cloning, *in vitro* fertilization, stem cell manipulation and genetic engineering that can help us redesign living organisms; and sociological, anthropological and psychological studies of learning and identity formation that help us to see subtle effects of discrimination. Our understanding of these developments and the possibilities they open for us can help us to make decisions that will create a more humane society.

Because the legal matters that can be informed by advances in science traverse the spectrum of human interaction, the law invites interdisciplinary study that benefits from two (or more) scholarly approaches. An example of interdisciplinarity within law occurs in civil procedure: procedure is ideally trans-substantive, or uniform across all areas of substantive law, so that our procedural analyses are to remain consistent whether the underlying claim sounds in contract,

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property, tort or constitutional law. Accordingly, every civil issue must be examined from a procedural perspective as well as from a substantive perspective. Examples of interdisciplinarity involving law and an outside discipline arise in an array of substantive legal fields. For example, environmental law treats matters that are understood through the natural sciences, antidiscrimination law governs matters that are understood through the social sciences, and issues in public health and security, intellectual property, and the regulation of science are informed by a variety of scientific disciplines.

To meet the goals of the law, we must understand complex issues such as how to restore ecosystem function or how to establish educational equality, for which in turn it is necessary to grasp the tools of and information yielded by numerous scientific disciplines. But interdisciplinarity itself poses challenges beyond simply learning the substance of a new field. In addition to learning a body of substantive material from courses and textbooks, an expert in a discipline has been socialized into the culture of that discipline, internalizing its values and becoming adept in embodying those values in her research, teaching, writing and speaking. An expert is much more than an encyclopedia of her field. She has succeeded in forming a professional identity as someone who lives and breathes ecosystem science, or sociology, and must protect that identity as she contributes to the work of a different field.

Interdisciplinary work thus involves developing cross-cultural understanding beyond simple linguistic understanding. In this sense, the challenges of interdisciplinarity are like those of diplomacy: they require not only proficiency in a second language, but also skill in the conduct of cross-cultural negotiation. Successful negotiation depends on the ability to listen actively with an open mind, to bracket or suspend one's personal values while imagining what the issues feel like to the stakeholders in the negotiation and to affected others, to craft creative possibilities for the stakeholders' common benefit, and to communicate with stakeholders in a way that demonstrates respect for their commitments and perspectives so that they can feel comfortable buying in to proposals and a binding agreement. Legal education and practice foster these skills of sympathetic detachment and deliberation,[2] and excellent lawyers should be well prepared to engage in interdisciplinary collaboration.

Yet interdisciplinarity remains challenging, even for lawyers. Psychological mechanisms that protect one's habits of thought can be difficult to suspend in order to open one's mind to others' ways of thinking and knowing,[3] and professional rewards are not seen to flow from respecting and incorporating others' methods and perspectives in one's primary field.[4]

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[2] Anthony Kronman attributes this kind of preparation to the case method of legal education and to a generalist form of legal practice, both of which the profession is losing under pressures of economic and cultural change, in ANTHONY T. KRONMAN, THE LOST LAWYER: FAILING IDEALS OF THE LEGAL PROFESSION (1993). The lawyer-statesman ideal that Kronman describes may remain available to the profession if it succeeds in attracting and retaining women; *see* Deborah M. Hussey Freeland, *Recovering the Lost Lawyer*, AMERICAN BAR ASSOCIATION JOURNAL OF THE PROFESSIONAL LAWYER (forthcoming 2014) and citations therein.

[3] Myra Strober views approaching contributions from other fields with an open mind as the fundamental challenge of interdisciplinarity. MYRA H. STROBER, INTERDISCIPLINARY CONVERSATIONS: CHALLENGING HABITS OF THOUGHT (2011).

[4] *See, e.g.*, MYRA H. STROBER, INTERDISCIPLINARY CONVERSATIONS: CHALLENGING HABITS OF THOUGHT (2011); STEPHEN SCHNEIDER, SCIENCE AS A CONTACT SPORT 229 (2009).

This paper examines the interdisciplinary challenges of Law & Science that cut across a diversity of legal contexts, such as the legislative, the judicial, the regulatory, and that of alternative dispute resolution. Legal scholars conduct cutting-edge research on a variety of issues in which scientific questions arise. This research could have greater impact and progress more rapidly if these fascinating advances were not to occur in isolation from each other. As a matter of course, a scholar who examines biological research in light of the Endangered Species Act will be identified primarily as an environmental law scholar, while a scholar who informs her legal research on racial equality with psychological research results will be identified primarily as an antidiscrimination law scholar. While this disciplinary organization fosters the development of scholarship concerning their respective specialized areas of substantive law, in so doing it obscures important synergies among these efforts and interferes with the development of our understanding of interdisciplinary research in law and science. As a consequence, "Law & Science" remains an umbrella term for multiple research communities that are practically isolated from each other. Despite the great interest it generates,[5] Law & Science has yet to emerge as a unified field, a coherent bridge effectively connecting the realms of law with those of science.[6]

This paper proposes that many of the ostensibly diverse problems of the isolated fields of Law & Science are actually specific examples of deeper issues that arise in all legal research involving science. In a broader sense, some of these problems are those of interdisciplinarity itself: problems of translation between disciplinary languages and cultures that can be better understood and managed once they are properly identified as instances of the more general challenges of cross-cultural communication. In a deeper sense, the problems of interdisciplinary translation that arise when law meets science are problems of epistemology, ethics and professional identity: of how we know, of our professional responsibilities with respect to knowledge, and of what it means to be a scientist or a lawyer.

Part II engages with the threshold question of how to define "science" in Law & Science, as arbitrary definitions contribute needlessly to the persistent incoherence of the field. Part III examines what it means to be a scientist, since this perspective is foreign to most legal professionals. This part also demonstrates how a term that is of central concern in both law and science, "uncertainty," is actually a homonym with diverging meanings and implications across the disciplinary divide, and uses this example to illustrate the value to a lawyer of understanding a scientist's view of the nature of science and of her professional responsibility to protect it.

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[5] *See*, *e.g.*, Lee Loevinger, *Law and Science As Rival Systems*, 19 U. FLA. L. REV. 530, 538 (1966-67) ("[S]cience appears to be such a major aspect of modern culture that a discipline which purports to establish normative principles for that culture [*i.e.*, law] would seem required at least to understand it."), and references *infra* n.6.

[6] Avner Levin, *The Problem of Observation*, 3 J. PHIL. SCI. & L. (2003) ("There is perhaps no area more popular or in demand among legal academics and faculties of law recently than the . . . area known . . . as 'law and science' . . . . [But a]cademics active in these areas . . . do not research law and science . . . as such"); Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373, 375 (2007) (collecting citations) ("The academic field of Law and Science appears to be in an exciting formative era, in which debate persists about whether it is an entire endeavor or a collection of questions that are more proper to a variety of established legal fields."); DAVID S. CAUDILL, STORIES ABOUT SCIENCE IN LAW: LITERARY AND HISTORICAL IMAGES OF ACQUIRED EXPERTISE 5 (2011) ("The law and science project is not so much a unified field of inquiry as it is a general recognition that the understanding of science and technology is crucial for numerous areas of law . . . . [T]he 'project' of law and science can be variously defined, and because its perceived elements are part of numerous other sub-disciplines . . . , its boundaries are vague.").

Understanding a scientist's professional identity and commitments—who scientists think they are, and what they think they are doing—enables the lawyer to use science effectively, and to prevent other lawyers from misleading her by distorting science. This Part further provides lawyers with criteria for spotting spurious arguments based on science. Part IV analyzes the current scope and state of Law & Science, selecting examples from the literature(s) to assess the state of the art and identify barriers to its further development. Part V describes a theoretical approach to Law & Science that frames the diverse issues within its scope in terms of epistemology, epistemological ethics, and interdisciplinary, cross-cultural communication. This approach foregrounds the features common to these otherwise diverse issues, promoting analytical coherence in Law & Science. Part VI concludes.

II. Defining Science: What Scientists Think They Are Doing

The first step toward interdisciplinary understanding is openness to and empathy for the perspective of an Other—someone from another culture, another discipline. Interdisciplinarity raises controversies over what kind of knowledge counts as belonging to one discipline or to another, as well as fraught questions of professional identity. These are both problems of demarcation. The epistemological demarcation problem concerns drawing a line around a discipline or body of knowledge that includes some production-methods and genres of information, but excludes others.[7] The problem of demarcation with respect to identity concerns drawing a line around a group of people that includes some, as it excludes others.[8]

Attainable goals for law students, lawyers and judges include developing an understanding of: (1) how scientists see science, and (2) scientists' professional commitments to ensuring that their research conforms to the standards of science. This Part focuses on the first of these, the scientist's epistemology, or the nature of knowledge that scientists produce in conducting research (what scientists think they are doing). The next Part focuses on the scientist's epistemological ethics, or the responsibilities that scientists feel with respect to the nature of the knowledge they produce. This sense of duty reflects a scientist's professional values and identity (who scientists think they are).

A. How Scientists See Science

"Science" seems like a natural term to define in legal scholarship on Law & Science. Many scholars note that explaining the nature of science is too large a task for a law review article or even a book, so either no definition is given, or an arbitrary choice of definition is made.[9] Much of the study of the nature of science has been theoretical, occurring in the philosophy of science

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[7] Drawing and policing this line has been called "boundary-work" in science studies. *See* Thomas F. Gieryn, *Boundary-Work and the Demarcation of Science from Nonscience: Strains and Interests in the Professional Ideologies of Scientists*, 48 AM. SOC. REV. 781 (1983).

[8] Judith Butler has discussed drawing and policing this line in terms of "othering." *See, e.g.*, JUDITH BUTLER, BODIES THAT MATTER: ON THE DISCURSIVE LIMITS OF "SEX" (1993).

[9] *See, e.g.*, Dana Remus Irwin, *Freedom of Thought: The First Amendment and the Scientific Method*, 2005 WISC. L. REV. 1479, 1487 and n.53 (describing Wikipedia as "offer[ing] a fairly accurate representation of generally accepted information" and relying on it for definitions of science and science-related terms, claiming that Wikipedia "provide[s] summaries of the terms' generally accepted meanings within the scientific community."). Actually, as discussed here, definitions of science held by the general public do *not* accurately represent those generally accepted within scientific communities.

and science studies.[10] While this theoretical work from outside the sciences is valuable in itself, its effectiveness in informing law increases when it is in turn informed and complemented by the perspectives of professional scientists. These can be incorporated by looking to empirical evidence of how scientists see their professional duties and performance. When we work with science and scientists, it is especially helpful for legal professionals to have a sense of what science is in terms of what the scientists we work with think they are doing. Similarly, it is very helpful to legal professionals to have a feel for the professional identities of scientists—to be able to understand their deeply held values and the professional commitments that make them scientists—to recognize who scientists think they are.[11]

A scientist's professional epistemology, or theory of scientific knowledge (for example, how we associate our research results with meaning) and a scientist's epistemological ethics, or our professional commitments to the quality of our research results, have been described from the perspectives of an interdisciplinary scientist.[12] These perspectives harmonize with those offered by the National Academies of Science, which provide a broad introduction to the nature of scientific work and scientists' role in society.[13]

Education scholars writing in science studies recently conducted an empirical study of how scientists see the nature of science ("NOS").[14] The researchers characterize science as it is described in textbooks in contrast to science as it is practiced, in a way reminiscent of Roscoe Pound's distinction between the law in books and the law in action.[15] Because this study's critiques of textbook science apply directly to the understanding of science that is generally held by non-scientists, including jurors, law students, lawyers, legislators and judges, I will use it to walk through some of the key distinctions between popular, received notions of science and the authentic experiences of actual scientists.

Wong and Hodson point out that although scholars of science education have urged teachers to include information about the nature of science in science classes,[16] science students and teachers "possess inadequate, incomplete, or confused NOS understanding" in part because of

[10] Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013) (collecting sources).

[11] Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013). It is notable that "scientists frequently do not recognize themselves or their actions in some of the ethnographic studies that have been published in recent years." Siu Ling Wong & Derek Hodson, *From the Horse's Mouth: What Scientists Say About Scientific Investigation and Scientific Knowledge*, 93 SCI. EDUC. 112 (2009) (citations omitted).

[12] Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373 (2007); Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013).

[13] NATIONAL ACADEMIES OF SCIENCE, ON BEING A SCIENTIST: RESPONSIBLE CONDUCT IN RESEARCH (2d ed. 1995; 3d ed. 2009).

[14] Siu Ling Wong & Derek Hodson, *From the Horse's Mouth: What Scientists Say About Scientific Investigation and Scientific Knowledge*, 93 SCI. EDUC. 109–130 (2009) (using the abbreviation "NOS" for "nature of science," a major area of study in this field).

[15] Roscoe Pound, *Law in Books and Law in Action*, 44 AM. L. REV. 12 (1910).

[16] Wong & Hodson, *supra* n.14 at 110 ("in addition to its intrinsic value, [information about the nature of science] enhances learning of science content, generates interest in science, and *develops students' ability to make informed decisions on socioscientific issues based on careful consideration of evidence*.") (emphasis added) (citation omitted). The last is an especially powerful reason for educating potential jurors, law students, lawyers, legislators and judges about the nature of science.

"stereotyped images of science and scientists consciously or unconsciously built into school science curricula and perpetuated by science textbooks."[17] The major stereotype they identify is that scientific research results are absolutely objective and certain.[18]

For example, they describe a textbook view of the scientist's work[19] that is analogous to a legal formalist's view of the judge's work, in which the judge is a transparent, agentless vessel through which objective law becomes manifest. But an individual scientist's creativity is essential to the progress of her research. Just as a legal professional must, a scientist exercises her creativity within the bounds of ethical practice:[20] legal professionals have duties to maintain the framework of law and legal ethics,[21] just as scientific professionals have duties to maintain the framework of science and scientific ethics.[22]

The need for a scientific professional to exercise creativity within bounds—which is analogous to the legal professional's need to use her independent professional judgment within the bounds of law and legal ethics[23]—is also evident in Wong and Hodson's empirical study of the "common textbook assumption that science follows a rigid stepwise procedure, beginning with the formulation of a hypothesis."[24] The authors are critical of presentations of the scientific method as a rigid, stepwise procedure that is uniform across disciplines,[25] as though it were a recipe that is to be followed mechanically to a given result. However, unlike legal argument which has its goal fixed *a priori*, scientific research must welcome unexpected research results: a scientist's commitment to finding an answer that was determined *a priori* is a form of research

[17] *Id*. (citations omitted). In teaching law students, one must similarly overcome stereotyped images of law and lawyers presented in popular culture, particularly with respect to professional ethics. *See, e.g.,* Mathlas W. Delort, *Some Thoughts on Enhancing the Reputation and Image of the Profession*, 15 CBA RECORD 40 (2001); Helena Whalen-Bridge, *The Lost Narrative: The Connection Between Legal Narrative and Legal Ethics*, 7 J. OF THE ASS'N OF LEGAL WRITING DIRECTORS 229, 243 (2010); Hon. Gary M. Farmer, *Civility and Professionalism in Legal Advocacy*, 23 NOVA L. REV. 809, 809, 810-11, 815-16 (1999).

[18] Wong & Hodson, *supra* n.13 at 124 ("Our data provide some 'from the horse's mouth' remarks to reinforce efforts to dispel the several prevalent myths about the absolute objectivity of science, the universality of its methods, and the certainty of the knowledge it produces.").

[19] *Id*. at 119 (noting that science textbooks promote the idea "that creativity is unnecessary (or even inappropriate) during and after data collection and that careful, dispassionate, and systematic analysis of data will lead unerringly to secure conclusions[.]").

[20] For example, the materials scientist interviewed by the authors stated that, "The design of a good experiment must involve a great deal of creativity in overcoming limitations, problems, etc. Likewise for the collection of data . . . creativity and imagination can also be important for saving time and labour. The analysis of data can be enhanced by these skills but clearly within a tight framework that does not over-interpret or modify data." *Id*. (ellipsis in original).

[21] *See, e.g.*, Robert W. Gordon, *The Independence of Lawyers*, 68 B.U. L. REV. 1, 10, 12 and *passim* (1988); Robert W. Gordon, *The Role of Lawyers in Producing the Rule of Law*, 11 THEORETICAL INQ. L. 441, 467 (2010).

[22] *See, e.g.*, NATIONAL ACADEMIES OF SCIENCE, ON BEING A SCIENTIST ix (3d ed. 2009).

[23] Deborah M. Hussey Freeland, *What Is a Lawyer? A Reconstruction of the Lawyer As an Officer of the Court*, 31 ST. LOUIS UNIV. PUB. L. REV. 425 (2012).

[24] Wong & Hodson, *supra* n.13 at 119.

[25] *Id*. at 125 (criticizing the presentation of "'what scientists do,' [for being] usually presented in terms of a sequence such as observation, generalization, hypothesis, experiment, and theory" so that the scientific method is portrayed as a "fixed, all-purpose approach").

misconduct that clearly can bias scientific research results.[26] It is troubling that the public (and funding agencies in particular) may require the scientific method to be presented in this oversimplified, linear way so that research proposals can be evaluated,[27] even though basic scientific research has the goal of exploring a question, and not of producing an initially specified answer.

Nonetheless, this theoretical account of "the" scientific method as a coherent, monolithic mode of inquiry provides a workable first approximation to understanding scientific research methods: while it requires refinement, it highlights the fundamental idea that procedural rigor is essential to the epistemological quality of scientific research results, just as it is to the fairness of judicial opinions. Even though the scientific method is not linear in that sometimes hypotheses drive experimental design while at other times they emerge from descriptive data, and even though the scientific method is not monolithic in that it manifests differently in different research contexts, this does not mean that there is no such thing as the scientific method. A method of inquiry that is constrained by empirical data, that is structured to minimize subjective bias and to account for uncertainties in the data, that acknowledges assumptions made in interpreting the data and that points the way to future research (acknowledging its provisionality) has many characteristics that will promote its recognition by scientists as a scientific method.

Wong and Hodson also find that scientists readily acknowledge that scientific research is "theory-laden"—that scientific research results are shaped by the questions chosen for research and the methods chosen to address those questions, rather than being objective in the sense of being theory-independent.[28] Further, when multiple theories could account for the same data, scientists aesthetically and practically choose the simpler theory until more complexity becomes necessary to account for new data; this reflects a value of parsimony.[29] However, because the subjective limits of one's research derive from the researcher's lack of omniscience—her unique subject-position informed by her experiences and values[30]—scientists value multidisciplinarity.[31]

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[26] *See, e.g.*, NATIONAL ACADEMIES OF SCIENCE, ON BEING A SCIENTIST (2d ed. 1995); Lee Loevinger, *Jurimetrics: Science in Law* 22, in SCIENTISTS IN THE LEGAL SYSTEM: TOLERATED MEDDLERS OR ESSENTIAL CONTRIBUTORS? (ed. William A. Thomas, 1974).

[27] Wong & Hodson, *supra* n.13 at 118 ("The molecular biologist said that in genomics research scientists have to pretend to be engaged in hypothesis-driven research because funding bodies regard purely open-ended work as little more than a 'fishing expedition.' But without these fishing expeditions, he said, potentially crucial information will be missed. 'We won't know the significance of any one piece of data if we don't have it all, which is why we need many groups of researchers, each working on a different aspect of the project.'").

[28] Wong & Hodson, *supra* n.13 at 124 ("[T]he theory-laden nature of scientific observation . . . is still only rarely elaborated in science textbooks, and is often overlooked by both teachers and students. In contrast, its recognition within the scientific community represented by our sample was universal.").

[29] For example, the astrophysicist interviewed by the authors stated that, "If there are two theories, one of which is more complex than the other one, we adopt the simpler one . . . This is consistent with our belief that the world is rational and easy to understand." *Id*. at 123.

[30] For example, the cancer biologist interviewed by the authors stated that, "The thinking of a biologist may be different from that of a geologist, physicist or archaeologist. Based on their knowledge or special interest in the field, each group might have focused differently from their point of view and come to different conclusions." *Id.* at 121.

[31] For example, the molecular biologist interviewed by the authors stated that, "Different interpretations may be a good thing because every mind is only a subset of the whole existing knowledge . . . and everyone's subset is different. Using the same observations or data . . . (scientists) with different subsets will generate different

When research informed by diverse theoretical perspectives and methodological approaches converges on a model of a natural phenomenon, its results are more robust to the subjective limitations of each contributing approach, and thus are taken to produce a stronger claim to objectivity.[32]

Scientists also have a teleological view that rigorous or professional science—science that conforms to professional standards—helps our understanding of nature to approach a true understanding.[33] Here, the labor of science under a correspondence theory of truth is evident: scientists work as though there is an objective reality that is knowable through meticulous, systematic and creative study, in that scientific research results so often serve as the bases for powerful technological developments across numerous fields.

Wong & Hodson's research also reflects scientists' awareness that scientific understanding is provisional, rather than absolute: even well established theories are expected to be revised in light of future data.[34] As a scientist, I found very exciting and motivating the possibility that the next experimental results could fail to conform to an established theory, so that I might find a way to develop the theory itself in light of my unexpected data.[35]

Because scientists realize that scientific knowledge is not complete,[36] it is counternormative and unethical—that is, unprofessional—for a scientist to describe her research results as though they have definitively, finally or absolutely proven something.[37] Being required to report scientific

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explanations . . . it is the combination of all the interpretations that, after many years, may finally lead to the real picture." *Id*. at 120 (parenthesis in original).

[32] For example, "Both the astrophysicist and the cancer biologist commented that although it is inevitable that a scientist's preconceptions will influence both the design and the interpretation of an inquiry, the 'truth' will eventually emerge (or biases will be recognized and corrected) when others, with different perspectives, investigate the same phenomenon or event." *Id*. at 120.

[33] *Id*. at 123 ("[A]ll our scientists subscribed to the view that the predictive power and technological applicability of current scientific theories can be taken as strong evidence that in many respects we are getting closer to the truth about the universe.").

[34] For example, the high-energy physicist interviewed by the authors stated that,

> Currently two theories, superstring and loop quantum gravity, have remained as areas of active research alongside other new ideas. . . . These two theories are well-established but tentative. Well-established in the sense that they have been around for about two decades and have still not been refuted by available data. Tentative in the sense that they are subject to change when more data reveal their inadequacy . . . other theories will emerge and replace the current ones when new experimental or observational data become available.

Wong & Hodson, *supra* n.13 at 121.

[35] The experimental particle physicist interviewed by the authors reported this feeling as well: "It is typically much easier to convince your collaborators to publish something that agrees with the so-called 'Standard Model.' Yet particle physicists often want to announce something new (violating the 'Standard Model'). But when they do so, they are extremely careful to check the results before they are satisfied about its reliability[.]" *Id*. at 120.

[36] *Id*. at 122 ("The astrophysicist, high-energy physicist, and molecular biologist all commented that the term 'law' should no longer be used in science because it is a confusing term that indicates an unjustifiable status as 'definitive and not subject to change.' They were adamant that all scientific knowledge, including 'laws,' is subject to modification when there is appropriate evidence and a convincing argument.").

[37] *See, e.g.*, NATIONAL ACADEMIES OF SCIENCE, ON BEING A SCIENTIST 16 (2d ed. 1995).

research results with certainty, as an expert witness or other informant to the legal system, thus can pose an identity crisis for a professional scientist.[38]

B. The Epistemological Quality of Science Depends upon Scientists' Professionalism

In sum, a view of how scientists see science indicates that the epistemological rigor of science depends on their professional commitments to implement a scientific method that is characterized by comparing creatively conceived models with empirical data; the data must be gathered in a way that minimizes the subjective influence of any individual scientist, must be submitted with the model for review by peers with different subject-positions, and must published so that it can be relied upon and thus tested further by an even larger and more diverse community of scientists. A scientific model or theory is viewed as a provisional placeholder for an objectively real, natural mechanism; the theory may be tentatively treated as knowledge and used accordingly until it is superseded by a better, more robust model. Professional scientific values for choosing among available theories reflect professional commitments to parsimony, to open communication of methods and results, to multidisciplinary research, to the correspondence theory of truth (that there is objective reality, and that knowledge is accurate to the extent that it corresponds to that reality), and to the teleological belief that science makes progress towards a complete understanding of a posited objective reality (buttressed by the utility of science in allowing engineers and physicians to produce technologies that enable us to do things that we could not do without the science). Scientists are socialized by their education and professionally committed to produce and present their research—the best of our empirical knowledge—with a vivid awareness of its limitations: to express assumptions and uncertainties as exhaustively as possible, and to avoid making claims that their data do not actually support.

III. Professional Identity: Who Scientists Think They Are

This Part examines the scientist's professional identity and its interaction with a lawyer's professional identity, framing the challenges of interdisciplinary interaction as those of cross-cultural communication. This communication is particularly troubled by the failure to recognize that a key term, like "uncertainty," has very different implications in law and science. Using the example of uncertainty, this Part provides lawyers with helpful criteria for identifying specious arguments.

A. The Marginality of Interdisciplinarity

Questions of legal professionalism and scientific professionalism are questions of identity. Even when interdisciplinarity is valued within the academy, there is a tug-of-war over whether an interdisciplinary scholar is *really* a scientist—or *really* a lawyer. This quandary is the marginality of interdisciplinarity. This pressure to have a single or primary identity that is already recognized by traditional disciplines is an aspect of identity formation more generally.[39] For example, suppose that one has two national identities, having grown up in Taiwan, but moved to the U.S. as a teenager and attended college, joined a profession, and become a U.S. citizen. Such a person may eventually feel that he has two national identities: one is Taiwanese,

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[38] Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013).

[39] For instance, even when an arbitrary, meaningless criterion is used to determine a group identity, members of the group will favor fellow group members over those who are not in the group. Henri Tajfel *et al.*, *Social Categorization and Intergroup Behaviour*, EUR. J. SOC. PSYCHOL. I 149 (1971).

and one is American. However, when this international person goes "home" to Taiwan, people treat him like an outsider—*really* an American—and when he goes back "home" to the U.S., people treat him as though he is *really* Taiwanese—not *really* an American. It is the same in academia: interdisciplinarity is fashionable, but when someone is (for example) both a scientist and a legal scholar, his colleagues want to know which one he *really* is: he may be fully both, but he may be treated as if he were fully neither.[40]

Identity reflects what a person values and devalues: I am this, and I am *not* that. Identity formation and maintenance entails a kind of boundary-work that defines *that* person. Lawyers can reflect on our own legal cultures, and we can learn about scientific cultures: what does it mean to be a scientist? What kinds of professional performances define a scientist for herself, and allow her to be recognized as a scientist by other scientists? Just as it is most useful to us in law to focus on what science means to the scientists who know it best, we should also understand who scientists are through a focus on who scientists believe they are. Lawyers must be sensitive to what kinds of work requests will respect or disrespect the professional identity of the scientists with whom they are working.

Legal professionals can understand their interactions with scientists as cross-cultural interactions that call for cultural sensitivity and respect. I use "epistemological ethics" to refer to the scientist's professional commitments and values with respect to the quality of the knowledge that he produces. As lawyers, we need to understand and respect the epistemological ethics of the scientific community, and of the scientists with whom we work. When we see that their professional commitments give science its epistemological power, we have a better chance of ensuring that this power is not lost in translation when we use it to inform the law.

A lawyer's professional identity formation begins in law school,[41] where she develops a critical understanding of the law in books and prepares to become an officer of the court, trusted by the court and her client to assist in the administration of justice by providing a fair representation of the client's case.[42] A lawyer learns to discover information about the case and frame it in terms of her best arguments for her client. A lawyer who does not perform in accordance with legal ethical commitments to the quality of knowledge performs illegally and unethically, risking disciplinary action and malpractice liability, and jeopardizing her professional identity[43]—her ability to be a lawyer.

A scientist develops an understanding of what counts as knowledge during the professional formation of graduate school, where she becomes responsible for producing original research and develops a commitment to striving to maximize the rigorous quality of scientific knowledge. A scientist who does not perform in accordance with scientific ethical commitments to the

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[40] *See also* Hélène Zimmerman, *Developing Empirical Legal Research in Legal Training: A Canadian Experience in a Civil Law School*, presented at Law & Soc'y Assn. Annual Conference (June 7, 2012) (discussing how researchers' "methodological choices also form a sort of crystallization point for identity"—as if one could not be, fully, both a sociologist and a jurist).

[41] *See, e.g.*, ANTHONY T. KRONMAN, THE LOST LAWYER: FAILING IDEALS OF THE LEGAL PROFESSION (1993).

[42] Deborah M. Hussey Freeland, *What Is a Lawyer? A Reconstruction of the Lawyer As an Officer of the Court*, 31 ST. LOUIS UNIV. PUB. L. REV. 425 (2012) and citations therein.

[43] Deborah M. Hussey Freeland, *What Is a Lawyer? A Reconstruction of the Lawyer As an Officer of the Court*, 31 ST. LOUIS UNIV. PUB. L. REV. 425 (2012).

quality of knowledge jeopardizes her professional identity as a scientist—her ability to be recognized as a scientist, and to be a scientist at all.[44]

In our formation as legal professionals, we take an oath to uphold our country's Constitutional values, such as those of justice and fair play.[45] In our training as scientists, we develop a professional commitment to maximizing the objective qualities of scientific research. These professional commitments complement each other: how can we decide fairly if we don't know, or have the wrong idea about, the facts at issue? And yet science—which when empirical data are called for, is the best of our knowledge—often loses its epistemological quality when it is used in legal decisionmaking: the epistemological power of science is often misdirected when translated into law. When this occurs, legal decisions are not as well informed as they should be: a decision that is informed by degraded "facts" is less likely to achieve a legal system's goals of reasonableness and fairness.

The problem of the marginality of interdisciplinarity poses a challenge for lawyers who must figure out how to work with science and scientists. Lawyers may resist immersion in truly interdisciplinary analysis in a variety of ways. In particular, a lawyer laboring under the "standard conception"[46] may feel erroneously that getting the facts right is not her job, while law students may seek assurance that interdisciplinary analysis is *really* legal analysis. Legal professionals of all kinds encounter science in so many contexts, but lawyers often do not know much about any of the sciences.[47] Some may have avoided the sciences as much as possible—for example, when law students are asked to evaluate statistical evidence, responses like "Argh! I was an English major!" are surprisingly common—and judges may share this feeling.[48]

The use of science to inform law requires careful, multifaceted translation.[49] We cannot just paste scientific language into legal processes and expect lawyers to hear what scientists are saying. In addition to translating scientific language into terms accessible to legal decisionmakers, we need to be able to identify and unpack homonyms—terms that appear to be

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[44] NATIONAL ACADEMIES OF SCIENCE, ON BEING A SCIENTIST 15 (3d ed. 2009). *See also* Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373 (2007); Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013).

[45] Deborah M. Hussey Freeland, *What Is a Lawyer? A Reconstruction of the Lawyer As an Officer of the Court*, 31 ST. LOUIS UNIV. PUB. L. REV. 425 (2012); *see also* Carol Rice Andrews, *The Lawyer's Oath: Both Ancient and Modern*, 22 GEO. J. LEGAL ETHICS 3 (2009).

[46] Gerald Postema coined the term "standard conception" to refer to and critique the idea that a lawyer is merely an agent of a client. Gerald J. Postema, *Moral Responsibility in Professional Ethics*, 55 N.Y.U. L. REV. 63, 74 (1980).

[47] Mara Merlino *et al.*, *Science in the Law School Curriculum: A Snapshot of the Legal Education Landscape*, 58 J. LEGAL EDUC. 190, 198 (2008) ("[A]ttorneys may have little educational background in the sciences, and many lack important insights about the methods and philosophies of science that would help them.").

[48] Students often make such exclamations as they prepare to interpret statistical claims. J. Rehnquist expresses a related concern in Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579, 600 (1993) (Rehnquist, J., dissenting in part): ("I defer to no one in my confidence in federal judges; but I am at a loss to know what is meant when it is said that the scientific status of a theory depends on its 'falsifiability,' and I suspect some of them will be, too.").

[49] Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373, 383 (2007); Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013).

identical across law and science, but actually have deeply different meanings in each discipline.[50] As in other instances of cross-cultural communication, "lawyers and scientists may be using the same words without realizing that they are talking past each other."[51] We also need to make cultural translations: legal and scientific professional norms concerning fact-finding overlap, but in some respects they conflict to the extent that the lawyer's professional behavior is the scientist's malpractice. When we understand that, and how, science and law speak different languages, we can expand this understanding to the idea that science and law have different cultures.

B. Scientists' Professional Commitments with Respect to Uncertainty

Lawyers need to be critically aware of unmarked translations in the meanings of homonymic terms interdisciplinary translation. For example, legal professionals may attribute some meanings to a word like "uncertainty" and assume that those meanings are common, without realizing that scientists may be using the term with very different denotations and connotations. A key component of their interdisciplinary understanding is an awareness of the distinctiveness of the concepts of uncertainty in law and science. As I discuss in other work, legal processes (most notably, the litigation process) tend to have repose as their goal, settling expectations and reducing uncertainties to promote the stability of social ordering under the law; in contrast, scientific progress can only occur as long as there is more to know—as long as uncertainties persist—and the acknowledgement and analysis of uncertainty is a hallmark of scientific rigor.[52] Since uncertainties do persist (we are not omniscient), science is open-ended; closure is not a goal, though often uncertainty can be managed well enough to allow applied scientists, engineers, physicians—and arguably, lawyers—to use scientific research results as a basis for developing effective technologies. However, the differences between what lawyers and scientists mean by "uncertainty," and their diverging normative commitments with respect to it, make the concept particularly difficult to translate between law and science.[53]

Scientists do not expect uncertainty to go away.[54] Mathematicians who design a closed universe can define all of the objects within it and the rules for finding more objects and rules within it, producing proofs. Empiricists, who seek to understand a reality that they did not create and of which their knowledge is incomplete, cannot: they produce the best of their knowledge under the circumstances of the moment. There are many genres of uncertainty, from the irreducible uncertainty stemming from having a limited (rather than omniscient) subject-position, to that which comes from the theoretically measurable but logistically impossible to measure (*e.g.*, how

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[50] Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289, 334-36 (2013).

[51] *Id*. at 289. *See also* Pauline Newman, *Law and Science: The Testing of Justice*, 57 N.Y.U. ANN. SURV. AM. L. 419, 423 (2000) (discussing this phenomenon from the perspective of a judge).

[52] Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013) ("Law, deriving authority from closure, strives to eliminate uncertainty, and will produce a decision regardless of it. In contrast, science values uncertainty as information for directing inquiry, and will attempt to account for it but not to eliminate it by fiat.").

[53] Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013).

[54] Wong & Hodson, *supra* n.13 at 122 ("[W]e don't believe that we can find an absolute and definitive law of the universe in our lifetime." (quoting the high-energy physicist interviewed by the authors)).

many fish are in the sea; how many fish were in the sea 1,000 years ago), to that which could be reduced if we were to make more measurements.[55]

When a scientist expresses the uncertainties attending her research, she is not simply pointing to a lack of knowledge.[56] Rather, she is indicating that she has exhausted her abilities to measure and model the phenomenon under study—demonstrating her meticulousness, rigor, and commitment to presenting her research as honestly and precisely as possible—including the attendant litany of imprecisions that she can identify. This performance signals her scientific professionalism and identity, and invites her peers to engage in helping her to understand the phenomenon.

The proper management of uncertainty is a significant part of a scientist's socialization into the profession. For example, an introductory guide to performing laboratory experiments signals to undergraduates in physics not only the definitions of various kinds of uncertainty, but also the norms that characterize professional behavior with respect to it.[57] Focusing on the normative instruction offered in this orientation to scientific research offers insights into the formation of a scientist's professional identity.

For instance, we see that it is considered "proper[]" for a scientist to "report an experimental result along with its uncertainty," so that the scientist can understand her own work and enable others to judge it as well.[58] This reflects the scientist's fundamental professional commitments to raising the epistemological quality of research in her own work, and through peer review.

The guide also reflects scientists' working under a correspondence theory of truth, and their awareness of practical limits to scientific knowledge:

> When we make a measurement, we generally assume that some exact or **true value** exists based on how we define what is being measured. While we may never know this true value exactly, we attempt to find this ideal quantity to the best of our ability with the time and resources available.[59]

Scientists are socialized to value consensus as a provisional indicator of the true value sought[60]—scientific knowledge is incomplete, but we proceed as though the consensus value were likely

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[55] Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373, 383 (2007).

[56] *Id*. *See also* Henry N. Pollack, *Scientific Uncertainty and Public Policy: Moving on Without All the Answers*, MARCH 2007 GSA TODAY 28 ("Clearly, we don't know everything about these phenomena, but that does not mean that we don't know anything."). For an approachable account of how carefully scientists analyze uncertainty, *see* Duane Deardorff, The University of North Carolina at Chapel Hill, Department of Physics and Astronomy, *Introduction to Measurements & Error Analysis*, *at* http://user.physics.unc.edu/~deardorf/uncertainty /UNCguide.html (Aug. 10, 2000) (last visited (Jan. 28, 2014)).

[57] Duane Deardorff, The University of North Carolina at Chapel Hill, Department of Physics and Astronomy, *Introduction to Measurements & Error Analysis*, *at* http://user.physics.unc.edu/~deardorf/uncertainty/ UNCguide.html (Aug. 10, 2000) (last visited Jan. 28, 2014).

[58] Deardorff, supra n.55 at 1.

[59] Deardorff, supra n.55 at 1 (emphasis retained).

[60] Deardorff, supra n.55 at 2 ("We can . . . retain a useful definition of accuracy by *assuming* that, even when we do not know the true value, we can rely on the best available accepted value with which to compare our experimental value.") (emphasis added).

correct until it is validly challenged and a new consensus forms.[61] Scientists strive to identify, categorize and manage various uncertainties, and value each other's ability to recognize and study uncertainties.[62] Scientists value open communication with peers to identify as many uncertainties as possible; this openness is necessary to the formation of a robust consensus.[63]

Among the sources of error to which the guide calls young scientists' attention, the description of personal errors is particularly revealing of scientific professional norms. Scientists expect and rely on each other to ensure that experimental procedures are performed correctly.[64] Carelessness, poor technique, and bias are unacceptable.[65]

Responsibility for reducing and reporting uncertainty is explicitly expressed in terms of a scientist's professional obligation: "The experimenter is the one who can best evaluate and quantify the uncertainty of a measurement based on all the possible factors that affect the result. Therefore, the person making the measurement has the *obligation* to make the best judgement possible and report the uncertainty *in a way that clearly explains what the uncertainty represents*[.]"[66]

Ultimately, scientists value not only their own and each other's ability to report and account for uncertainties, but also uncertainty itself:

> **Anomalous** data points that lie outside the general trend of the data may suggest an interesting phenomenon that could lead to a new discovery, or they may simply be the result of a mistake . . . . Extreme data should never be "thrown out" without clear justification and explanation, because you may be discarding the most significant part of the investigation![67]

That is, results that do not conform to a model that is being tested or to the rest of the data could lead to a fascinating discovery in themselves. Not only is the manipulation of unexpected results regarded as dishonest and unprofessional, but the unexpected results are positively valued.

Furthermore, justification is required before data is intentionally manipulated or "cleaned up" for presentation in other ways. For example, it is "unethical" to present data with exaggerated

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[61] This theory of scientific knowledge resembles the idea of paradigm shifts suggested by Thomas Kuhn. THOMAS KUHN, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS (2d. ed. 1970).

[62] Deardorff, supra n.55 at 3 ("Our strategy is to reduce as many sources of error as we can, and then to keep track of those errors that we can't eliminate. It is useful to study the types of errors that may occur, so that we may recognize them when they arise.").

[63] Deardorff, supra n.55 at 3 ("The best way to account for these sources of error is to brainstorm with your peers about all the factors that could possibly affect your result."); *see also* Tore Schweder, *Distortion of Uncertainty in Science: Antarctic Fin Whales in the 1950s*, 3 J. OF INT'L WILDLIFE L. & POL'Y 73, 74 (2000) ("Honesty and trust among members of the scientific community is critical.").

[64] Deardorff, supra n.55 at 4 ("As a rule, gross personal errors are excluded from the error analysis discussion because it is generally assumed that the experimental result was obtained by following correct procedures.").

[65] Deardorff, supra n.55 at 4 (advising scientists to watch out for personal errors in which "[t]he experimenter may measure incorrectly, or may use poor technique in taking a measurement, or may introduce a bias into measurements by expecting (and inadvertently forcing) the results to agree with the expected outcome.").

[66] Deardorff, supra n.55 at 5 (emphasis added).

[67] Deardorff, supra n.55 at 8 (emphasis retained).

uncertainty, so that measurements appear to overlap and thus appear to agree.[68] Other forms of overclaiming are likewise described as offensive to professional ethics. For instance, framing a measurement or a calculation as though it were more precise than it is by writing too many digits after the decimal place is "dishonest,"[69] "unreasonable," and "WRONG!"[70]: precision must be justified by a sufficiently large and reliable body of measurements.[71] This meticulous care and commitment to exactitude in conducting and presenting scientific research is a basic scientific professional ethic.

C. Spurious Uses of Uncertainty

A better feel for the nature of scientific uncertainty can usefully inform our evaluation of arguments about uncertainty in legal settings. A variety of rhetorical and situational characteristics can help us to identify suspect arguments.

1. Demanding Certainty from Science

Clearly, it is inappropriate to demand certainty from science.[72] Arguments that science must be black-and-white, or that the only acceptable alternative to uncertainty is certainty, are spurious. In science, statements of "proof" that are not confined to mathematical proofs are suspect: lawyers can take this cue and subject empirically based statements of proof to stronger scrutiny.

2. Citing Uncertainty As a Reason for Delay

Similarly, it is a recognized delay tactic to exaggerate the significance of scientific uncertainty when the scientific community acknowledges uncertainty but proceeds to build on the results it attends. This effort to exaggerate, misframe or "manufacture uncertainty" has been identified in the context of the regulation of a variety of industries.[73] Statistician Tore Schweder has raised the question whether "the intentional injection of controversy for non-scientific reasons," which he calls the "distortion of uncertainty," should be considered an act of scientific misconduct along with falsifying data, fabricating data, and plagiarism.[74]

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[68] Deardorff, supra n.55 at 16 ("It would be unethical to arbitrarily inflate the uncertainty range just to make the measurement agree with an expected value. A better procedure would be to discuss the size of the difference between the measured and expected values within the context of the uncertainty[.]").

[69] Deardorff, supra n.55 at 13 ("For the same reason that it is dishonest to report a result with more significant figures than are reliably known, the uncertainty value should also not be reported with excessive precision.").

[70] Deardorff, supra n.55 at 14 ("For example, if we measure the density of copper, it would be unreasonable to report a result like: measured density = 8.93 ± 0.4753 g/cm^3 WRONG! The uncertainty in the measurement cannot be known to that precision.") (emphasis retained).

[71] Deardorff, supra n.55 at 14 ("in order for an uncertainty value to be reported to 3 significant figures, more than 10,000 readings would be required to justify this degree of precision").

[72] *See supra* n. 17 and accompanying text.

[73] David Michaels & Celeste Monforton, *Manufacturing Uncertainty: Contested Science and the Protection of the Public's Health and Environment*, 95 PUB. HEALTH MATTERS S39 (2005); *see also* DAVID MICHAELS, DOUBT IS THEIR PRODUCT (2008); NAOMI ORESKES & ERIK M. CONWAY, MERCHANTS OF DOUBT: HOW A HANDFUL OF SCIENTISTS OBSCURED THE TRUTH ON ISSUES FROM TOBACCO SMOKE TO GLOBAL WARMING (2010); Wendy L. Lipworth, *Managing Scientific Uncertainty in Health Legislation*, 37 INTERNAL MED. J. 119 (2007); Henry N. Pollack, *Scientific Uncertainty and Public Policy: Moving On Without All the Answers*, 17 GEOL. SOC'Y OF AMER. TODAY 28 (2007).

[74] Tore Schweder, *Distortion of Uncertainty in Science: Antarctic Fin Whales in the 1950s*, 3 J. OF INT'L WILDLIFE L. & POL'Y 73, 73, 89 (2000).

3. Mismatching Claims and Expertise

In evaluating arguments about uncertainty, one should check whether the field of the scientific research presented and the field of an expert's expertise match. For example, a statistician may well have a great deal of experience with metallocene chemistry, but this is not usually the case. When it is not the case, the statistician's opinion regarding chemistry should not be treated as an "expert" opinion. While the *Daubert* factors guide judges to match the expert with the expertise,[75] this connection can more easily be left unchallenged in the legislative, regulatory, or treaty negotiation contexts.[76] Because a responsible scientist refuses to make claims beyond his expertise, such claims call into question their own validity. As discussed above, scientists are very concerned about overclaiming.

4. Exploiting Properly Reported Uncertainty

In evaluating arguments about uncertainty, it can be helpful to notice whether uncertainty is reported accurately and cited as a sign of the scientist's professionalism, or is exaggerated and cited as a sign of a generic lack of knowledge. A scientist who points out uncertainties in his own work gains the reputational benefit of being recognized as a professional scientist. He is pointing out the limits of his research and showing fellow scientists where they can step in to contribute further, or warning them of analogous uncertainties to watch out for in their own work. A scientist who points out the uncertainties or limitations in another scientist's work may be indicating where his contribution comes in—how it relates to the work on which he builds—which is an expected professional behavior. Arguments that point out the uncertainties in scientific research results in a way that overstates them or frames them as signs of the *poor* quality of the research (rather than its high quality) call for special scrutiny, as they turn the meaning of scientific uncertainty on its head.

5. Conflicts of Interest

Similarly, sources and mechanisms of research funding should be inspected:[77] is the research produced for, reviewed by, or published by an entity that would benefit from a specific, predetermined outcome? Is the research funded by an agency that engages a broad base of independent reviewers and conducts a blind or double-blind review based on scientific merit as evaluated by the appropriate scientific community? Who decides when, where and what to publish: the researcher or the funder? Legal professionals working with science should examine the funder's, the researcher's, and the publisher's potential conflicts of interest, which are now often reported with the publication of the research in a scientific journal.

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[75] Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579 (1993).

[76] Tore Schweder, *Distortion of Uncertainty in Science: Antarctic Fin Whales in the 1950s*, 3 J. OF INT'L WILDLIFE L. & POL'Y 73, 88 (2000) (noting that even though "it became obvious that [an anatomist] did not understand the concept of density dependence in population dynamics . . . there is no evidence that any steps were taken" to prevent him from emphasizing its uncertainties in an international regulatory setting).

[77] Tore Schweder, *Distortion of Uncertainty in Science: Antarctic Fin Whales in the 1950s*, 3 J. OF INT'L WILDLIFE L. & POL'Y 73, 89 (2000):

> Contacts between science and government or industry are, of course, not necessarily bad. Scientists need to understand the needs of society, and scientific research requires funding. But too intimate contacts might influence scientists to such a degree that they become biased. They might even become instruments to further the political or economic goals of their funders and friends, sacrificing the pursuit of objective scientific knowledge.

6. Distorting Uncertainty As Professional Malpractice

Scientists understand the interaction of law and science to be one of using science to inform the law.[78] For example, epidemiologists have framed the connection of their research to public health law in terms of providing the best scientific evidence; in turn, "the public health system must ensure that scientific evidence is evaluated in a manner that assures the public's health and environment will be adequately protected."[79] This means that the scientific evidence must not be distorted[80]—which suggests that Schweder's question about whether the distortion of uncertainty constitutes scientific malpractice could be raised in legal settings as well: is it unethical for a lawyer to distort the meaning of scientific research results (or of the uncertainties that complement them) that she is using to support an argument before a court?[81] Michaels and Monforton indicate that this is unethical in legislative and regulatory contexts.[82] Just as scientists have professional commitments to maintain rigorous epistemological standards, so do lawyers. Public trust is invested in both professions, and as officers of the court, lawyers have fundamental duties to ensure that legal decisions are based on honest representations.[83]

IV. The Scope of Law & Science

A threshold challenge of interdisciplinary study is defining the scope of an interdisciplinary field. One might take a diagrammatic approach to this problem by drawing a boundary around one field, a boundary around another, and trying to identify their overlap. Alternatively, one might focus on a single aspect of the use of science in law, and define the field in terms of this issue. Perhaps because law and science are each themselves broad disciplines encompassing diverse questions and methods, these approaches invite gross oversimplification.

A related question is how to define boundaries between law and science *within* the interdisciplinary field of Law & Science. Alvin Weinberg has suggested that scientists must serve the public by distinguishing science from "trans-science," where trans-science comprises questions of moral and aesthetic judgment that science cannot answer.[84]

Some scholars have taken the more comprehensive approach of both acknowledging the difficulty of cataloguing (let alone defining) the scope of Law & Science, and nonetheless persevering in mapping a range of instances in which law engages with science and calling to

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[78] *See, e.g.*, Jane Lubchenco, *Entering the Century of the Environment: A New Social Contract for Science*, 279 SCIENCE 491 (1998); Gary K. Meffe, *Conservation Scientists and the Policy Process*, 12 CONSERVATION BIOL. 741 (1998).

[79] David Michaels & Celeste Monforton, *Manufacturing Uncertainty: Contested Science and the Protection of the Public's Health and Environment*, 95 PUB. HEALTH MATTERS S39, S39 (2005).

[80] *Id*. ("This strategy of manufacturing uncertainty is antithetical to the public health principle that decisions be made using the best evidence available.").

[81] Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013); Deborah M. Hussey Freeland, *What Is a Lawyer? A Reconstruction of the Lawyer As an Officer of the Court*, 31 ST. LOUIS UNIV. PUB. L. REV. 425 (2012).

[82] David Michaels & Celeste Monforton, *Manufacturing Uncertainty: Contested Science and the Protection of the Public's Health and Environment*, 95 PUB. HEALTH MATTERS S39 (2005).

[83] Deborah M. Hussey Freeland, *What Is a Lawyer? A Reconstruction of the Lawyer As an Officer of the Court*, 31 ST. LOUIS UNIV. PUB. L. REV. 425 (2012).

[84] Alvin M.Weinberg, *Science and Trans-Science*, 10 MINERVA 209, 213, 216 (1972); *see also* Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289, 293-94, 324-25 (2013).

others to contribute. These mapping approaches laudably begin to gather data on the scope of Law & Science, providing dots that later researchers might connect to develop an understanding of how these superficially disparate interfaces are related.

This Part examines a variety of attempts to characterize a problem in terms of Law & Science, identifying in the relevant literature four major approaches to defining its scope. The next Part further works toward developing a theoretical framework for Law & Science that is flexible enough to encompass the variety of research that could be recognized as part of the field, but for which this overarching interdisciplinary identity remains latent.

A. The Diagrammatic Approach

The diagrammatic approach to Law & Science tends to reduce the scope of law, science, or both, and then study the overlap of what remains. For example, "law" may be reduced to litigation, so that "Law & Science" denotes expert witness testimony in court.[85] While the use of scientific expert testimony in court has generated a vast literature (especially since *Daubert*[86]), this focus does not by any means exhaust the discipline of Law & Science. Legislative, regulatory, and alternative dispute resolution processes also routinely involve scientific expertise.

Another example is presented by the reduction of "science" to technology, so that Law & Science becomes patent law, or perhaps the study of the regulation of technological development. As discussed above, "science" denotes knowledge produced in accordance with the scientific method,[87] ideally involving controlled experimentation.[88] Scientists are engaged in intellectual activity focused on building accurate and comprehensive models of aspects of a posited objective reality of the natural world. A scientist defines a question about a natural phenomenon, devises ways to investigate it, and carefully collects the responses of the natural system to his query. These responses are data, research results which are to be interpreted in light of other science, with all assumptions and limitations of the question, method, and modes of interpretation accounted for. Scientists are professionally committed to establishing and maintaining the integrity of their research results, acting individually and collectively according to the ethics and norms of their discipline to identify, minimize, and alert others to any effects of noise or bias, so that future research can be properly informed. Science is the best of our empirical knowledge at a moment—additional research that complements earlier research contributes to a fuller, more accurate model of the phenomena under study.

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[85] *See, e.g.*, Lee Loevinger, *Jurimetrics: Science in Law* 14, in SCIENTISTS IN THE LEGAL SYSTEM: TOLERATED MEDDLERS OR ESSENTIAL CONTRIBUTORS? (ed. William A. Thomas, 1974) ("Most of the seminars for lawyers offered in past years under the title of 'Science and Law' had to do with the use of medical science in ascertaining the extent of personal injuries in accident cases.").

[86] Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579 (1993).

[87] OXFORD ENGLISH DICTIONARY ONLINE, SCIENTIFIC, ADJ. AND N., SPECIAL USES S2., SCIENTIFIC METHOD N. (2d ed. 1989) ("a method of procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses.").

[88] OXFORD ENGLISH DICTIONARY ONLINE, SCIENCE, N., 5.B (2d ed. 1989) ("In modern use, [science is] often treated as synonymous with 'Natural and Physical Science', and thus restricted to those branches of study that relate to the phenomena of the material universe and their laws, sometimes with implied exclusion of pure mathematics. This is now the dominant sense in ordinary use.").

For the purpose of considering the scope of Law & Science, it is useful to be able to distinguish science from technology. "Technology"[89] can mean applied science generally; most pertinently, it refers to the products[90] of engineering, which is "the development and modification of engines (in various senses), machines, structures, or other complicated systems and processes using specialized knowledge or skills, typically for public or commercial use."[91] Science builds our fundamental understanding of nature, whereas technology consists of gadgets—products for public or commercial use. On the basis of this distinction, technology is either entirely distinguished from science, or is recognized as its margin far downstream from basic science: science produces information that is robust to the rigors of the scientific method (such as discovering electrons, and understanding their behavior in various materials); this information is so reliable that from it we can develop technologies (such as semiconductors).

Patent law has long been regarded as an archetypical example of Law & Science.[92] But patent law concerns inventions—technologies produced from the application of scientific research to a given engineering problem. In the realm of patents, law meets technology, or science in its application rather than science in itself.

Through this distinction we can better appreciate the scope of Law & Science. As a scholarly field, Law & Science extends beyond the interaction of scientific research results with law, which occurs for example when a court needs to determine how school segregation affects African American students,[93] or whether a species protected by the Endangered Species Act is impacted by overfishing.[94] Law & Science also encompasses the problems of technology, treating legislation, regulation and litigation concerning issues such as the direction of technological development,[95] the protection of the public from its ill effects,[96] and the patent law

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[89] OXFORD ENGLISH DICTIONARY ONLINE, TECHNOLOGY, N., 4.A (3d ed. 2009).

[90] OXFORD ENGLISH DICTIONARY ONLINE, TECHNOLOGY, N., 4.C (3d ed. 2009).

[91] OXFORD ENGLISH DICTIONARY ONLINE, ENGINEERING, N., 1 (3d ed. 2010).

[92] Over 160 years ago, the challenges of harmonizing law and science were already longstanding problems in patent law. *See* WILLIAM SPENCE, PATENTABLE INVENTION AND SCIENTIFIC EVIDENCE 102 (1851) (describing "the substitution of a scientific, for the present legal, tribunal" as a "proposal which does not seem to acquire strength from its age and constant repetition[.]"). *See also* David F. Cavers, *Science and the Law Symposium: Introduction*, 63 MICH. L. REV. 1325, 1326 (1964-1965) ("that arena of contact between law and science which is at once the most venerable and the most direct of them all: namely, that created by the patent laws.").

[93] *See, e.g.*, Brown v. Bd. of Educ., 347 U.S. 483 (1954); *see also* Lynne N. Henderson, *Legality and Empathy*, 85 MICH. L. REV. 1574 (1987).

[94] *See, e.g.*, Greenpeace v. Nat'l Marine Fisheries Serv., 106 F. Supp. 2d 1066, 1080 (W.D. Wash. 2000); *see also* Beth C. Bryant, *Adapting to Uncertainty: Law, Science, and Management in the Steller Sea Lion Controversy*, 28 STAN. ENVTL L.J. 171 (2009).

[95] *See, e.g.*, Mark B. Brown & David H. Guston, *Science, Democracy, and the Right to Research*, SCIENCE & ENGINEERING ETHICS 351 (2009) (regarding the assertion of scientists' rights to conduct research in debates over the regulation of stem cell research).

[96] *See, e.g.*, FEDERAL FOOD, DRUG, AND COSMETIC ACT, 21 U.S.C. ch. 9; WORLD HEALTH ORGANIZATION, PANDEMIC INFLUENZA PREPAREDNESS FRAMEWORK FOR THE SHARING OF INFLUENZA VIRUSES AND ACCESS TO VACCINES AND OTHER BENEFITS (2011) (promoting the sharing of influenza viruses and vaccines to improve the World Health Organization's global surveillance and response system, and discouraging treating these technologies as intellectual property).

concerning its ownership.[97] Research concerning new technological developments and their implications for law and policy clearly should be recognized as tiles in the mosaic of Law & Science, even when such efforts do not explicitly identify themselves as such. For example, Law & Science embraces multidisciplinary treatments of law and stem cell research,[98] and of law and nanotechnology.[99] Interestingly, the editors of a recent book on the societal implications of nanotechnology treat the field of law and nanotechnology just as earlier editors have treated the field of Law & Science of which it is a part, echoing the urgent need for interdisciplinary understanding and hoping to make a "small start" in its direction.[100]

Just as we should understand the "Law" in Law & Science to encompass not only litigation, but also legislation, regulation and alternative dispute resolution, we should understand the "Science" in Law & Science to be very broad, reaching the physical sciences, the social sciences, and technology in their relation to all forms of legal processes.

B. Focus on a Single Aspect of the Use of Science in Law: Science Is Not Certainty

As discussed above, it is clear to scientists that science is not certainty. Yet in law, we are tempted to act as though it is. Since this phenomenon can be observed in a variety of legal contexts, it is sometimes treated as the central or perhaps sole issue of Law & Science.

For example, in exploring the "potential for a hybrid law, literature, and science project,"[101] David Caudill deploys the tools of literary criticism and rhetorical analysis to examine fictional and historical narrative accounts of the engagement of law with science. Caudill cautions against the extreme positivistic view that science is a "collecti[on of] irrefutable facts"[102] as well as against the extreme social constructivist view that scientific research results are fully determined by social contingencies.[103] His literary analysis suggests that a "modest view of the scientific enterprise is appropriate in legal contexts."[104] Caudill urges that science has much in common

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[97] *See, e.g.*, U.S.C. Title 35: Patents.

[98] *See, e.g.*, RUSSELL KOROBKIN & STEPHEN R. MUNZER, STEM CELL CENTURY: LAW AND POLICY FOR A BREAKTHROUGH TECHNOLOGY (2006).

[99] *See, e.g.*, NANOTECHNOLOGY: RISK, ETHICS AND LAW (eds. Geoffrey Hunt & Michael Mehta, 2006).

[100] *Id*. at 9 ("Transdisciplinary thinking is vital, discomfiting as it will be for those embedded in their separate expert discourses. We hope this book makes a small start by pointing out some important directions for fresh thinking and truly global ethical concern."). *See infra* Part IV.D.

[101] DAVID S. CAUDILL, STORIES ABOUT SCIENCE IN LAW: LITERARY AND HISTORICAL IMAGES OF ACQUIRED EXPERTISE 5 (2011).

[102] *Id*. at 11 (internal citation omitted).

[103] *Id*. at 2 (noting that this view could be "caricature[d] as [that of] complete relativists with no appreciation for scientific progress."). Working in science and technology studies, Sheila Jasanoff has focused on the mechanisms of social construction that lead to the legitimation of some interpretations of science but not others—put another way, she has examined how legal processes manage the demarcation problem of sifting science from non-science. Taking a social constructivist approach farther than does Caudill, she finds it necessary *a fortiori* to emphasize that science is not certainty. *See, e.g.,* SHEILA JASANOFF, SCIENCE AT THE BAR 206-07 (1995) ("[G]ood science is not a commodity that courts can conveniently shop for in some extrasocietal marketplace of pure knowledge. There is no way for the law to access a domain of facts untouched by values or social interests. Scientific claims that are imported into the legal process are colored not only by the interests of the offering parties but also by the social, cultural, and political commitments of other actors in society[.]").

[104] *Id*. at 140.

with law in that both are "rhetorical, social, and institutional, involving ethical dimensions, credibility, cultural authority, and unstable interpretations,"[105] and that these aspects of science "together determine the place of science in law."[106]

As both a lawyer and a scientist, I find it fascinating that this argument needs to be made. The outcome of Caudill's narrative analysis appears to be that "[t]he apparent objectivity of scientific discourse" can be "called into question,"[107] though he also indicates some resistance to the argument that science is unreliable.[108] But as we have seen above, the rhetoric of science does not consist of absolute claims to objectivity.[109] Scientific rhetoric reflects the scientist's professional commitment to bracket his individual subjectivity in an effort to optimize the chances of learning about a posited, objective reality.[110] Accordingly, scientific rhetoric is cautious, tentative, and very conservative: professional scientists understand that their models reflect the assumptions required by the reductionistic approach that makes experimentation tractable, and that uncertainties from numerous sources (such as instrument sensitivity and measurement error) inhere in their experimental results. Moreover, scientists must report these limitations of their research, both to demonstrate their rigor in accounting for and trying to control for as much error as possible, as well as to indicate to other scientists how additional research efforts best may be allocated to make progress in understanding the phenomenon under study.

Scientists are aware of (and even value) the ethical dimensions of their work, the instability of their interpretations, and their professional need for credibility (which is based on procedural rigor) that supports the cultural authority of science.[111] A scientist who overclaims his research acts unethically and loses credibility, the reputational capital that is essential to his professional identity. The strength of scientific objectivity claims derives not from scientific rhetoric itself, but from the demonstrated applicability of science to develop technologies that enable us to influence the natural world in desired (and undesired) ways: the actions of science speak louder than its words.

Thus, although scientists routinely call the objectivity of their work into question—as is required by scientific professionalism[112]—some legal scholars describe their profession as one that

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[105] *Id*. at 2.

[106] DAVID S. CAUDILL, STORIES ABOUT SCIENCE IN LAW: LITERARY AND HISTORICAL IMAGES OF ACQUIRED EXPERTISE 10 (2011).

[107] *Id*. at 140.

[108] *Id*.

[109] *See supra* Parts II and III.

[110] Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373, 383 (2007); Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013).

[111] *See, e.g.*, Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013); COMMITTEE ON SCIENCE, ENGINEERING AND PUBLIC POLICY OF THE NATIONAL ACADEMY OF SCIENCES, NATIONAL ACADEMY OF ENGINEERING, AND INSTITUTE OF MEDICINE, ON BEING A SCIENTIST: RESPONSIBLE CONDUCT IN RESEARCH 16 (2d ed. 1995).

[112] Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013) (and citations therein). *See also* Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373, 383 (2007).

perceives science as falsely advertising its objectivity.[113] For example, Robin Feldman argues that law must adapt to social changes under uncertainty and turns to science for certainty and authority in doing so—but since it turns out that science does not provide certainty, legal professionals must learn to accept incompleteness and imperfection in law.[114]

Similarly, while arguing for a view of science that is somewhere between the extremes of positivism and constructivism, Caudill's effort seems to start from a positivistic view of science and pull us toward the conclusion that the socially contingent aspects of science "need to be acknowledged and their implications understood in legal contexts."[115] But in science these aspects are already acknowledged, and significant work is devoted to understanding their implications.[116]

Legal scholarship is capable of reflecting the understanding that scientists do not see their results as definitive proofs.[117] So how does the extreme positivistic view of science enter legal discourse? Perhaps through the media and science textbooks, as suggested by Wong & Hodson.[118] In adjusting for this, how can legal discourse avoid an overcompensatory swing to the also inaccurate view that science has no information with any strong claims to objectivity that can significantly inform the law? Promoting the cross-cultural understanding that affords lawyers an appreciation of how scientists see science, and why scientists speak and must speak in terms of assumptions, uncertainties, and provisional results, may offer lawyers a way to protect themselves and those they counsel from arguments that distort scientific uncertainty.

C. Law, Science and Trans-Science: Questions That Science Cannot Answer

Scientists have long noted that non-scientists tend to mistake the boundaries of their discipline. For example, interlocutors in political debate may look to scientific research to provide answers to policy questions that require value judgments instead of or in addition to scientific information.[119] Science alone cannot provide answers to these questions. Scientists can provide

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[113] *See, e.g.*, ROBIN FELDMAN, THE ROLE OF SCIENCE IN LAW 48 (2009) ("We begin with an overexuberant embrace of a science as a solution to our difficult legal problems. Over time, the limitations of that science in the legal realm become apparent.").

[114] *Id*.

[115] DAVID S. CAUDILL, STORIES ABOUT SCIENCE IN LAW: LITERARY AND HISTORICAL IMAGES OF ACQUIRED EXPERTISE 140 (2011).

[116] COMMITTEE ON SCIENCE, ENGINEERING AND PUBLIC POLICY OF THE NATIONAL ACADEMY OF SCIENCES, NATIONAL ACADEMY OF ENGINEERING, AND INSTITUTE OF MEDICINE, ON BEING A SCIENTIST: RESPONSIBLE CONDUCT IN RESEARCH (2d ed. 1995).

[117] *See, e.g.*, EDWIN. W. PATTERSON, LAW IN A SCIENTIFIC AGE 6 (1963) ("Is science 'infallible'? Surely, as John Dewey said, only some gullible 'literary' people believe that."); Fiona E. Raitt, *A New Criterion for the Admissibility of Scientific Evidence: The Metamorphosis of Helpfulness*, in LAW AND SCIENCE (ed. Helen Reece) (1998) 173 (internal citation omitted) ("In its quest for 'truth' the judicial process seeks the impossible—the quest for certainty. This is an unattainable and ultimately pointless endeavor for, as some scientists have acknowledged, 'to keep silent until our understanding is complete is to keep silent forever'."); Lee Loevinger, *Law and Science As Rival Systems*, 19 U. FLA. L. REV. 530, 550 (1966-67) ("This is not to say that any amount of money or effort will provide data that will disclose easy solutions of social and legal problems. *Science neither promises* nor provides instant salvation.") (emphasis added).

[118] *See supra* n.17 and accompanying text.

[119] Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373, 455 (2007) (showing that the question of the optimal water-level in a lake depends on the prior value-judgment that determines what is to be optimized); Deborah M. Hussey Freeland,

empirical research that sheds light on the consequences of various political decisions, and can more fundamentally educate decisionmakers concerning which questions are amenable to scientific methods—doing the boundary work[120] of "mak[ing] clear where science ends and trans-science begins."[121]

Many have noted that legal actors are repeatedly tempted to punt to science when grappling with a difficult question of legal line-drawing, and these authors have attempted to dissuade them from looking for scientific answers to legal questions.[122] This argument echoes in a legal context Weinberg's argument about the demarcation problem in science: scientific questions should be addressed by science, and trans-scientific questions should not. As Chief Judge Howard Markey notes, science is descriptive, while the law is normative: "Science teaches us what we can do: law tells us whether we should."[123]

Both the perception of and the failure to perceive the distinction between scientific and political questions are reflected in recent work on international regulation of environmental and health risks.[124] As Jacqueline Peel notes, "Narrowly focused science-based approaches to risk regulation . . . perpetuat[e] a myth that complex risk questions can be reduced to matters of science."[125] Apparently, this myth persists in practice despite judges' and scholars' efforts to call

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Speaking Science to Law, 25 GEO. INT'L ENVTL. L. REV. (2013) (citing Alvin M. Weinberg, *Science and Trans-Science*, 10 MINERVA 209, 213 (1972)).

[120] Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013) (and citations therein).

[121] Alvin M. Weinberg, *Science and Trans-Science*, 10 MINERVA 209, 220 (1972) (indicating that "trans-scientific" questions are those which "science is inadequate [to answer] simply because the issues themselves involve moral and aesthetic judgments: they deal not with what is true but rather with what is valuable."); Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 399, 462 (2007).

[122] Lee Loevinger sees this as a general tendency of humankind that has plagued law throughout its history. Lee Loevinger, *Law and Science As Rival Systems*, 19 U. FLA. L. REV. 530, 531 (1966-67) (finding a "natural tendency in the human mind to cast the burden of its doubts upon a higher power, and to relieve itself from the effort of decision[.]"); *see also* David L. Bazelon, *Coping with Technology Through the Legal Process*, 62 CORNELL L. REV. 817, 820 (1977); Howard T. Markey, *Science and Law—Toward a Happier Marriage*, 59 J. PAT. OFF. SOC'Y 343, 348 (1977) ("Our people have acquired an eager readiness to look to science for salvation. But 'scientific salvation' is a shibboleth. Salvation lies not in knowledge alone, but in what man chooses to do with the knowledge science gives him."); ROBIN FELDMAN, THE ROLE OF SCIENCE IN LAW 1 (2009) ("[W]e look to science to rescue us from the experience of uncertainty and the discomfort of difficult legal decisions.").

[123] Howard T. Markey, *Science and Law—Toward a Happier Marriage*, 59 J. PAT. OFF. SOC'Y 343, 345 (1977); *see also* Lee Loevinger, *Law and Science As Rival Systems*, 19 U. FLA. L. REV. 530, 535 (1966-67) ("In the most simple and elementary terms it may be said that the function of science is descriptive and that of law is prescriptive. The essential legal function of prescribing norms is not and cannot be scientific in any sense which the contemporary scientific community would recognize as scientific."); *see also* EDWIN. W. PATTERSON, LAW IN A SCIENTIFIC AGE 32 (1963).

[124] JACQUELINE PEEL, SCIENCE AND RISK REGULATION IN INTERNATIONAL LAW 10-11 (2010) (calling for "a realistic understanding of the capacities of science to support risk assessment, as well as those of international legal and governance structures to accommodate non-scientific inputs in a fair and transparent manner.").

[125] *Id*. at 11.

our attention to it for decades[126]—though at least in international governance the question of "how scientific *and* non-scientific inputs might be blended" is now "emerging."[127]

D. Mapping the Fragments of Law & Science

Over the years several attempts have been made to collect into a single volume articles on a disparate variety of issues in which law encounters science. The motive for these endeavors is the observation that law must grapple with science in a widening variety of contexts, and their aspiration is therefore to promote interdisciplinary understanding. Unfortunately, no theoretical foundation is provided on which to develop such an understanding.

For example, LAW AND THE SOCIAL ROLE OF SCIENCE[128] is a collection of reports prepared for a conference on the funding and regulation of science. The editor notes that "a book ten times as long as this one could not deal exhaustively with the impact of science on law or of law on the social role of science,"[129] and makes a significant effort to compensate for this limitation by offering a bibliography on law and science by Morris L. Cohen and Betty J. Warner, which was updated by Cohen and others in 1978 and 1980.[130]

In an introductory essay David Cavers "seek[s] simply to sort out and characterize some of the diverse situations in which law and science must take each other into account."[131] Cavers' goal in presenting this survey of contact points between law and science—which he acknowledges is incomplete—is to "demonstrate[] that in the years to come the lawyer and the scientist will have to resolve many problems of concern to both . . . ."[132] Writing in 1966, Cavers already felt that "it is high time that we learn to work together, so that we can get on with these jobs."[133]

Cavers' survey of examples of law-science interfaces is sparse, and he does not offer a theoretical perspective from which to examine them. Nonetheless, he usefully categorizes them into five sorts of situations: those in which: (1) adjudication requires scientific information (the situation of the expert witness in court[134]); (2) scientific developments entail changes in legal

[126] *See, e.g.*, David L. Bazelon, *Coping with Technology Through the Legal Process*, 62 CORNELL L. REV. 817, 819 (1977) ("[W]e are all becoming increasingly conscious of the extent to which many supposedly scientific or technical decisions involve painful value choices, and pose difficult policy problems."); Howard T. Markey, *Science and Law—Toward a Happier Marriage*, 59 J. PAT. OFF. SOC'Y 343, 350 (1977) ("Neither science nor law should be . . . looked to for all the answers. Though technology creates problems, they are not technical problems. Like all man's problems, they are moral and ethical, and that's where the law lives.").

[127] JACQUELINE PEEL, SCIENCE AND RISK REGULATION IN INTERNATIONAL LAW 10 (2010).

[128] LAW AND THE SOCIAL ROLE OF SCIENCE (ed. Harry W. Jones, 1967).

[129] *Id*. (introduction).

[130] MORRIS L. COHEN *ET AL*., LAW & SCIENCE: A SELECTED BIBLIOGRAPHY (eds. Vivian B. Shelanski & Marcel C. La Follette, 1978); MORRIS L. COHEN *ET AL*., LAW & SCIENCE: A SELECTED BIBLIOGRAPHY (eds. Vivian B. Shelanski & Marcel C. La Follette, 2d ed. 1980).

[131] David F. Cavers, *Law and Science: Some Points of Confrontation*, in LAW AND THE SOCIAL ROLE OF SCIENCE 5 (ed. Harry W. Jones, 1967) (hereinafter, *Points of Confrontation*).

[132] *Id*. at 15.

[133] *Id*.

[134] As discussed above, "Law & Science" is sometimes used narrowly to refer to the presentation of scientific evidence in court, though this is but one aspect of Law & Science. This may occur in part because there is an extensive literature on expert testimony in litigation, especially since the U.S. Supreme Court designated the judge

doctrine; (3) new technological hazards require regulation; (4) government directs scientific research; (5) science results in new social interactions which in turn require new legal developments. Categories (3) and (5) can be seen as specific instances of category (2), so that the kinds of interactions between law and science that Cavers describes are the situation of the expert witness, legal responses to scientific progress, and the legal shaping of scientific progress through funding and regulation.

Regarding (1), Cavers captures the incompatibility of the adversary system with "the scientific method and the temperament of scientists"[135]:

> Counsel tries to extract a slanted picture from the [scientific expert] witness, and, on cross-examination, opposing counsel seeks to slant the picture the other way. To the man trained to objectivity, this is a perversion of a quest for truth and justice. That some of his colleagues have adapted successfully to its pressures makes the situation all the more obnoxious to him.[136]

Cavers felt that this incompatibility could not be resolved "as long as the scientist is cast in a partisan role[.]"[137] Before the promulgation of the Federal Rules of Evidence, he recommended the use of the "impartial expert"[138] selected from a roster provided by a medical society, and called by the court. This suggestion was a compromised version of what he regarded as the best solution, in which an inquisitorial judge seeks expert advice.[139]

Jennifer Mnookin has concluded that the judge's role is unlikely to grow in its inquisitorial dimension.[140] But supporting the judge's inquisitorial capacity would not be a radical new development, as is sometimes perceived.[141] Justice Stephen Breyer urges judges to avail themselves of the provisions of Rule 706 of the Federal Rules of Evidence, which explicitly provides for the court to appoint its own expert witnesses.[142] Rule 706 could ameliorate the incompatibility that Cavers describes by associating the scientific neutral with the legal neutral, rather than casting her in alliance with an adversary.[143]

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as the gatekeeper who is to distinguish science from non-science. *See* Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 U.S. 579 (1993).

[135] *Points of Confrontation* at 6.

[136] *Id*.

[137] *Id*. at 7.

[138] *Id*.

[139] *Id*. at 8; *see also* John H. Langbein, *The German Advantage in Civil Procedure*, 52 U. CHI. L. REV. 823, 841 (1985).

[140] Jennifer L. Mnookin, *Expert Evidence, Partisanship, and Epistemic Competence*, 73 BROOK. L. REV. 1009, 1033 (2008).

[141] Amalia D. Kessler, *Our Inquisitorial Tradition: Equity Procedure, Due Process, and the Search for an Alternative to the Adversarial*, 90 CORNELL L. REV. 1181 (2005) (noting that the inquisitorial aspects of our procedural framework persisted as late as the nineteenth century, and were not abolished by the merger of law and equity).

[142] Stephen Breyer, *The Interdependence of Science and Law*, 82 JUDICATURE 24 (1998).

[143] *See, e.g.*, Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013).

Another example of a mapping effort is provided in SCIENTISTS IN THE LEGAL SYSTEM: TOLERATED MEDDLERS OR ESSENTIAL CONTRIBUTORS?.[144] The variety of articles in this collection most directly concern Law & Science itself, in that they tend to focus on the role of science in law and on assessing the professional relationships between lawyers and scientists. For instance, one article discussed a survey that was sponsored by the National Science Foundation and sent to the Natural Resources Law Section of the American Bar Association in 1971 to assess "the communication gap between law and science."[145] While most of the lawyer-respondents criticized scientists for inadequate communication, several respondents suggested improving communication by promoting interdisciplinary studies by both scientists and lawyers.[146]

The editor's goal in assembling this collection was not to theorize Law & Science, but simply "to encourage scientists . . . to become more actively involved in our legal system."[147] The collection was "not meant to provide encyclopedic coverage, but rather to present an overview of ways in which scientists and lawyers interact to resolve issues. The spectrum is broad and diverse indeed, as reflected by the range of subjects covered by the authors,"[148] from questions of technological assessment by courts, to those of law and medicine, to those of environmental law. This fascinating volume provides useful data on issues that fall within the scope of Law & Science, but does not attempt to offer a theoretical framework for elucidating how these disparate subjects are related.

Providing yet another example from the same editor almost a decade later, SCIENCE AND LAW: AN ESSENTIAL ALLIANCE[149] is a collection of reprinted articles, each with a fragment related to Law & Science. For example, this volume touches on issues in areas such as the regulation of technology, environmental law, forensic science and patent law. The editor describes the collection as a "sampler" rather than a complete survey of science and law, which is presented with the hope of raising awareness of the need for multidisciplinary solutions to multidisciplinary problems.[150]

The editor's goal was to "promot[e] better understanding by lawyers and scientists of each of the aspirations and limitations of each other's profession" so that "the misunderstandings that often inhibit joint efforts by the two professions" may be overcome.[151] Though each article calls for improvements in interdisciplinary interaction, no theoretical framework for relating the collected articles is presented, nor is any analysis indicating how the disparate articles are to promote interdisciplinary understanding.

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[144] SCIENTISTS IN THE LEGAL SYSTEM: TOLERATED MEDDLERS OR ESSENTIAL CONTRIBUTORS? (ed. William A. Thomas, 1974).

[145] James W. Curlin, *Law, Science and Public Policy: A Problem in Communication* 36, in SCIENTISTS IN THE LEGAL SYSTEM: TOLERATED MEDDLERS OR ESSENTIAL CONTRIBUTORS? (ed. William A. Thomas, 1974).

[146] *Id*. at 42.

[147] SCIENTISTS IN THE LEGAL SYSTEM: TOLERATED MEDDLERS OR ESSENTIAL CONTRIBUTORS? v (ed. William A. Thomas, 1974).

[148] *Id*.

[149] SCIENCE AND LAW: AN ESSENTIAL ALLIANCE (ed. William A. Thomas, 1983).

[150] *Id*. at x (echoing Lee Loevinger, *Law and Science As Rival Systems*, 19 U. FLA. L. REV. 530, 538 (1966-67)).

[151] *Id*. at iii.

Another map of several points is provided by LAW AND SCIENCE,[152] a symposium volume collecting papers touching on issues in areas such as tort, expert witness testimony, and public health. Like other such collections, it offers no theoretical apparatus for understanding how the disparate contributions are related: the editor simply describes the commonality among these fragments of Law & Science as their concern for "the intersection between law and science."[153] Echoing the distinction between science as the realm of "is" and law as the realm of "ought"—the descriptive/normative division that was identified by Loevinger and by Markey almost a half-century ago[154]—the editor again proposes an interdisciplinary division of labor among the fields of law and science: "it is for scientists to reveal as much as they can about reality, and for the law to determine what should be made of the discoveries."[155] While this observation is consistent with Weinberg's distinction between science and trans-science, and with the scientist's professional role as the gatekeeper at that boundary, its bare reiteration over several decades indicates no progress in the development of Law & Science as a unified field.

The examples discussed so far include one collection from each decade from the 1960s to the 1990s. In 2008 a collection composed of article excerpts drawn from a variety of disciplines and concerning some aspect of Law & Science was published as part of a series on law and society.[156] Though this collection draws from authors outside of the realm of legal scholars, interestingly, the excerpts are categorized roughly along the lines sketched long ago by David Cavers, with by far the largest number falling under category (1) (science in court), and all but three of the remaining articles (which concern epistemology[157]) falling under the other two categories. The collection is offered to explore more deeply how law and science are related, but again, no theoretical framework for conducting this analysis is offered.[158]

In addition to articulating the problem of disciplinary boundary work within Law & Science, this Part illustrates various strategies that scholars have taken to grappling with Law & Science: a diagrammatic approach that artificially reduces the scope of law, science, or both; an approach that focuses on a single aspect of interaction between law and science, such as the distortion of scientific uncertainty; and a mapping approach, that collects small sets of data about the contents of the field. All of these fail to engage with the actual scope of Law & Science, though the last is a promising approach if carried out exhaustively. Scholars have noted an urgent and growing need for interdisciplinary understanding among lawyers and scientists and have sought to

[152] LAW AND SCIENCE (ed. Helen Reece, 1998).

[153] *Id*. at ix.

[154] *See supra* n. 122 and accompanying text.

[155] LAW AND SCIENCE (ed. Helen Reece, 1998).

[156] SUSAN S. SILBEY, LAW & SCIENCE (2008).

[157] While these articles focus on legal and scientific epistemology, other epistemological inquiries are relevant to Law & Science as well. For example, scholarship concerning the epistemological nature of testimony itself—where testimony simply means the reports of others and is not confined to the narrower denotation of oral evidence given in court—may fruitfully be applied to the science-in-court situation. A collection of such scholarship is provided in THE EPISTEMOLOGY OF TESTIMONY (eds. Jennifer Lackey and Ernest Sosa, 2006).

[158] Ashgate, *Law and Science, Volumes I and II*, *at* http://www.ashgate.com/isbn/9780754625001 (last visited May 28, 2014) ("These two volumes collect exemplary law and society scholarship to look beneath the surface connections and antagonisms between these two powerful modern institutions. The first volume collects . . . .").

promote this understanding by having lawyers and scientists talk with each other, creating symposia with an assortment of papers each of which speaks to its specific issue that has a legal and a scientific dimension. None of these efforts has provided a theoretical understanding of the nature of Law & Science as a unified field. Some scholars have pointed out the need for linguistic translation in the process of using science to inform law;[159] this is a step in a helpful direction.

V. Toward a Unified Field

There is a tendency for interesting work that would fall within the boundaries of a map of Law & Science to stay close to the specific substance with which it engages. As discussed above, this disciplinary focus is encouraged through traditional academic structures that build literatures and careers focused on narrow topics. Academic institutions are becoming aware of the problem of disciplinary "silos" that effectively pose barriers to cross-cutting work. Nonetheless, even when rhetoric and funding are made available to support interdisciplinary collaboration, it is very challenging for a collection of scholars each focused on performing for her home discipline to succeed in interdisciplinary engagement.[160] Further, individual scholars who are interdisciplinary in themselves suffer from the marginality of interdisciplinarity: it is harder for them to become established where the margins of two or more fields touch, because they do not seem to fit squarely at the center of either or any of the interacting fields' literatures nor departments.

Fortunately, some scholars who are well established in a traditional discipline are able to reach towards the intersections of their fields with Law & Science and contribute to its growth. For example, in a book on the philosophy of science Susan Haack includes a chapter titled, "Entangled in the Bramble Bush: Science in the Law."[161] The chapter begins by acknowledging the vast variety of ways in which science is entangled with law, and narrows the focus of the chapter to the problems of scientific evidence in court.[162] Most of the chapter reviews the legal apparatus, and then Haack offers a few pages of epistemological commentary that handily critique the assumptions about scientific epistemology on which the relevant legal structure depends. Haack handily describes in the context of the courts the problem with defining science that I see in legal scholarship:[163]

> Evidently the majority of the *Daubert* Court succumbed to the seduction of the honorific use of "scientific" . . . looking for a simple criterion of demarcation that

[159] *See, e.g.*, THE ROLE OF SOCIAL SCIENCE IN LAW (ed. Elizabeth Mertz, 2008) (discussing a the need for linguistic translation between those inside the legal system and social scientists who study it from the outside); James Boyd White, *Intellectual Integration*, 82 NORTHWESTERN U.L. REV. 1, 15 (1987) (taking a literary and linguistic perspective on the "law and" genre of interdisciplinarity: "[T]he hope would be to bring together in the mind at once two systems of discourse, two sets of questions and methods and motives, with the aim of making new texts that would incorporate both . . .. We would put ourselves in the position of translators, those who know that what is said in one language cannot simply be set over into another without loss or gain and who therefore conceive of their task as the creation of new compositions that will establish mutually respectful relations between them.").

[160] MYRA H. STROBER, INTERDISCIPLINARY CONVERSATIONS: CHALLENGING HABITS OF THOUGHT (2011).

[161] SUSAN HAACK, DEFENDING SCIENCE—WITHIN REASON (2003).

[162] *Id*. at 234 ("Even this relatively limited topic presents formidable complexities . . . .").

[163] *See supra* n.9 and accompanying text.

> federal judges could use to determine whether proffered testimony was genuine science . . . and hoped (apparently having read someone who read someone who read Popper) that Popper's criterion would do the trick.[164]

Haack then explains how neither the philosophy of Karl Popper nor that of Carl Hempel means what the Court seems to think it means. Examining epistemological mismatches in a variety of contexts in which legal processes engage with science would likely identify similar misunderstandings; maps of such data have the potential to inform the development of a theoretical apparatus for analyzing interdisciplinary epistemological translation and increasing its fidelity.

Another example of a scholar at the top of his traditional field whose work can inform the development of Law & Science more generally is Stephen Schneider. Schneider was an atmospheric scientist who devoted his career to the study of climate change, and tried to use the results of scientific research in that field to inform the development of climate change law, for example, in his capacity as a Coordinating Lead Author of a Working Group of the Intergovernmental Panel on Climate Change preparing a report on risk assessment. While his contact with Law & Science was completely focused on climate change, his reflections on the process of using science to inform law led to insights that are applicable to this interdisciplinary engagement more broadly. For example, Schneider cautions scientists about the difficulty (and perhaps the impossibility) of speaking professionally as scientists in the form of media soundbites. In a blog concerning the role of scientists in ensuring that the public is properly informed about climate change, he expressed the concern that "[b]alancing the need to be effective in sound-bite situations with the responsibility to be 'honest' (*i.e.*, fully disclosing complexities) is what I call the 'double ethical bind,'"[165] in that "as scientists we are ethically bound to the scientific method, in effect promising to tell the truth, the whole truth, and nothing but—which means that we must include all doubts, the caveats, the ifs, ands and buts."[166] This problem of the need to accommodate professional scientific speech and cultural norms arises across the scope of Law & Science.[167]

Another insight from Schneider's work that applies across Law & Science is the need for the public to "learn how to separate what part of the discussion is over scientific disputes and what part is over worldviews,"[168] and by so doing to make ourselves "less susceptible"[169] to political speech that distorts the science on which it purports to be based. This harmonizes with interdisciplinary themes developed here concerning the need for non-scientists—including legal professionals—to be educated in the nature of science.

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[164] SUSAN HAACK, DEFENDING SCIENCE—WITHIN REASON 251 (2003).

[165] Stephen H. Schneider, *Mediarology*, at http://stephenschneider.stanford.edu/Mediarology/Mediarology.html (last visited May 28, 2014).

[166] *Id*.

[167] *See, e.g.*, Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289 (2013); Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373 (2007).

[168] STEPHEN SCHNEIDER, SCIENCE AS A CONTACT SPORT 232 (2009).

[169] *Id*. at 281.

Because each instance of Law & Science involves cross-cultural communication, we can develop a theoretical approach to Law & Science that applies to all of its manifestations by building an understanding of the interaction of lawyers and scientists in terms of their professional identity and ethics, especially with regard to knowledge. That is, a focus on the epistemology of science and the epistemological ethics of scientists allows us to understand how fields as diverse as antidiscrimination law and the regulation of nanotechnology are related to each other. Each of these is not only a field of study in its own right, but is also a specific example of the interdisciplinary interaction of law and science more generally. Accordingly, this overarching interdisciplinary perspective allows us to identify features that are common to the problems of both subfields of Law & Science, and to use insights from interdisciplinary analysis to disentangle the issues that arise from interdisciplinarity itself and from the engagement of law with science, from other issues that pertain specifically to the substantive problem at hand.

For example, I have designed a model of interdisciplinary interaction that frames science as a knowledge-producing realm that is distinct from but in communication with a legal or public decisionmaking realm.[170] The model is based on an analogy to living cells that must regulate the contact between their internal environments and the external medium to ensure their viability; cells accomplish this through the use of a gated membrane, an outer boundary that is only permeable to particular materials under controlled circumstances. But this model can be imagined more simply as a line drawn down a page, with science on one side, law on the other, and their interaction mediated by a gatekeeper who translates information from one realm to the other. Focus on the functions of the gatekeeper abstracts the specific substantive issues on either side, foregrounding the modes of communication that will and will not be effective in promoting interdisciplinary problem-solving.

To demonstrate the breadth of the model's applicability, I analyzed two very different forms of engagement between law and science. The first was a case study of a major ecosystem restoration effort pursuant to federal law and involving coordination with state and tribal governments, in which the Florida Everglades were to be restored and protected while the agricultural and urban economies that depend on Everglades water management were to be sustained.[171] While it may sound impossible to manage Everglades water simultaneously to sustain these economies and to restore water to the wetlands, 1.7 billion gallons of freshwater per day that were being diverted to the sea instead could have been redirected for other purposes, including being allowed to percolate through the parched wetlands.[172] The legal mechanisms for accomplishing the ecosystem's restoration were based on section 601 of the federal Water Resources Development Act of 2000, which required the promulgation of a regulatory program featuring the creation of a multidisciplinary team of scientists who were to ensure that the highest quality science would be incorporated into the implementation of the program.[173] Thus, in the regulatory structure the scientist-administrators on this team were in the position of translating requests for scientific information from the legal realm into questions that scientific research could address, as well as for communicating scientific research results into the legal

[170] Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373 (2007).

[171] *Id*. at 378-451, 401-02.

[172] *Id*. at 407, 420 (citations omitted).

[173] *Id*. at 401-31.

process in ways that would protect the epistemological integrity of the research along with the professional integrity of the researchers.[174] This function of translating between the regulatory and scientific cultures—of finding ways to use science to inform the law without compromising its epistemological quality nor the professional ethics of the scientific researchers involved—is a problem of interdisciplinary epistemological ethics and cross-cultural communication that occurs across the map of Law & Science. Analysis in terms of this model yielded insights into how the regulatory structure could be refined to use science more effectively to reach the goals of the law.[175]

I also deployed the model in the analysis of a very different form of engagement between law and science, that of a science-based method of alternative dispute resolution.[176] The method features a consensus-building strategy that involves getting the stakeholders in a negotiation to work together to determine the kinds of scientific information that would facilitate their decisionmaking.[177] While this strategy may facilitate negotiation and promote the formation of an agreement, mapping the communication between scientists and decisionmakers in terms of the model identified potential problems for the participating scientists and with the resulting science.[178] Focus on the boundary-work required to maintain the integrity of science in this context cautions alternative dispute resolution practitioners to ensure that scientists are not stakeholders in the negotiation, and that stakeholders refrain from becoming so involved in the science that their perspectives bias the scientific research results.[179] Neither should the scientists be mediators who must serve the stakeholders equally, because the independently conducted science may turn out to favor one stakeholder's position over that of another, thereby posing role-conflict for the scientist-mediator.[180] In addition to identifying procedural standards to ensure the proper function of science in science-based alternative dispute resolution, combining this analysis with that of the dispute-resolution functions embedded in the Everglades restoration plan generated additional insights into how the plan could be refined to take advantage of science-based dispute resolution in its implementation.[181]

The fulcrum in this structure of interdisciplinary communication is clearly the gatekeeper between the realms of science and law, whom I have described as both a guardian of the boundary and a translator between the realms it separates.[182] More deeply, this gatekeeper is a maieutic actor, a kind of Socratic midwife who is ethically bound to bracket her personal interests to focus on bringing information across the boundary with high fidelity, in a new form

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[174] *Id*. at 442, 395, 397-401.

[175] Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373, 395, 442, 447-51 (2007).

[176] *Id*. at 451-67.

[177] *Id*. at 451-59 (citations omitted).

[178] *Id*. at 451-64.

[179] *Id*.

[180] Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373, 464 (2007).

[181] *Id*. at 467-70.

[182] *Id*. at 381.

that is legible and meaningful on the other side.[183] This process of maieutic boundary-work involves more than linguistic translation. Rather, the process involves cultural translation and representation: the re-presentation of material carefully gathered on one side and transformed into something different that faithfully communicates the matter in a way that the other side can recognize. For example:

> The maieutic ethic of the scientist requires her to serve as a conduit for nature's responses to scientific inquiries. While she would be disingenuous to represent herself personally as though she lacked political inclinations or allies, representation of herself in a professional role signals to the audience that she is not about to speak as a private person, but as a representative of something else.[184]

In law, professional performance governed by maieutic ethics include: the formation of a lawyer from an applicant to the bar through procedures that culminate in the applicant's taking the lawyer's oath of office; the representation of a client's matter before a court; the judge's interpretation of a general law for a specific case; and the formation of a single nation from various states through the ratification of a Constitution.[185] The concept of maieutic action captures the interpretive functions of the scientist and of the lawyer,[186] and the maieutic ethics that govern these functions are manifest in the scientist's commitment to avoid fudging or otherwise distorting data,[187] as well as in the lawyer's commitment to avoid misleading the court or otherwise acting dishonestly.[188]

The professional performance of the gatekeeper or translator at an interdisciplinary interface is similarly governed by maieutic ethics. To perform her maieutic function most effectively, this interdisciplinary professional ideally will be fully at home on both sides of the boundary; in this instance, she must be not only fluent in both the language of the law and the language of science, but also socialized to understand how to perform according to the rules, ethics and norms of both disciplinary cultures. This cultural sensitivity enables the interdisciplinary professional to see what matters in one discipline, and see that it matters when she represents it to the other.

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[183] *Id*. at 380-91. ("The term 'maieutic' derives from midwifery and describes a method of assisting one to realize that which is latent in the mind (as does the Socratic method).").

[184] *Id*. at 383. The concept of the scientist's maieutic ethic captures a point made by scientist Karl Pearson over a century ago: "The scientific man has above all things to strive at self-elimination in his judgments, to provide an argument which is as true for each individual mind as for his own." KARL PEARSON, THE GRAMMAR OF SCIENCE, § 2 *Science and Citizenship* 6 (1892).

[185] Deborah M. Hussey Freeland, *What Is a Lawyer? A Reconstruction of the Lawyer As an Officer of the Court*, 31 ST. LOUIS UNIV. PUB. L. REV. 425 (2012).

[186] Harry W. Jones, *Legal Inquiry and the Methods of Science*, in LAW AND THE SOCIAL ROLE OF SCIENCE 120 (ed. Harry W. Jones, 1967) ("The man of science and the man of law were both interpreters: the scientist striving to discern and formulate the eternal laws of nature that explain physical phenomena, the lawyer striving to apprehend and make effective the moral structures of God's natural law for man.").

[187] Deborah M. Hussey Freeland, *Maieusis Through a Gated Membrane: "Getting the Science Right" in Public Decisionmaking*, 26 STAN. ENVTL. L.J. 373, 380-81 (2007); Deborah M. Hussey Freeland, *Speaking Science to Law*, 25 GEO. INT'L ENVTL. L. REV. 289, 306 (2013).

[188] Deborah M. Hussey Freeland, *What Is a Lawyer? A Reconstruction of the Lawyer As an Officer of the Court*, 31 ST. LOUIS UNIV. PUB. L. REV. 425, 449, 475, 487, 490-92, n.82 (2012).

Writing about the communication gap between law and science in 1974, James Curlin noted that "[i]t is paradoxical that both professions must rely on third parties not skilled in either discipline to translate for each other."[189] With the advent of J.D.-Ph.D. programs that could produce professionals who have studied how to effect better communication between law and science (and ideally, who also have put this study into practice in the course of their graduate education), soon we may need no longer to entrust this maieutic function to those who are unskilled in either or both disciplines. However, the quality of the literature of legal scholarship remains at the mercy of law students, who serve as the gatekeepers who draw the boundary around legal scholarship. It would make sense for this demarcation process that confers legitimacy on research reports to be conducted by experts in the field, as it is in the scientific literature. But law students are (by definition) not yet experts in law, and most are not experts in any other field of scholarship. How can a non-expert, who is aware of neither the substance nor the nature of science, nor of scientific professional ethics, properly perform this gatekeeping function for the Law & Science literature?

Unfortunately, it appears that they cannot. For example, consider an article by Richard Sander, accepted and published in the Stanford Law Review, purporting to have found through the statistical analysis of empirical data that affirmative action results in the poorer performance of African-American students.[190] The research was so deeply and obviously flawed that social scientists had no trouble in demonstrating that the results were spurious.[191] However, the law-student editors were ill equipped to recognize the problems with the article.[192] Because of the failure of the gatekeeping process, the best that the scholarly community could do was divert time and energy from productive research to "substantially dispose[] of his paper"[193] and to "rebuke"[194] the law review (and the author) for its failure at maintaining the integrity of the literature. Meanwhile, damage had been done as the abilities of African-American students and the benefits of racial desegregation were baselessly called into question.[195]

Every legal professional should have at least a basic understanding of the nature of science as described above, since professional competence often requires the legal professional to effect

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[189] James W. Curlin, *Law, Science and Public Policy: A Problem in Communication* 43, in SCIENTISTS IN THE LEGAL SYSTEM: TOLERATED MEDDLERS OR ESSENTIAL CONTRIBUTORS? (ed. William A. Thomas, 1974).

[190] Richard H. Sander, *A Systemic Analysis of Affirmative Action in American Law Schools*, 57 STAN. L. REV. 367 (2004).

[191] *See, e.g.*, Michele Landis Dauber, *The Big Muddy*, 57 STAN. L. REV. 1899 (2005); Ian Ayres & Richard Brooks, *Does Affirmative Action Reduce the Number of Black Lawyers?*, 57 STAN. L. REV. 1807 (2005); David L. Chambers *et al.*, *The Real Impact of Eliminating Affirmative Action in American Law Schools: An Empirical Critique of Richard Sander's Study*, 57 STAN. L. REV. 1855 (2005); Daniel E. Ho, Scholarship Comment, *Why Affirmative Action Does Not Cause Black Students To Fail the Bar*, 114 YALE L.J. 1997 (2005).

[192] Michele Landis Dauber, *The Big Muddy*, 57 STAN. L. REV. 1899, 1912 (2005) ("[T]he editorial review of Sander's empirical work consisted solely of rerunning a limited subset of Sander's analyses to verify that the output of the statistical package matched the numbers in his tables. It is probably unreasonable to expect students with this low level of expertise to realize that an analysis of social science data is not merely a mechanical exercise, and therefore that the broader scientific community must have access to the underlying data in order to test a researcher's methodological and substantive judgments.").

[193] *Id*. at 1914 (2005) (referring to Marta Tienda's review of Sander's article).

[194] *Id*.

[195] *Id*.

interdisciplinary translations on her own.[196] Incorporating the study of the nature of science and the epistemological ethics of scientists into legal education would help law schools to generate more competent legal professionals, who are better prepared to perform proper interdisciplinary translations.

The theoretical approach I describe is fruitful not only in scholarly analysis, but also in teaching non-scientists how to evaluate representations of science in the context of legal or political debate. After introducing students to the nature of science and the professional commitments of scientists with respect to the epistemological quality of their research results, I explain the gated membrane or interfacial model that maintains a realm of science distinct from but in communication with a legal or public decisionmaking realm. We then use this framework to diagram the flow of information and requests for information through the legal procedures under study, dropping in the substance of an issue (such as climate change) and mapping out the apparati for interdisciplinary communication as it is, and determining how it could be better designed to protect the integrity of science and scientists while informing the relevant legal or public decisionmaking processes. Students find this eye-opening, and over the course of a semester become better equipped and more confident in their abilities to deal with science and scientists in their professional work.

VI. Conclusion

For legal decisionmaking to be informed by the best of our knowledge, lawyers need to understand what science is and what constitutes the professional integrity that scientists must maintain. Because scholarship in Law & Science has remained fragmented and resisted theoretical development, the theoretical insights that could inform the engagement of law and science are scarce.

This paper argues that to use science effectively to inform law, lawyers and legal scholars should rely on scientists' definitions of science, and consider scientists' professional commitments with respect to its quality. Analyses of how scientists define "science" and of their professional commitments with respect to it yield several criteria for identifying spurious arguments that appear to be based in science.

The paper further identifies some of the theoretical barriers to understanding Law & Science as a unified field. The scope of the field is vast, but arbitrarily reducing it to make it more tractable distorts our comprehension. Over many decades several scholars have attempted to sample the field of Law & Science, generating collections of essays that are diverse in substance but that have in common some engagement with both law and science. While these aggregates provide some data about the scope of Law & Science, they do not provide a theoretical approach to interpreting how Law & Science coheres as a field in its own right.

A theoretical approach that begins with a focus on the challenges of interdisciplinarity does much to reveal the features that superficially distinct questions of Law & Science have more deeply in common. In all instances, progress in treating questions of Law & Science depends on

[196] *See, e.g.*, Lee Loevinger, *Jurimetrics: Science in Law* 22, in SCIENTISTS IN THE LEGAL SYSTEM: TOLERATED MEDDLERS OR ESSENTIAL CONTRIBUTORS? (ed. William A. Thomas, 1974) ("At a minimum, law school graduation should require a general knowledge of the elements of scientific method, including operational definitions, reliance on empirical evidence, quantification and indeterminacy, testing by multiple hypotheses, replicability, and the concept of disclosure and peer review.").

an understanding of the nature of science, especially with regard to its epistemological power and to the professional commitments of scientists that are necessary to establish and maintain the strength of its claims to objectivity. The objectivity of science is universally acknowledged by scientists to be imperfect, but in their striving to maximize it, they produce knowledge that has been reliable enough to generate a vast array of technological developments. Interfering with their professional performance undermines the epistemological rigor of science that makes it useful for public decisionmaking in the first place. Concern for the epistemological qualities of science and for the ethics that govern the representation of science in the field of law can lead to the more effective use of science to inform law across the field of Law & Science. Understanding the interdisciplinary interaction of lawyers and scientists as instances of cross-cultural communication, that requires both linguistic and cultural translations, can facilitate interdisciplinary problem-solving in Law & Science as well.

Both in theory and in practice, we can learn to use our science and our law to develop thoughtful structures for addressing societal concerns, meriting the public trust that we place in each profession.