The Language of Law, the Sociology of Science, and the Troubles of Translation: Defining the Proper Role for Scientific Evidence of Causation

Charles Kester
Lingle Law Firm

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I. INTRODUCTION

Bertrand Russell once observed that "[s]ociety cannot exist without law and order, and cannot advance except through vigorous innovators." Russell's observation neatly captures a fundamental distinction between law and science. Both disciplines have created vast social and conceptual structures but for drastically different purposes. An understanding and recognition of these differences between the social and conceptual structures of law and science has several concrete implications for the use of scientific evidence as proof of legal causation.

The function of law is to provide a mechanism for the peaceful resolution of disputes. In pursuit of this goal, legal rules have incorpo-
rated a realist\textsuperscript{4} causal paradigm that posits pre-existing causes "out there" in the external world. In contrast, scientists seek to advance\textsuperscript{5} their respective research areas by engaging in experimental research and disseminating the results to other scientists. This scientific enterprise is best explained by an anti-realist causal paradigm. The anti-realist causal paradigm posits causes that, rather than being "out there" with real existence, are socially constructed pragmatic fictions. In contrast to the realism embodied in the law, the anti-realist views "the theories of science [as] mere calculating devices, useful fictions, convenient methods of representation, or the like, helpful only for predicting and organizing" observations.\textsuperscript{6}

\begin{itemize}
\item \textsuperscript{4} The term "realism" has been used in many different ways and therefore must be carefully defined. For example, one of the great (but for present purposes irrelevant) philosophical debates concerns ontological realism. Ontological realism is the belief that abstract objects called "universals" have an independent and perhaps even logically prior existence to the physical particulars which are instantiations of those universals. See Dictionary of Philosophy 264 (Dagobert D. Runes ed., 15th ed. rev. 1960)(defining ontological realism).
\item A second sense in which the term "realism" is used refers to epistemological realism. Epistemological realism refers to the belief that one's perceptions of the world mirror the way the world "really is." \textit{Id.}; Robert Audi, \textit{Belief, Justification, and Knowledge} 15-17 (1988). See also Bertrand Russell, Human Knowledge: Its Scope and Limits 319-32 (1962)(discussing relation of epistemological realism to physics). Realism as used in this Article will refer to a particular species of epistemological realism that posits that common sense or scientific theories "give a literally true account of the way the world is." When applied specifically to scientific theories, this position is referred to as "scientific realism." Janet A. Kourany, \textit{Realism Versus Anti-Realism: The Ontological Import of Scientific Knowledge, in Scientific Knowledge: Basic Issues in the Philosophy of Science} 336, 338 (1987) [hereinafter "Kourany I"]). As used herein, realism is essentially equivalent to a verificationist view of science, although technically, realism also includes falsificationism. For discussion of verificationism and falsificationism, see infra section III.A.
\item Although not particularly instructive, the term "advance" has been retained out of deference to the prevailing conventions. For discussion of the history of ideas relating to technological advance, see, e.g., The Idea of Progress: A Collection of Readings (Frederick J. Tegggart & George H. Hildebrand eds., rev. ed. 1949) (collecting primary sources); John Losee, A Historical Introduction to the Philosophy of Science 169-20 (2d ed. 1980)(surveying and describing modern theories). Explanation of the aversion to the term "advance" may be found infra in sections III.B and III.C.
\item Kourany I, supra note 4. There are different degrees of commitment to the anti-realist thesis. Science consists of a mix of observable facts, paradigms that are generally untestable, and various gradations in between these two extremes. Thus, the different types of facts encountered by science evoke different degrees of concern among anti-realists. Many extreme anti-realists, including the author of this Article, dismiss the distinction between observed data and theory and are skeptical about even the most directly observable facts. Cf. Kuhn, supra note 3, at 50-76. Many less extreme anti-realists (and many who would label themselves realists) posit the externalized existence of individually observed data, but would remain skeptical about the existence of entities contained in the more general hypotheses.
\end{itemize}
The differences in structure between the scientific and legal communities have not gone unnoticed. Whereas science "is the American faith," law fares much more poorly in the eyes of the American public. Even the legal community has not escaped the influence of the American fetish for things scientific. Courts frequently uncritically adopt a verificationist philosophy of science that exaggerates the role of science in law. The thesis of this Article is that because courts do not adequately consider the sociology of science, they have failed to recognize the translation difficulties created by the use of scientific evidence, which incorporates an anti-realist concept of causation, to prove the existence of realist legal causation. Ignorance of these difficulties in the translation of scientific evidence has dramatically increased the risk that scientific evidence will be accidentally misused, or "mistranslated," by the fact finder.

Part II of this Article examines the role of causation in tort law and argues that the causation a plaintiff must prove, although expressed in a single set of legal terms, is based upon either of two realist paradigms of causation depending upon the identity of the trier of fact. When a jury is the fact finder, jurors bring their everyday experiences into the courtroom and apply a "folk paradigm" of causation. The jury's operative concept of cause-in-fact is a common sense realism that conceptualizes causation as a relation between two links in a single externally existing causal chain. When a judge serves as the trier of fact, the assessment of causation is no longer made by inexperi-

Fortunately, these disagreements need not be resolved, for causation is not a directly observable fact but is a more general theoretical construct of science. Thus, anti-realist concerns are at their peak when examining the issue of causality. The constructed nature of judgments of causality is highlighted by the Burch-Lilienfeld debate over the import of the Surgeon General's Report of the Health Consequences of Smoking. Burch criticizes the inference of causation contained in the report because the data do not permit elimination of the "third variable" or "common cause" problem. P.R.J. Burch, The Surgeon General's "Epidemiologic Criteria for Causality": A Critique, 36 J. Chron. Dis. 821, 821-36 (1983). Lilienfeld rebuts Burch's argument by explicitly recognizing the discretion implicit in "scientific proof" of causation. In an exceedingly candid passage, Lilienfeld notes that "[g]iven this [existing] body of data in its totality, one arrives at a scientific judgment that there is a sufficiently high probability that the causal hypothesis is true." Abraham M. Lilienfeld, The Surgeon General's "Epidemiologic Criteria for Causality": A Criticism of Burch's Critique, 36 J. Chron. Dis. 837, 838 (1983).

9. See, e.g., Bert Black & David E. Lilienfeld, Epidemiologic Proof in Toxic Tort Litigation, 52 Fordham L. Rev. 732, 770 (1984) ("Good epidemiologic evidence is not only accepted by courts; in at least one case, it has been required."); Brock v. Merrell Dow Pharmaceuticals, Inc., 884 F.2d 166, 167 (5th Cir. 1989) (reversing judgment on jury verdict because absence of "statistically significant epidemiological proof that Bendectin causes limb reduction defects" rendered evidence insufficient).
enced lay persons but by a legal specialist. As a legal specialist, the judge has assimilated a uniquely legal view, and thus applies a "legal paradigm" of causation. In contrast to the jurors' single causal chain, in the legal paradigm, the world is composed of realist "causal webs" that give rise to legal liability when policy considerations of fairness and responsibility indicate that liability is appropriate. Although the legal and the folk paradigms contain significant differences from one another, they share the common element of a realist concept of causation.

Part III of this Article conducts a sociological examination of the scientific community, concluding that a scientific causal claim does not state a fact that is isomorphic with the structure of reality but is instead merely a useful fiction. This sociological examination begins by first surveying and ultimately rejecting the various traditional theories of scientific realism. The examination concludes by adopting an anti-realist framework for analyzing science.

This anti-realist framework is then applied in Part III to reveal several key concepts that illuminate the process through which scientists produce "causal claims." This Article will show that scientists demarcate specialties through boundary work, and that each segregated specialty has a distinct hierarchy. One of the primary goals of these specialized communities is the production of inscriptions, or written records of research activities. Causal claims resulting from this research are contingent upon one's acceptance of the community conventions that give rise to those claims. Through successive incorporation of inscriptions, these socially constructed claims are eventually reified and posited as independently existing facts. This anti-realist sociological account concludes that a scientific causal claim is a socially constructed artefact that differs from the fact of causation that is traditionally sought by the law.

Part IV examines the philosophical problems created by the use of scientific evidence to prove legal causation and proposes a solution in the form of a model jury instruction. The difficulties inherent to the use of scientific evidence to prove legal causation revolve around the fact that the causation sought by the fact finder is not necessarily congruent with the causation about which the scientific expert testifies. First, the scientist's causal paradigm is substantively different from the realist causal paradigm of the law. Contrary to the traditional view, scientific proof of causation, which reflects a consensus among the relevant scientific community that given certain common assumptions, certain procedures have been followed with certain results, does

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not automatically resolve the issue of legal causation. Instead, scientific concepts must be translated into legal concepts. Second, because the scientific and legal communities are so segregated, the language used to convey scientific concepts must be translated from the language of the scientific community into that of the legal community. Ignorance of these difficulties in translating the concepts and language of scientific causal claims encourages the fact finder to assume that scientific and legal causation are identical. In order to properly assess the weight of scientific evidence, the jury must be instructed to recognize the nature of scientific evidence and the difficulties involved in its translation to a legally useful form.

II. THE LANGUAGE OF LAW

A. Law has adopted a realist “but for” test for cause-in-fact.

In order to recover, a tort plaintiff must prove not only that the defendant acted tortiously, but also that the defendant’s tortious conduct caused the plaintiff’s injury.\(^{11}\) The inquiry into whether an alleged tortfeasor caused the plaintiff’s injury is an attempt to ‘determine whether the [tortfeasor] has . . . produced the harm . . . for which he is sought to be held responsible . . . [so that] the law [will] regard his conduct as the cause of the harm.”\(^{12}\) This aspect of causation is termed “cause-in-fact.”\(^{13}\) The traditional test for this type of causation is the “but for” or \textit{sine qua non} test.\(^{14}\) The but for test queries whether the plaintiff’s injury would have occurred had the de-

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11. Restatement (Second) of Torts § 430 (1977). Although the rule is framed in the context of negligence, it applies to strict liability and intentional torts as well. \textit{Id.} at cmt. e. The claimant need not be a plaintiff (e.g., the causation issue might arise within the context of a counterclaim), however, for the sake of simplicity it will be assumed that the claimant is a plaintiff.

12. Restatement (Second) of Torts Ch. 16 scope note (1963-64).


14. Joseph H. King, Jr., Causation, Valuation and Chance in Personal Injury Torts Involving Preexisting Conditions and Future Consequences, 90 Yale L.J. 1353, 1355 (1981). \textit{See also Keeton et al., supra} note 13, at 266; Ford v. Trident Fisheries Co., 122 N.E. 389 (Mass. 1919)(unavailability of lifeboat not but for cause of death of drowning victim where victim could not have used lifeboat had it been available); Stacy v. Knickerbocker Ice Co., 54 N.W. 1091 (Wis. 1893)(absence of fence surrounding hole in ice not but for cause of death of horses where fence would not have stopped horses from falling into hole).
The plaintiff's injury does not occur in the absence of the defendant's act. Conversely, the but for test is not satisfied, and there is no cause-in-fact, where the plaintiff's injury would occur in the absence of the defendant's act.

The "merging fires" cases illustrate the application of the but for test of cause-in-fact. Merging fires cases involve some version of the following facts: Two fires are set independently by A and B. These fires merge and burn property belonging to C. Each fire would have burned C's property in the absence of the other. In a merging fires case, strict application of the but for test would preclude any recovery by C, since neither fire is the but for cause of the damage to C's property. Each fire would have independently burned C's property. Thus, A's fire is not a but for cause of C's injury because C's property would have burned in the absence of A's fire (as a result of B's fire). Similarly, B's fire is not a but for cause of C's injury because C's property would have burned in the absence of B's fire (as a result of A's fire). Situations such as the merging fires cases, where two independent causes are each sufficient to bring about an effect, may be called "joint causation" situations. The effect of strict application of the but for test to a joint causation situation is to force C to bear the loss notwithstanding the fact that both defendants A and B may be negligent.

Faced with the inequity of this result in joint causation cases, courts began to formulate an alternative to the but for test. This alternative seeks to mitigate the harshness that would otherwise result from applying the but for test in joint causation situations. In Anderson v. Minneapolis, St. Paul & Sault Ste. Marie Railway Co., the Minnesota Supreme Court introduced what has become known as the "substantial factor" test for cause-in-fact. Anderson involved a variation on the merging fires cases; the defendant railway allegedly

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15. KEETON ET AL., supra note 13, at 266. Formally, the test may be expressed as the sentence: "If not-D, then not-P" (where D is the defendant's action and P is the plaintiff's injury).

16. KEETON ET AL., supra note 12, at 266. See also, e.g., Hayes v. Michigan Central R.R., 111 U.S. 228 (1884) (failure to fence in railroad tracks but for cause of child's death due to collision with train). In this case, the sentence "If not-D, then not-P" is true.

17. KEETON ET AL., supra note 13, at 266. See also, e.g., Peterson v. Nielsen, 343 P.2d 731 (Utah 1959) (excessive speed not but for cause where accident would have occurred at slower speed). In this case, the sentence "If not-D, then not-P" is false, whereas the sentence "If not-D, then P" is true.

18. RESTATEMENT (SECOND) OF TORTS § 432 illus. 3 (1965-64).


20. 179 N.W. 45 (Minn. 1920).

21. Id. at 46.
caused two fires, one in a bog near the plaintiff's property, and another at nearby Kettle River. There was, in addition to these two fires, a third fire of unknown origin in the vicinity. Anderson's property burned, and he sued the railroad under a Minnesota strict liability statute for allegedly causing the fire which destroyed his property. The only contested issue at trial was the issue of causation. The jury was instructed that the defendant railway would be liable if the Kettle River fire merged with the fire of unknown origin (for which the defendant was not responsible) before burning the plaintiff's property, provided that the Kettle River fire remained a "material or substantial factor" in causing the plaintiff's injury. This instruction gave rise to what has come to be known as the substantial factor test.

Since its initial formulation in Anderson, the substantial factor test has been widely accepted. Even under the substantial factor test, however, but for causation is still a requirement in all cases except special joint causation cases, and it is in some respects required even in joint causation cases. The substantial factor formulation is actually not a new test for causation, but a refinement in the traditional but for test designed to accommodate the special category of joint causation cases. For this reason, although the predominant formula is the "substantial factor" formula, the operative conceptual test continues to be the but for test. Although its precise contours differ slightly in application depending upon the finder of fact, the but for test for cause-in-fact elicits the application of a realist causal paradigm regardless of whether the trier of fact is a judge or a jury.

B. Application of the but for test by a jury involves a realist folk paradigm of causation.

Application of the but for test of cause-in-fact has traditionally been largely left to the fact finder on the theory that ascertaining the

22. Id.
23. Id.
24. Id. at 47.
25. Id. at 46.
28. Id.
29. KEETON ET AL., supra note 13, at 267.
30. RESTATEMENT (SECOND) OF TORTS § 432(1) (1963-64); King, Jr., supra note 14, at 1356. But for causation is required in joint causation cases because each cause must in isolation be a but for cause of the plaintiff's injury. RESTATEMENT (SECOND) OF TORTS § 432(2) (1963-64); King, Jr., supra note 14, at 1356. The joint causes must also together be a but for cause of the plaintiff's injury. KEETON ET AL., supra note 13, at 268.
31. KEETON ET AL., supra note 13, at 267.
presence or absence of cause-in-fact is a common sense endeavor conducted as easily by a lay jury-person as by a judge. This view of the role of the fact finder rests upon the realist premise that causation is a fact of life, and that assessment of its presence or absence requires no special expertise. Thus conceived, application of the but for test by the lay jury-person involves application of a realist folk paradigm of causation that views the relation between cause and effect as a mechanistic series of events that are links in a causal chain. A billiard shot is a classic example of a causal chain. The cue ball strikes the 2-ball, which then strikes the 3-ball, which in turn strikes the 6-ball, causing the 6-ball to fall into the pocket. This series of events may be depicted in the following form:

```
Cue
/|
| 2
/|
| 3 4
/|
| 5 6 7 8
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32. Id. at 264-65.
33. Audi, supra note 4, at 15-17; Troyen A. Brennan, Causal Chains and Statistical Links: The Role of Scientific Uncertainty in Hazardous-Substance Litigation, 73 Cornell L. Rev. 469, 478-486 (1988). The view that reality conforms to one's perceptions and thoughts which is "thought to represent untutored common sense - has been called naive realism." Audi, supra note 4, at 15-16.

Brennan uses slightly different terminology to make the same point. Although he does not refer specifically to the jury, Brennan notes that the approach of the law to causation has largely resembled that of Newtonian physics, which relied upon a Lockean epistemological framework that "postulated the existence of fundamental particles in which inhered . . . 'primary qualities.'" Brennan, supra note 33, at 478. See also 5 Frederick Copleston, A History of Philosophy 86-90 (Image ed. 1985)(discussing Locke's theory of primary and secondary qualities); Losee, supra note 4, at 97-98 (discussing Locke's atomism and vacillating skepticism). Causation, although a relation between ideas, had as its basis "the power to be a cause" which was one of these primary qualities which existed "out there" in the world. Id. at 96-98 (discussing Locke's views of causation).
34. Brennan, supra note 33, at 486.
According to the realist folk paradigm, this causal chain is not merely the player's mental construction,\textsuperscript{35} it is actually out there on the table. The 2-3-6 causal sequence (\textit{i.e.}, the \textit{lines connecting} the 2-ball, 3-ball and 6-ball in the above diagram) is as real as are the balls themselves. The causal chains are not merely heuristic devices or conceptual models that explain observations; rather, they are real components of the external world. Causal chains are, in essence, part of the "furniture of the universe."

When applying this realist paradigm of causation, the task of the jury is to look out into the world to see if the plaintiff's injury and the defendant's action are both links in a single causal chain. The jury begins with the plaintiff's injury, then identifies the correct causal chain and traces it backwards through time to ascertain whether the defendant's action is a link in that same chain. This task is akin to identifying the 6-ball, and then tracing the causal sequence backwards through the actions and reactions of the 3-ball and the 2-ball, to see if the cue ball caused the 6-ball to sink.

The distinctive feature of the folk paradigm of causation is that when the causal chain is traced backwards through time, only one choice is possible at each link. For example, when tracing the causal chain backwards from the 6-ball, the only possible choice at the first link in the causal chain is the 3-ball. Similarly, when looking backwards from the 3-ball, the 2-ball is the only potential choice for the next link in the causal chain. If the defendant's action is not one of the links in the chain of causation leading to the plaintiff's injury, the causal inquiry is at an end. If, however, the defendant's actions are a link in the appropriate causal chain, liability attaches.

The sole exception to this result is in cases in which the defendant's actions are temporally too distant, so that \textit{proximate cause} is not present. Acts or events that terminate liability by interrupting the causal chain are "superseding"\textsuperscript{36} or "intervening"\textsuperscript{37} causes that serve to link the plaintiff's injury to another causal chain for which the defendant is not responsible. By tracing the causal chain backwards through time, the jury discovers a single causal series to the exclusion of all other possible causal series. Thus, under this folk conception of causal analysis, an effect is traced along a single chain of causation through a series of causes, all of which have a real external presence.

\textsuperscript{35} If pressed, most epistemological realists would maintain that although causation may be to some extent a mental construct, this construct has its origin in certain relations between external events. \textit{See supra} note 33 (discussing Locke's similar approach).

\textsuperscript{36} \textit{See Restatement (Second) of Torts} § 440 (1963-64)(defining superseding cause).

\textsuperscript{37} \textit{See Restatement (Second) of Torts} § 441 (1963-64)(defining intervening cause).
SCIENTIFIC EVIDENCE OF CAUSATION

In sum, the jury discovers causality, it does not create it. Pre-existing causes and effects are simply part of the external world.

C. Application of the but for test by a judge involves a realist legal paradigm of causation.

Although initially appealing, the folk paradigm of causation ultimately proves unsatisfactory. Upon reflection, it should become apparent that an event, such as a plaintiff's injury, is generally not the result of a single chain of causes. Instead, an event is likely to be the result of the convergence of several causal chains, as illustrated below:

```
12 -- Cue -- 13
   \ / \ / \ 
   11 \ / 
   / \ / \ 
  10 2 9
   \ / \ / 
   3 4 
   / \ / 
  5 6 7 8 
```

In this regard, it might be more appropriate to talk of webs, rather than chains, of causation. An event, such as the action of the 6-ball, is more properly seen as the result of the intersection of numerous causal strands, rather than as the result of a single chain of causation. When the causal sequence giving rise to the motion of the 6-ball is traced backwards through time, it is likely that several balls acted in conjunction to cause the 6-ball to sink. Thus, when looking backwards, one may identify several simultaneous causes, rather than an individual link in a single-stranded causal chain. For example, the action of the 3-ball is not due solely to the action of the 2-ball but is also related to the action of the 10-ball. The action of each of these balls, in turn, is caused by one or more other balls. When a jury traces causation along a causal chain, the number of causes increases arithmetically as additional links are added one by one. However, causal webs may increase the number of causes geometrically as increasing numbers of strands are encountered.

38. Brennan, supra note 33, at 485.
Viewed in this way, causal analysis ceases to serve as the common sense limitation that it was under the jurors' causal chain approach. While identification of an isolated causal chain would exclude the numerous other possible chains, recognition that these chains might be interdependent rather than mutually exclusive removes much of the value of cause-in-fact as a device of exclusion. In the case of the 6-ball in Illustration 2, only five of the thirteen balls (i.e., the 4, 7, 8, 9 and 13-balls) are excluded from the causal web. Thus, while cause-in-fact remains a useful device to eliminate those few cases in which it is wholly absent, it is still in need of some other limitation. Without an additional limitation, the scope of liability is potentially unlimited. Thus, in order to limit the scope of liability under the legal paradigm of causation, potentially infinite real causal webs are restricted by deliberate choices of legal policy as to how far liability should be extended. These choices are made under the rubric of proximate cause.

The wedding of policy-based proximate cause to realist causal webs (cause-in-fact) creates a new legal causal paradigm. Judges do not deal with the folk paradigm of causation; rather, they apply a uniquely legal paradigm of causation. This legal paradigm involves a different view of reality and a series of choices about individual responsibility and societal functioning. Under the legal paradigm of causation, interrelated causal webs, rather than simple mutually exclusive causal chains, are seen as having independent externalized existence. A single effect such as a plaintiff's injury may be the result of numerous causes along various strands of the web. Because this concept of causation generates too many causes to be a useful limit, policy-based limitations are used to exclude "distant" causes. Although the content of the precise policies underlying the policy-
based limitations may vary, the basic structure of the formula remains constant.

The substantive policies underlying policy-based limitations on causation have been extensively analyzed by proponents of the Law and Economics movement. A brief sketch of two influential proposals indicates that although the substance of the policy may vary, the legal paradigm of causation relies on a policy-based limit to exclude certain real causes from creating liability. For example, Guido Calabresi views the policy basis for limiting causation as a species of economic efficiency.45 According to Calabresi, causation is a doctrine that serves to further the goals of the tort system.46 The goals of tort law are wealth distribution (compensation) and minimization of inefficient actions through deterrence.47 As if to reinforce this point, Calabresi terms his analysis of the legal doctrine of causation a "functional analysis."48 For Calabresi, certain causes are selected from the overabundance of causes-in-fact and are recognized under the legal rubric of proximate cause. The criterion for selecting causes for recognition is whether such recognition furthers the goals of wealth maximization and efficiency. Thus, Calabresi espouses a policy-based limit on causation. Richard Epstein adopts a similar view, but perceives the goal of tort law as more normative. According to Epstein, tort law is designed to protect individual spheres of autonomy by providing redress for encroachment upon a plaintiff's sphere of autonomy by others.49 Various real causes are selected from the web as is dictated by this normative view; one is liable for damage for which one should be held responsible. Although Calabresi and Epstein posit different substantive policies as the guiding policy behind proximate cause, they agree that cause-in-fact is limited by a doctrine of proximate cause that incorporates policy concerns into the causal calculus. On either theory, the ultimate causal analysis consists of an investigation into "real causal webs" that is truncated by the relevant policy concerns of efficiency or morality.

The basic realist paradigm of causal analysis used by both judge and jury has proven to possess remarkable staying power. It has endured despite the increasing complexity of factual situations encountered by the courts. This basic framework requires the plaintiff to prove the existence of a realist cause-in-fact. The precise contours of the plaintiff's burden will depend upon the trier of fact, but they al-

46. Borgo, supra note 45, at 424; Calabresi, supra note 45, at 74-77.
47. Brennan, supra note 33, at 486-89; Calabresi, supra note 45, at 69-70.
48. Calabresi, supra note 45, at 70.
ways remain realist. If the trier of fact is a jury, the jury instructions will elicit application of a realist folk paradigm of causation. If the trier of fact is a judge, the operative legal paradigm will be rather different and will involve policy-based limitations upon realist webs of causes-in-fact. Both paradigms are thoroughly realist in that they seek to ascertain pre-existing states of affairs in the external world. Accordingly, the legal concept of cause-in-fact, whether in the form of the folk or the legal paradigm, is one that differs significantly from the causal accounts generated by science.

III. THE SOCIOLOGY OF SCIENCE

A. Realist accounts of the scientific enterprise prove inadequate.

Scientists conduct experimental research in order to advance their field by tracing out the implications of the theories with which they work. When, on the basis of such research, a scientist claims to have proven the existence of a causal relationship, that scientist makes a "causal claim." Exactly what do such causal claims mean? What weight should be given to causal claims derived from experimental research? The status of scientific claims derived from experimental research is a subject of immense debate, the history of which is largely a tale of three theories: the Positivist theory of verificationism, the Popperian theory of falsificationism, and anti-realist theory.

Some version of the Positivist theory of verificationism has dominated the philosophical landscape since the Copernican Revolution signalled the rise of the modern science it purports to explain. Galileo's Dialogue Concerning the Two Chief World Systems appeared in 1632, and later that same year Galileo was called before the Papal Inquisition for transgressing the infamous Injunction of 1616. Almost simultaneously, Sir Francis Bacon attempted the first comprehensive treatment of the "new" scientific method in his Novum Organum, which appeared in 1620. Bacon's treatise, the first philosophy of science text specifically to address the methodology of modern sci-

50. Verificationism is used here in a broader sense than the more technical meaning ascribed to it by the members of the Vienna Circle. See William Bechtel, Philosophy of Science: An Overview for Cognitive Science 19 (1989) (discussing verification theory of meaning held by members of Vienna Circle). For an instructive and accessible account of this broader verificationism, see J.P. Moreland, Christianity and the Nature of Science 86-92 (1989).

51. Anti-realism is actually not a single theory, but a group of related theories which deny the central realist premise. See infra note 74.


54. Id. at 226.

55. Losee, supra note 5, at 60-69; Russell, supra note 52, at 541-45.
ence, introduced the inductive method which later culminated in the Positivist theory. Bacon's inductive method was further developed by John Stuart Mill, who introduced the seeds of verificationist theory in the form of a "verified hypothesis." From these early formulations, the belief that observation provides evidence that verifies the truth of the tested hypothesis grew until it became the received orthodoxy of the philosophy of science and was incorporated into law. Under the mature verificationist theory of Karl Hempel, scientific hypotheses are thought to be "confirmed" by experimentation. Although a favorable experimental result does not "afford complete proof of the hypothesis, it provides at least some support, some partial corroboration or confirmation for it." It follows that increasing amounts of experimental confirmation provide increasing evidential support for the hypothesis. Thus, although a hypothesis will never be 100% verified, experimentation provides direct support for a hypothesis, such as a causal claim, by providing direct supporting evidence for the truth of the hypothesis.

Thus, under a verificationist theory, scientific and legal paradigms of causation are virtually identical: both concepts of causation are realist and purport to find externalized causes in the world of nature. For the verificationist, a hypothesis that A causes B is proven to be

57. LOSEE, supra note 5, at 148-58.
58. Id. at 153-54.
61. HEMPEL, supra note 60, at 33.
62. MORELAND, supra note 50, at 87.
63. A causal claim is actually a complex judgment (or explanation) based upon the justification of several related hypotheses rather than a single simple hypothesis. Alfred S. Evans, Causation and Disease: A Chronological Journey, 108 Am. J. Epid. 249, 254 (1978) [hereinafter Evans I]; Alfred S. Evans, Causation and Disease: The Henle-Koch Postulates Revisited, 49 YALE J. BIO. & MED. 175, 191-192 (1976) [hereinafter Evans II]. See also, e.g., Lilienfeld, supra note 6, at 838 (defending judgment that smoking causes cancer). However, although a causal claim is a complex judgment, the justification of that judgment is dependent upon the status of the individual hypotheses that the judgment purports to explain. Thus, although it is an oversimplification, it is useful to think of the causal claim as a single hypothesis.

In actuality, experiments will normally be formulated as attempts to disprove a "null hypothesis" rather than as attempts to confirm a causal hypothesis. CLAIRE SELTZ ET AL., RESEARCH METHODS IN SOCIAL RELATIONS, reprinted in JOHN MONAHAN & LAURENS WALKER, SOCIAL SCIENCE IN LAW: CASES AND MATERI-
true (or at least very probably true) when the results predicted by that hypothesis are observed.\textsuperscript{64} However, despite the continuing influence of verificationism among scientists and jurists, philosophers of science have abandoned it because of its serious deficiencies as an explanation of the scientific endeavor.\textsuperscript{65}

A second theory that seeks to explain the theoretical products of empirical observation is Karl Popper's theory of falsificationism. Popper advocates a view in which "conjectures,"\textsuperscript{66} or unjustified guesses, serve to generate hypotheses that are then subjected to empirical testing. While the discovery of such conjectures is not subject to justification,\textsuperscript{67} the hypotheses derived from the conjectures are subject to testing and justification.\textsuperscript{68} This testing takes the form, not of confirmation as the Positivists believed, but of falsification.\textsuperscript{69} According to Popper, scientific knowledge is always contingent because in order to be scientific, it must be subject to falsification.\textsuperscript{70}

In the eyes of a falsificationist, scientific and legal causal inquiries are similar. A causal hypothesis, although always contingent and subject to disproof, is shown to be possibly true when the predicted results are observed.\textsuperscript{71} Although science can only demonstrate that a
causal relationship possibly exists, a demonstration of possible truth is a demonstration about the state of the external world,72 and thus mirrors the type of causal inquiry in which the law engages.

However, falsificationism has serious problems too, not the least of which is that data virtually never will bear on a single falsifiable hypothesis.73 For this and other reasons, falsificationism is also an insufficient account of the relation between scientific activities and the resulting scientific theories. Because neither version of realism has provided an adequate description of the relation between the scientific enterprise and the theories it generates, one must turn to the alternative theories provided by the anti-realists.

B. Anti-realism provides a more accurate account of the scientific enterprise.

The anti-realist theory of the scientific method is actually a cluster of loosely related theories denominated by various names such as conventionalism, instrumentalism and pragmatism.74 The common thesis of these various anti-realist theories is that, in contrast to the postulates of realist theories, observation has little if anything to do with the truth or falsity of a causal hypothesis. The fact that the results predicted by a causal hypothesis are observed means only that the hypothesis provides a useful model for explaining the phenomena observed. A successful scientific model is one that continues to account for the observed phenomena. However, “saving the phenomena” may occur irrespective of the “truth” of the model, or in other words, regardless of whether the model reflects the real state of the external world. For example, Ptolemaic astronomy and phlogiston theory in chemistry both “saved” their relevant phenomena until a sufficient number of anomalies finally rendered the theories untenable.75 Notwithstanding the early success of these theories, no one today contends that they are true of reality. This same reasoning applies to the theories that replaced them, and indeed, to all scientific models.

Although the concerns of the anti-realist become more persuasive as scientific models become increasingly abstract, the agnosticism of the anti-realist is not limited solely to the general theoretical level or

72. Id.
73. This criticism is known as the “Duhem-Quine Thesis.” GILLIES, supra note 56, at 205, 210-14. See also MORELAND, supra note 50, at 85. For additional criticisms see id. at 85-86.
74. Kourany II, supra note 60, at 115-19 (discussing conventionalism of Pierre Duhem, “methodology of scientific research programmes” of Imre Lakatos and sociological approach of Thomas Kuhn); MORELAND, supra note 50, at 83, 172-202 (discussing conventionalism, pragmatism, instrumentalism, phenomenalism, operationalism, constructive empiricism, and Kuhn’s sociological approach).
75. See KUHN, supra note 3, at 68-72 (discussing Copernican and chemical revolutions as examples of paradigm changes).
to explanations of observed phenomena. To varying degrees, the anti-realist's skepticism extends to the observations themselves.\textsuperscript{76} In sum, anti-realists view science as a process through which scientific "facts" are socially constructed, rather than constituting a direct reflection of natural phenomena.\textsuperscript{77} Traditional realists believed the scientific community to be a group of neutral and objective observers that would, absent some distortion, achieve knowledge that is "increasingly isomorphic to the structure of reality,"\textsuperscript{78} but the anti-realists insist that science is a much more socially-oriented endeavor through which the external world "operates through the meanings created by scientists in their attempts to interpret that world."\textsuperscript{79} Once the realist myth of the objective scientist who merely mirrors nature is rejected, "there is no alternative but to regard the [theoretical] products of science as social constructions like all other cultural products."\textsuperscript{80}

Rejection of the realist philosophies of science reveals the problems created by the use of scientific evidence to prove legal causation. As long as scientists and lawyers were both thought to be engaged in ascertaining the truth about reality, scientific assessments of causation that were purportedly isomorphic to the structure of reality could be assumed to be directly relevant to the legal inquiry into that same reality.\textsuperscript{81} However, once science is viewed as a theory-building enterprise that is detached from reality, it becomes necessary to question the relevance of the products of this process to the distinct causal inquiry embodied in the law. Because the nature of the scientific process defines the contours of the difference between causation in the eyes of science and law, one must begin by carefully examining the nature of science on the anti-realist theory.

One of the most influential anti-realist theorists is Thomas Kuhn. According to Kuhn, the history of science is divided into periods of

\textsuperscript{76} Different anti-realists would press this point to different degrees. Some anti-realists argue that even the most basic and apparently purely observational fact, for example, the observation of a virus through an electron microscope, is affected by the scientific paradigm. While this is probably correct, such an all encompassing anti-realism is unnecessary to raise questions about causal judgments because causal judgments are not purely observational, but contain a large theoretical component. \textit{See supra} note 6.


\textsuperscript{78} MULKAY, \textit{supra} note 77, at 62-63.

\textsuperscript{79} \textit{Id.} at 61.

\textsuperscript{80} \textit{Id.}

\textsuperscript{81} From a philosophical point of view, this assumption is not altogether unproblematic even on the realist thesis, for it assumes that the relation between causality in science, law and nature is transitive. Moreover, even if precisely the same concepts are employed by the legal and scientific paradigms, the linguistic reference difficulties in translation remain. Of course, if the concepts employed by scientists and lawyers match up exactly, it would very likely be harmless error to ignore any uncertainty introduced in the process of translation.
“normal science”\textsuperscript{82} and periods of “revolutionary science.”\textsuperscript{83} Most of the history of science consists of normal science, which is essentially a series of “mopping up operations” that are directed toward articulating an accepted paradigm and the phenomena that it predicts.\textsuperscript{84} Because normal science consists mostly of attempts to fill in the holes of a paradigm by extending its scope and increasing its precision, normal science is exceedingly cumulative and progressive. Normal science also involves “puzzle-solving,” which is an activity through which phenomena that resist explanation under the accepted paradigm are gradually incorporated into that paradigm.\textsuperscript{85}

However, as the scope of the accepted paradigm is expanded, more and more puzzles will resist solution under that paradigm.\textsuperscript{86} Thus, expansion of the accepted paradigm causes “anomalies” to accumulate.\textsuperscript{87} When the accumulation of anomalies becomes sufficiently serious, scientists begin to feel insecure with the old paradigm, and alternative paradigms start to form.\textsuperscript{88} This event signals a period of crisis. A period of revolutionary science is born when a viable competitor to the established paradigm emerges.\textsuperscript{89} The revolution concludes with the adoption of a new paradigm.\textsuperscript{90} Throughout this enterprise, social relations are central. A new paradigm is adopted not because it is true, but because “its opponents eventually die, and a new generation grows up that is familiar with it.”\textsuperscript{91}

In his 1969 Postscript, Kuhn resolved ambiguities in his earlier work, \textit{The Structure of Scientific Revolutions}, by making extensive reference to the structure of the scientific community.\textsuperscript{92} The resulting

\textsuperscript{82} Kuhn, supra note 3, at 10. See also id. at 10-42 (discussing the role of normal science). Kuhn defines normal science as “research firmly based upon one or more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice.” Id. at 10.

\textsuperscript{83} Id. at 92-135 (discussing nature of scientific revolutions). Kuhn defines revolutionary science as “non-cumulative developmental episodes in which an older paradigm is replaced in whole or in part by an incompatible new one.” Id. at 92.

\textsuperscript{84} Id. at 24.

\textsuperscript{85} Id. at 35-42. These puzzles for which solutions are sought have generally expected solutions and rules governing both the range of acceptable solutions and procedures which may be used to reach a solution. Id. at 38.

\textsuperscript{86} Id. at 52.

\textsuperscript{87} Id. at 52-53.

\textsuperscript{88} Id. at 67-68. Not every accumulation of anomalies precipitates a full fledged crisis. Rather, the accumulation of anomalies generally must interact with prevailing circumstances in order to make resolution of the accumulated problems particularly urgent. Id. at 81-83.

\textsuperscript{89} Id. at 77.

\textsuperscript{90} Id. at 90-91.

\textsuperscript{91} Id. at 151 (quoting Max Planck, \textit{Scientific Autobiography and Other Papers} 33-39 (F. Gaynor trans., 1949)). See also id. at 90.

\textsuperscript{92} Although influential, Kuhn’s theory has not escaped criticism, especially at points upon which the theory is ambiguous. See Moreland, supra note 50, at
anti-realist theory has provided a framework (or paradigm) within which sociologists of science have sought to understand the actual workings of the scientific community. Kuhn's anti-realist view of science provided the impetus for investigation into the sociology of scientific knowledge, and as this sociological research has progressed, a more precise account of the social construction of scientific facts has emerged. This account features five prominent concepts. Integration of these five concepts produces a more detailed variation of Kuhn's theory, under which scientists manufacture causal claims in a manner that is essentially unconcerned with the "real causes" sought by the law.

C. An anti-realist sociology of science consists of five elements.

1. Scientists establish communities through "boundary work."

The first element of the sociological account of the construction of scientific facts is the concept of "boundary work." Researchers use boundary work to self-define their community and maintain consensus among the members of that community. The resulting communities consist of relatively small, homogenous and well-defined groups of scientific specialists. These communities preserve a series of "negotiated agreements within a research community about a host of issues ranging from the applicable theoretical paradigm to the norms of peer review and publication." In order to achieve such a high degree of consensus, scientific disciplines become differentiated in a manner such that the members of any particular discipline share a culture and

93. Kuhn's theory need not be reified in order for the observations generated by it to be instructive. If some modification of Kuhn's theory is reified, then scientists are in fact not describing reality. If the theory is not reified, an agnostic position is taken as to whether scientists do in fact describe reality. The non-reified theory is merely one way (perhaps the most coherent way) to view the activities of scientists. See Charles M. Kester, Note, Is There a Person in That Body: An Argument for the Priority of Persons and the Need for a New Legal Paradigm, 82 Geo. L.J. 1643 n.166 (1993)(discussing reification in context of personal identity and philosophy-law interface).

94. We remain largely ignorant in the area of sociology of science, despite the importance of science to modern society. Stephen Cole, Making Science: Between Nature and Society 1 (1992); Latour & Woolgar, supra note 10, at 17.

95. See Marlan Blissett, Politics in Science 93 (1972).

a mythology. The existence of shared myths serves as the defining feature of a disciplinary group.

This mythology is not limited to the substance of scientific theories but also consists of histories and biographies. These elements assist the community members to integrate their unique scientific paradigm into their broader set of beliefs. Furthermore, a shared mythology embodies the consensus necessary for effective research and provides an important component of a "symbolic universe" that enables an individual to locate herself in reality and to give meaning to her experiences. The boundaries separating the community that shares these myths from "outsiders" who do not share them are reinforced both through formal channels of communication such as published articles in peer reviewed journals and through informal means of communication, such as the "invisible college."

The concept of community self-definition through boundary work is important because it explains the reactions of scientists to unfavorable facts and experimental results. Proponents of aberrant results may be "converted" from their wayward views through "therapy," thereby permitting them to remain within the research community without creating cognitive dissonance for the other community members. Alternatively, members might seek to preserve the community by subjecting non-conformists to "nihilation." Nihilation is a process that marginalizes aberrant views by assigning deviants to an inferior professional or social status in order to relegate their observations to an inferior ontological status.

Aberrant members of the research group may be nihilated through either of two mechanisms. First, non-compliant members may be nihilated through reclassification as non-members of the relevant community. Thus, the disciplinary insiders classify the proponents of

97. LATOUR & WOOLGAR, supra note 10, at 54-55.
98. Id. at 55.
99. Id. at 54.
100. BLISSETT, supra note 95, at 93.
102. LATOUR & WOOLGAR, supra note 10, at 52-53.
103. DIANA CRANE, INVISIBLE COLLEGES: DIFFUSION OF KNOWLEDGE IN SCIENTIFIC COMMUNITIES 12 (1975). An invisible college is a group of scientists involved in various fields of research who interact for the purpose of providing each other with information that is necessary to conduct their respective research projects in such a manner as to prevent the delay of their research efforts that would result if the only source of this information were peer review journals. J. Gaston, Communication and the Reward System of Science: A Study of a National "Invisible College", in THE SOCIOLOGY OF SCIENCE 25 (Paul Halmos ed., 1972).
104. BERGER & LUCKMANN, supra note 101, at 104.
105. Id. at 104-05.
106. Id. at 105-06.
107. Id. at 106.
aberrant views as members of a different discipline (or as non-scientists altogether) in order to safely discount their proposals. A second means of nihilation is characterizing the aberrant community member as a rebellious iconoclast.108 In such cases, although the non-conformist remains a member of the community, aberrant behavior is dismissed as unimportant because it is to be expected from "someone like that." Through this careful use of boundary work, the members of a disciplinary group effectively insulate themselves from criticism,109 are able to perpetuate the accepted paradigm, and are able to minimize recognition of the contingencies of their findings.

2. Scientific communities have rigid hierarchical structures.

A second major element of an account of the social construction of science is "hierarchy." Hierarchy affects the credibility and influence of members of the disciplinary group. The maintenance of the paradigm and mythology of the scientific discipline through nihilation and therapy is greatly simplified by the existence of a hierarchical structure. The hierarchical position of a scientist essentially determines her credibility with other members of the discipline110 and allows one to talk about the "right" result or measurement.111

Credibility is significant for two reasons. First, the credibility of the experimenter influences the results that will be accepted as the "right" results in an experiment that is likely never to be replicated.112 Therefore, acceptance of the results of an experiment may ultimately be based upon the invocation of the experimenter's position in the hierarchy. This position is likely to be a function of the time and energy one has invested in the established paradigm, and thus promotes a highly conservative interpretation of data.113

Relatedly, the second reason for the importance of credibility is due to "experimenters' regress."114 Even when replication is attempted, a second experiment can never be an exact replication of the previous experiment. Failure to replicate the results of the first experiment may always be blamed on a failure in the second experiment. Moreover, even if the experiments were identical, variant results are always subject to ad hoc explanations or outright dismissal.115

108. See, e.g., id. at 115; Jasanoff, supra note 96, at 78 (citing Thomas F. Gieryn, Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists, 48 Am. Soc. Rev. 781 (1983)).
110. LATOUR & WOOLGAR, supra note 10, at 213.
111. Id. at 239.
112. COLE, supra note 94, at 12-14.
113. See generally KUHN, supra note 3, at 151-52 (arguing that older scientists resist paradigm shifts in part due to investments in old paradigm).
114. Jasanoff, supra note 96, at 78.
115. See id.; KUHN, supra note 3, at 73-83.
such as these, credibility provides a criterion that facilitates selection among varying results.

A scientist's position also affects her influence. Influence is the ability of the occupant of a higher social position to impose costs upon those scientists occupying lower positions. A more influential scientist may seek to perpetuate an established paradigm by imposing costs upon deviants, thereby discouraging deviant behavior.\(^{116}\)

This imposition of costs occurs in two ways. First, the influential scientist may impose costs to the conceptual commitments of deviants.\(^{117}\) For instance, a senior scientist may use equipment or procedures that are more firmly grounded in the accepted paradigm, so that her results are more intimately tied up with the paradigm. Thus, any questioning of her results would call a substantially larger number of components of the established paradigm into question. This in turn creates a greater level of cognitive dissonance for the deviant, and is therefore more costly.

A second method of imposing discouraging costs upon deviants is for the more influential scientist to use her influence over the personal careers of deviants.\(^{118}\) Thus, the senior scientist might exert raw political power over the future careers of subordinates by threatening, either implicitly or explicitly, to give poor recommendations to an uncooperative subordinate. Empirical research has demonstrated the existence and exploitation of extensive hierarchical structures among self-defined scientific communities.\(^{119}\)

3. **Scientific communities exist to produce inscriptions.**

The third element of a sociological account of the social construction of a scientific fact is the concept of "inscription." The results of modern science frequently take the form of numbers, charts and graphs.\(^{120}\) The generation of such inscriptions is one of the primary purposes of experimental science.\(^{121}\) Inscriptions are important because they are one vehicle through which "reification"\(^{122}\) occurs. By progressive evolution through the literature and incorporation into later dependent inscriptions, the modalities\(^{123}\) of a statement such as

\(^{116}\) Bissett, supra note 95, at 93; Berger & Luckmann, supra note 101, at 104-05.
\(^{117}\) Latour & Woolgar, supra note 10, at 241-42.
\(^{118}\) Berger & Luckmann, supra note 101, at 114-15.
\(^{119}\) See Bissett, supra note 95, at 107-26.
\(^{120}\) Jasenoff, supra note 96, at 78.
\(^{121}\) Latour & Woolgar, supra note 10, at 51-52.
\(^{122}\) For a discussion of the concept of reification, see infra subsection III.C.5.
\(^{123}\) Modalities are syntactic qualifiers revealing the contingencies of the statements to which the qualifiers are attached. Latour & Woolgar, supra note 10, at 77 (footnote omitted).
a causal claim are removed, and the statement begins to appear more fact-like.\textsuperscript{124}

Inscriptions also encourage reification in a second way. Inscriptions are the major export of the scientific community, and in packaging their wares for export, scientists transform them. Visual depictions of phenomena that are used by members of the active scientific community are generally abstract and highly schematic, seeking merely to serve as a shorthand signifier for the phenomena signified.\textsuperscript{125} These depictions are not realistic because there is no need to convince members of the community to accept the underlying theory since they already share a paradigm. In contrast to the "theoretical" depiction found in peer reviewed journals, however, introductory textbooks and popular disseminations contain highly realistic depictions of these same phenomena.\textsuperscript{126} These realistic depictions encourage outsiders to associate the drawings with objects in nature. This association results in reification when the depictions are no longer viewed as explications of a theory but as depictions of reality. In other words, the theory sheds its contingency and theoretical postulates become objects of nature.

4. \textit{The products of scientific communities are contingent upon communal commitments.}

The fourth main element in an account of the social construction of a scientific fact is contingency. "[S]cientific claims are never absolutely true, but are always contingent on such factors as the experimental or interpretive conventions that have been agreed to within the relevant scientific communities."\textsuperscript{127} One useful model for explaining this contingency is provided by sociologists Bruno Latour and Steve Woolgar, who utilize the concept of an "agonistic field."\textsuperscript{128} If scientists are engaged in the construction of scientific facts through operations designed to gradually eliminate the modalities from accounts of those facts, it follows that the activities of the scientist are not directed solely toward nature but are also directed toward these modality-reducing operations. The agonistic field consists of all these modality-reducing operations.\textsuperscript{129}

The key to creating a scientific fact is to distinguish a single fact-statement from the "background noise" created by the existence of

\textsuperscript{124} \textit{Id.} at 69. For a detailed model of the process through which these modalities are dropped, see \textit{infra} notes 147-153 and accompanying text.


\textsuperscript{126} \textit{Id.} at 141-43.

\textsuperscript{127} Jasanoff, \textit{supra} note 96, at 78.

\textsuperscript{128} LATOUR \& WOOLGAR, \textit{supra} note 10, at 237.

\textsuperscript{129} \textit{Id.}
other potential fact-statements within the community.\textsuperscript{130} If the agonistic field within the community contains several equally probable statements, the purported fact-statement will not achieve fact-like status because it will be indistinguishable from the background noise.\textsuperscript{131} If, however, the purported fact-statement may be differentiated from its competitors, it has begun the journey toward fact status. It matters not how this journey commences; whether through intimidation of inferiors or inherent theoretical plausibility, the result is the same.\textsuperscript{132} 

The contingency of many commonly accepted scientific facts may be demonstrated through deconstruction of those facts.\textsuperscript{133} Deconstruction of scientific discourse reveals that scientists employ several types of discourse, or repertoires. Normal scientific discourse is dominated by an "empiricist repertoire" that ignores the contingencies involved in the social construction of scientific facts. The empiricist repertoire prefers to describe the actions and beliefs of scientists as if they "follow[ed] unproblematically and inescapably from the empirical characteristics of an impersonal natural world."\textsuperscript{134} Use of this empiricist repertoire minimizes any reference to the author of the causal claim, presenting her solely as a research tool with no discretionary participation in the experiment.\textsuperscript{135} Equally probable alternative explanations within the agonistic field are omitted from the empiricist account of the experiment.\textsuperscript{136}

In contrast to the empiricist repertoire that dominates formal communication, scientists also employ a "contingent repertoire" that reveals contingent elements of experiments that are normally obscured by the empiricist repertoire.\textsuperscript{137} The contingent repertoire is often employed to explain and minimize inconsistent experimental results by deconstructing them.\textsuperscript{138} To avoid inconsistency between these two seemingly incompatible types of discourse, scientists employ a "truth will out device" (TWOD) to create a temporal separation between the two types of discourse.\textsuperscript{139} By employing the TWOD, a scientist is able to dismiss inconsistent experimental results by asserting

\begin{itemize}
  \item \textsuperscript{130} Id. at 240.
  \item \textsuperscript{131} Id. at 241.
  \item \textsuperscript{132} Id.
  \item \textsuperscript{133} Jasanoff, supra note 96, at 78.
  \item \textsuperscript{134} Gilbert & Mulkay, supra note 125, at 56.
  \item \textsuperscript{135} Id. at 47, 56.
  \item \textsuperscript{136} Id. at 47. This omission of equally probable alternatives also contributes to the process of reification.
  \item \textsuperscript{137} Id. at 57-58.
  \item \textsuperscript{138} Id. at 79-82; Latour & Woolgar, supra note 10, at 23 (scientists emphasize social aspects in cases of "error").
  \item \textsuperscript{139} Gilbert & Mulkay, supra note 125, at 91-111.
\end{itemize}
that the error\textsuperscript{140} producing the inconsistency will eventually be discovered and exposed. Put differently, the empiricist repertoire is justified by using the contingent repertoire to describe inconsistencies and positing that eventually the truth of the empiricist statements will "out." This procedure dismisses the contingencies involved in experimentation and thus restores the primacy of the empiricist repertoire.\textsuperscript{141} This insistence of the scientific community on engaging in empiricist repertoire leads many outside observers to complain that scientists routinely misrepresent their true activities.\textsuperscript{142}

5. The contingent products of scientific communities are reified.

The fifth element of an account of the sociology of science is the concept of "reification." Reification describes what happens to a fact-statement once it stabilizes within the agonistic field through the progressive elimination of modalities.\textsuperscript{143} When a statement becomes reified, it loses all its original connections to human activity and becomes, as the Latin implies, "thing-ified." Reification is "the apprehension of human phenomena as if they were things, that is, in non-human or possibly supra-human terms."\textsuperscript{144} Reification has a temporal element, for as the modalities of a statement are progressively eliminated through successive inscriptions, the statement becomes increasingly fact-like. For example, a study of the social construction of the neuroendocrinological "fact" that the chemical structure of the releasing agent known as TRF is Pyro-Glu-His-Pro-NH\textsubscript{2} resulted in the identification of the precise point in time at which the chemical structure of TRF ceased to be a hypothesis posited by a pair of experimental neuroendocrinologists, and instead became accepted as an externalized fact of nature.\textsuperscript{147}

The phenomena of contingency and reification are elucidated by a model consisting of a series of five statement types. A Type 5 statement is one that (in the course of communicating some other fact) communicates implicit taken-for-granted knowledge.\textsuperscript{148} A Type 4 statement is of the form "A has a certain relation to B."\textsuperscript{149} These

\textsuperscript{140} In order to avoid the creation of an anomaly for the existing paradigm, the adherent must posit that the aberrant result was due to an error.
\textsuperscript{141} GILBERT & MULKAY, supra note 125, at 110.
\textsuperscript{142} LATOUR & WOOLGAR, supra note 10, at 28.
\textsuperscript{143} Id. at 238.
\textsuperscript{144} BERGER & LUCKMANN, supra note 101, at 89.
\textsuperscript{145} Releasing agents are chemicals of a peptidic nature which are emitted by the brain and which allow the brain to control the endocrine system. LATOUR & WOOLGAR, supra note 10, at 55-56.
\textsuperscript{146} Id. at 175.
\textsuperscript{147} Id.
\textsuperscript{148} Id. at 76-77.
\textsuperscript{149} Id. at 77.
statements are rare in the laboratory, but quite frequent in texts. The difference between Type 5 and Type 4 statements is illustrated by an epidemiologist's statement that, "Smoking causes lung cancer." This statement is a Type 4 statement about the relation between smoking and lung cancer, but it is also an implicit Type 5 statement about the causal relation. If the uninitiated were to ask about the causal relation, she would receive a lecture on the Henle-Koch-Evans Postulates. A Type 3 statement is a Type 4 statement with a modality such as "It is thought that," "It was reported that," or "It is believed that" attached to it. Thus, the statement "It is believed that smoking causes lung cancer" is a Type 3 statement. A Type 2 statement is similar to a Type 3 statement except that the statement is phrased so that it appears to be more like a claim or an assertion than an accepted fact. These statements frequently contain first or third-person references to specific researchers. Lastly, a Type 1 statement is a single scientist's conjecture or speculation.

As a statement moves from a Type 1 toward a Type 5 statement, it becomes progressively reified, and the modalities and original authors of the statement are lost. Conversely, as a statement is deconstructed, its history, modalities and contingencies are revealed, thus moving it from a Type 5 toward a Type 1 status. In addition to reification through deletion of modalities, a statement may quickly become reified through reliance upon the statement in instrumentation. If a statement is relied upon in instrumentation, all future measurements will implicitly incorporate that statement. Statements relied upon in this manner quickly become Type 5 statements.

Integration of these five concepts into a single sociological account produces a picture of a small, highly homogenous scientific community that is committed to a single substantive paradigm and certain procedural and social conventions. This community seeks to perpetuate its paradigm through engaging in normal science and abiding by the procedural conventions that the community shares with the larger scientific community. If non-conformists insist upon challenging the accepted paradigm or culture, the mechanisms of hierarchy and boundary work are used to either therapize or nihilate the renegades. These mechanisms are also used in the selection of fact-statements.

150. Id.
151. For discussion of these postulates, see Evans II, supra note 63, at 191-92.
152. LATOUR & WOOLGAR, supra note 10, at 77.
153. Id. at 78.
154. Id. at 79.
155. Id. at 81-86.
156. Id.
from background noise and in the reification of the selected statements. As a result, the scientific "facts," such as causal claims, produced by this process are highly contingent. They are not individually true of nature, but are dependent on a host of shared conventions and assumptions common to the community that produced the fact.

This account of the scientific community provides several challenges for the law. When scientific "facts" such as causal claims are introduced as evidence in a legal dispute, these contingent and highly specialized products of a scientific community must be translated into a product that is usable by participants in the legal process. Thus, two types of translation must occur if scientific evidence is to be properly used by the finder of fact. First, the concepts employed by the scientist must be translated into concepts used by the jury or judge. Second, the terms of the scientist must be translated into the terms of the lawyer. Although the scientist and the lawyer use homophones, it is far from clear that both groups mean the same thing by these terms. Indeed, the courts' uncritical assumption that scientists and lawyers mean the same thing when they discuss causation has caused courts to exaggerate the role of science by failing to recognize the implicit process of translation.

IV. THE TROUBLES OF TRANSLATION

Ultimately the issue of legal cause-in-fact is decided by the fact finder, often a jury, which is instructed on the appropriate legal test (e.g., the but for test) and then applies this test to the facts before it. When scientific evidence of causation is introduced as proof of legal causation, the scientific concepts and terms comprising that evidence must be translated into concepts and terms the fact finder can understand. The unexamined assumption of the courts that scientific evidence of causation is dispositive of the legal issue ignores the critical process of translation.

The translation of scientific terms and concepts pose two separate but interrelated philosophical problems. First, if the scientist and the fact finder possess different paradigms of causation, the concepts of the scientific causal paradigm must be translated into the concepts of the legal causal paradigm. Even if most of the terms used by the scientist and the lawyer have basically the same meanings, the paradigms that employ those terms must be translated. Only when there is some degree of congruence between the two paradigms is scientific evidence of causation relevant to the issue of legal causation.159

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158. Homophones are terms that sound the same. Oxford American Dictionary, supra note 1, at 313. Here both scientists and lawyers use terms pronounced "kawz."

159. Although discussion of other contexts in which a court must assess the legal value of scientific evidence is beyond the scope of this Article, it should be noted
ond, in addition to the substantive differences created by the existence of separate legal and scientific paradigms, the scientific and legal communities speak different, albeit homophonic, languages. Not only must scientific concepts be translated, but the terms used to express those concepts must be translated as well.160

Recognition of the necessity of these types of translation reveals a risk of mistranslation. Mistranslation occurs when the fact finder assumes that the scientific and legal causal inquiries are more alike

that several analogous situations require courts to perform similar weighing functions. For example, as a threshold matter, a court must evaluate the probative of the proffered scientific evidence. Fed. R. Evid. 401, 402. Additionally, in deciding whether to admit scientific evidence, a judge must decide whether proffered evidence could allow any reasonable juror to find the fact of causation to be more probable with the evidence than without the evidence. McConnell on Evidence 340 (John W. Strong ed., 4th ed. 1992).

Similarly, in deciding the admissibility of scientific expert testimony under Daubert v. Merrell Dow Pharmaceuticals, 113 S. Ct. 2786 (1993), a trial court must decide "whether the reasoning or methodology underlying the testimony is scientifically valid and . . . whether that reasoning or methodology properly can be applied to the facts in issue." Id. at 2796. See also Sorenson v. Shaklee Corp., 31 F.3d 638, 648 (8th Cir. 1994). This task requires the court first to examine the acceptability of the expert's reasoning within the scientific community. Second, the court must examine whether, assuming the reasoning is valid for the purpose for which it was used, the reasoning may be applied to the "facts in issue." Since the facts in issue involve legal causation, the court must perform a weighing function and assess whether the reasoning applies to these facts "enough" to warrant admission. Third, once evidence is determined to be probative, the court must balance this probative value against the potential for "unfair prejudice, confusion of the issues, or misleading the jury." Fed. R. Evd. 403.

Finally, once scientific evidence of causation has been introduced, the court must decide whether this evidence is sufficient to support a jury verdict. See, e.g., Pritchard v. Liggette & Myers Tobacco Co., 350 F.2d 479 (3rd Cir. 1965), cert. denied, 382 U.S. 987 (1966)(testimony of epidemiologist sufficient to support jury verdict on issue of causation).

160. The precise translation will differ depending upon whether a judge or jury serves as the trier of fact. The judge is a legal specialist who speaks "legalese." Jurors live in a common sense world (assuming that they are not all scientists) and speak neither science-ese nor legalese, but some species of common sense language. Thus, the difficulties of translation assume slightly different dimensions depending upon whether a judge or a jury determines the issue of causality. When a scientific "fact" of causation is introduced as evidence to support a jury's conclusion that legal causation is present, both the causal concepts and the language used to express these concepts must be translated into those of the lay person. This requires translation from the scientific to the "folk" language and paradigm, and involves the same issues as translation from the scientific to the judge's legal paradigm.

The astute reader will notice that the same arguments that apply to translating from the specialized scientific community to the lay (or legal) community also apply to translating from the specialized legal community to the lay (or scientific) community. However, in order to simplify the discussion of translation, this Article will talk of translation only from science to law, and will subsume both the jury and the judge under the heading "law."
than is justified. Mistranslation increases the potential for misleading
the fact finder and prejudicing the party against whom scientific evi-
dence is introduced because of the overreliance upon scientific evi-
dence that results from mistranslation. The most appropriate means
by which to reduce this potential for mistranslation and overreliance
is to ensure that judges understand the difficulties involved in transla-
tion and that they apply their knowledge by bringing these problems
to the jury's attention where appropriate.\textsuperscript{161}

A. Scientific concepts must be translated into legal
concepts.

The first difficulty created by the translation of scientific evidence
of causation into a legally useful form is that the trier of fact applies a
legal paradigm of causation which differs substantively from the sci-
entific paradigm.\textsuperscript{162} As noted above, the legal concepts of causation
applied by the fact finder are realist, while the causal models of sci-
ence are contingent constructs dependent upon community conven-
tions and processes. When a scientist states that smoking causes
cancer, she invokes a certain scientific paradigm that not only defines
causation but also governs the conventions for proof.\textsuperscript{163} Thus, even
assuming the fact finder is familiar with the terms used
by the scien-
tist, the concepts relied upon
by the scientist must be translated if the
fact finder is to understand the scientist.

The scientist and the lawyer possess different causal paradigms
and for this reason see the world in completely different ways. Even
scientists in one field frequently create paradigms distinct from those
of another scientific field. In fact, the history of science is full of in-
stances where scientists simply live in different worlds because they
possess different paradigms.\textsuperscript{164} A particularly instructive example is
provided by the "relativity revolution" in physics.\textsuperscript{165} Space-time and

\textsuperscript{161} See Jasanoff, supra note 96, at 78-32 (making similar proposal in context of appli-
cations of Daubert).

\textsuperscript{162} David Carson, Psychologists Should Be Wary of Involvement With Lawyers, in
LAwYERS ON PSYCHOLOGY AND PSYCHOLOGISTS ON LAw 27, 30 (Peter J. van Kop-
pen et al. eds., 1988).

\textsuperscript{163} For example, the logic governing permissible inferences differs in the two commu-
nities. D.H. Kaye, Proof in Law and Science, 32 JURIMETRICS J. 313 (1992). Dif-
ferent rules of evidence also apply. Lee Loevinger, Standards of Proof in Science

\textsuperscript{164} See KUHN, supra note 3, at 53-62, 68-74 (listing examples from astronomy, chem-
istry and physics).

\textsuperscript{165} Although this example concerns two scientific communities rather than a scien-
tific community and a legal community, it is nonetheless relevant. In fact, the
example increases in persuasive force as the two communities move "further
apart" because as this occurs, the two communities share fewer common ele-
ments. Thus, the problems encountered by two communities of physicists who
share certain procedural commitments will become even more pronounced be-
causal laws are intimately connected, so an example involving translation between paradigms of space-time illustrates the prospects of translating between paradigms of causation. Newtonian physics was based upon a conception of absolute space and absolute time. Although Newton’s use of absolute space had been heavily criticized, these criticisms proved largely ineffective. However, repeated failures to detect the “ether-drift” predicted by Newtonian theory of absolute space, coupled with the acceptance of Maxwell’s final version of electromagnetic theory, which did not incorporate Newtonian ether, led to the proposal of an alternative paradigm that took the form of the relativity theories of Lorentz, Fitzgerald and Einstein. Because they operated under a different paradigm, relativity theorists simply lived in a different world than did adherents to the Newtonian paradigm. The space-time paradigm that each group of physicists applied provided the world view, or gestalt, that allowed the physicists to give meaning to their experiences and measurements of the world.

As the “relativity revolution” in physics demonstrates, in order for meaningful communication to take place, the concepts of one paradigm must be translated into the other paradigm. If this conceptual translation is to occur, the need for translation must be explicitly recognized. It is imperative that members of any one paradigm desist from merely assuming that a single paradigm is shared and that translation is unnecessary.

B. Scientific homonyms must be translated into legal terms.

As has already been implied, the legal and scientific communities differ in several important respects. For example, the legal and scientific communities differ in focus. The scientific community almost inevitably is concerned with predictive statements, while the legal community is generally concerned with postdictive statements. In other words, the scientific community is concerned with applying theo-

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166. RUSSELL, supra note 4, at 326-27.
167. Kuhn, supra note 3, at 72 (absolute space); Losee, supra note 5, at 84 (absolute space and time).
168. Kuhn, supra note 3, at 72-73.
169. Id. at 73-74.
170. Id. at 111.
171. Id. at 85, 121-22.
172. Kuhn was initially skeptical whether this type of translation between paradigms was possible. Id. at 114-15. However, the paradigms involved need not be wholly incommensurable in order for this problem to persist. Id. at 201-04.
173. A homonym is a homophone that has a different meaning. OXFORD AMERICAN DICTIONARY, supra note 1, at 313.
174. Loevinger, supra note 163, at 328; Carson, supra note 162, at 29.
ries to predict future facts, while the lawyer generally is interested in applying legal rules to temporally pre-existing facts. Second, the procedural conventions of lawyers and scientists are different. The procedures used to present evidence and arguments and to arrive at decisions in the two communities differ drastically. Lawyers rely heavily upon the adversarial process, whereas scientists rely upon peer review. Third, the standards of proof and types of permissible proof differ in each community. Fourth, while scientists seek to cover as many contingencies as possible with a statement, and thus try to formulate broad generalizable theories, lawyers are usually concerned only with the specific consequences to particular clients. Lastly, scientists work with levels of degree and quantification, while lawyers work in terms of categories. These differences serve to distinguish the communities of lawyers and scientists. Full-fledged membership in one community is virtually certain to preclude such membership in the other.

Because of these differences between the two communities, the lawyer and the scientist literally speak different languages. As the language of the scientist differs from that of the lawyer, scientific terms must be translated into terms that have meaning to legal professionals and lay persons. When the scientist mounts the witness stand and asserts that experimental research has proven that cigarette smoking causes lung cancer, this statement is not one which the fact finder immediately understands, although the fact finder may believe that she understands the statement. Causation is a relatively complex concept, and notwithstanding the appearance of communication between the scientist and the fact finder, the homophones uttered by the scientist may as easily turn out to be homonyms as synonyms.

A famous hypothetical illustrates this point. The simplest terms to translate are those which refer to "present events that are conspicuous to the linguist and his informant." Consider the simplest application of such a term: "A rabbit scurries by, the native says 'Gavagai', and the linguist notes down the sentence 'Rabbit' (or 'Lo, a rabbit') as tentative translation . . . ." The linguist accepts this hypothesis and begins to test it by observing repeated uses in similar situations. The problem with the translation, however, is that the hypothesis is untestable. The sensory stimulus eliciting the remark "Gavagai" is not a simple unitary one. "Gavagai" may refer not only to a rabbit, but may

175. Loevinger, supra note 163, at 332-33.
176. Id. at 329-33.
178. Id.
179. Preface to LAWYERS ON PSYCHOLOGY AND PSYCHOLOGISTS ON LAW iii (Peter J. van Koppen et al. eds., 1988).
180. WILLARD VAN ORMAN QUINE, WORD AND OBJECT 29 (1960).
181. Id. at 29.
also refer to "stages of rabbits, integral parts of rabbits, the rabbit fusion, and rabbithood."182 One of these several potential meanings cannot be isolated merely by pointing to the sensory stimulus, for "[p]oint to a rabbit and you have pointed to a stage of a rabbit, to an integral part of a rabbit, to the rabbit fusion, and to where rabbithood is manifested."183 Any attempt to isolate one of these potential meanings requires inquiry into identity and diversity, which in turn requires far greater command of the native's language than has been justified, given the fact that the linguist cannot connect a single meaning to a simple sensory stimulus.184 If one cannot tell whether or not the native is referring to a rabbit, it certainly seems improbable that one may accurately translate more complex abstract terms such as "cause."

It may be objected that the "Gavagai" hypothetical does not apply to the courtroom because the hypothetical involves two natural languages, whereas all participants in the courtroom speak a single natural language. However, the same indeterminacy that plagues translation between natural languages plagues "homophonic translation" within a single natural language.185 Despite the fact that the terms used by both speakers sound the same, the meaning assigned to them may be different. In fact, the appearance of communication when understanding may be absent increases the danger of mistranslation. If the terms were clearly different, the need for translation would be obvious and mistranslation would be less of a problem. Moreover, to distinguish between the courtroom situation and the hypothetical on the basis of the number of natural languages involved assumes that the speaker and the listener in the courtroom both are members of the same speech community and speak the same natural language.186 However, the segregation of the scientific and legal communities gives rise to the very real possibility that these two communities do not share a single natural language.187 Rather than both

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182. Id. at 52.
183. Id. at 52-53.
184. Id. at 53.
186. Id.
187. Much research has shown that segregated communities develop different linguistic patterns and usages even though they apparently speak a single natural language. In a very real sense, these communities speak different languages. See, e.g., SHIRLEY B. HEATH, WAYS WITH WORDS: LANGUAGE, LIFE AND WORK IN COMMUNITIES AND CLASSROOMS (1983); WALTER J. ONG, ORALITY & LITERACY: THE TECHNOLOGIZING OF THE WORD (1982). For the theory supporting such observations, see TERRY EAGLETON, LITERARY THEORY: AN INTRODUCTION 5, 127-50 (1983).

In its extreme form, this line of hermeneutical argument insists that each individual language user is trapped "inside her own skin" and cannot effectively
speaking a single version of "standard English," the two communities may speak completely different "Englishes."

This indeterminacy of linguistic references creates a second layer of problems in translation. The analysis of conceptual translation reveals that the concepts of the scientist simply may not match legal concepts. The scientist is engaged in model-building, not in reality-description. Thus, there is no reason to assume that the models produced by science have anything at all to do with the realist causal inquiry of the law. These conceptual difficulties occur even assuming that a single language is used by both communities. When the additional variable of language is added on top of this conceptual confusion, it becomes impossible to tell whether the same concepts are used by both paradigms or not. The conceptual referents of the terms used by the scientist are simply impossible to ascertain due to the inscrutability of linguistic references. In light of these tremendous philosophical difficulties, it is a fair question whether the fact finder can ever properly translate scientific evidence.

C. Solving the troubles of translation: a modest proposal.

The inscrutability of linguistic references to causes and the incommensurability of causal paradigms create serious philosophical problems whenever scientific evidence of causation is offered as proof of the existence of legal causation. These problems notwithstanding, it seems intuitively obvious that scientific proof of causality should contribute to proof of legal causation. As will be shown, while a theoretical basis exists for the use of scientific evidence in the legal arena, a balance must be reached that takes the difficulties of translation into account.

The question of the legal use of scientific evidence has two aspects. The most fundamental aspect of this question is whether there is any justification for the use of scientific evidence in proving legal causation despite the persistent philosophical problems with the use of such proof. If an extreme position is taken as to the inscrutability of scientific references to causes and the incommensurability of causal paradigms of law and science, the lawyer and the scientist would never communicate, and scientific evidence would never be relevant to the legal issue of causation. The use of a single English term to refer to

communicate with others, or at least cannot justifiably rely upon the existence of such communication. See, e.g., Hazard Adams, Introduction to CRITICAL THEORY SINCE 1965, at 1, 17-18 (Hazard Adams & Leroy Searle eds., 1986); JONATHAN CULLEN, ON DECONSTRUCTION 110-31 (1982); Stanley Fish, Is There a Text in This Class?, in CRITICAL THEORY SINCE 1965, at 525, 525-533 (Hazard Adams & Leroy Searle eds., 1986). Although this Article does not make the claim made by the radical deconstructionists, such a claim is not inconsistent with the arguments made herein.
both the scientific and legal inquiries obscures the plausibility of this extreme position. A simple thought experiment removes this obscurity. Suppose that scientists eliminated all causation related terms from their vocabulary, replacing the term "causation" with "erdichtung." A tort plaintiff offers a scientific expert witness to testify on the legal issue of causation. From the proffer of testimony it becomes clear that the scientist will testify that science has proven the existence of erdichtung. The judge, perplexed by this statement, questions the scientist as to what she means when she says that science has proven the existence of erdichtung on these facts. In response, the scientist provides a sociological account similar to that contained in Part III of this Article. Should the judge reject the expert testimony?

Although rejection is certainly plausible, this extreme position is unattractive; both lawyers and the general public believe that scientific proof is probative on the issue of legal causation. This general perception provides the theoretical basis for the use of scientific evidence of causation. The chief asset of the legal system is its legitimacy. In order to maintain this legitimacy, the courts should be loathe to exclude evidence which, even on the most extreme anti-realist model, embodies the best guess of a community of intelligent and highly respected persons as to an explanation of the relevant phenomena. Across-the-board-exclusion of such apparently probative evidence would surely undermine confidence in the judicial system. Put differently, science works. More importantly, the American public believes that science works. Thus, since the legal system is designed to resolve disputes among members of this very public, the abstract problems of the philosopher should not be allowed to trump the commonly held beliefs of the disputants. Notwithstanding the serious problems created by the introduction of scientific evidence, the parties involved in the dispute believe that science is relevant to the legal issue. Because of this belief, the losing party is willing to accept the judgment of a court when that judgment is based on scientific facts. The key distinction is that the use of scientific evidence is justified by the public perception of the usefulness of scientific evidence, rather than the unfounded assumption that science and law both engage in parallel inquiries into causality.

Having established a philosophical basis for the use of scientific evidence, a second issue arises concerning the proper balance between the benefits of the use of scientific evidence and recognition of the philosophical problems created by this evidence. Much has been written

on the benefits of scientific proof. Against the background of these claims and the troubles of translation, it appears that the predominant problem is overreliance upon scientific evidence through mistranslation. Given the American penchant for things scientific, there seems to be little danger of underutilization of scientific evidence. Ultimately, the only effective way to prevent mistranslation of scientific evidence is to call the fact finder’s attention to the philosophical issues involved in translation. This admonition will counterbalance the natural tendency toward assuming the scientific and legal paradigms are identical by exposing the differences between the causal inquiries of science and law.

In order to combat the tendency to assume that science inquires into the realist causes sought by the law, the jury should be instructed in a way that brings to its attention the various elements of a sociological account of science. By providing this instruction, the jury is given a framework that enables it independently to assess the probativity of the scientific evidence on the issue of legal cause-in-fact. The need for curative or cautionary instructions to correct undesired jury tendencies and the ability of the jury to follow them are both well established legal principles.

Thus, when scientific experts are used to establish legal causation, the jury should receive an instruction that begins:

You will recall that the witness(es) [state names] testified concerning [his, her, their] qualifications as [an] expert[s] in the field[s] of [state professions] and gave [his, her, their] opinion concerning whether the defendant caused the plaintiff’s injury.

This portion of the instruction reminds the jury that a scientific expert has testified and helps the jury to recall the specific testimony to

192. MCCORMICK ON EVIDENCE, supra note 159, at 85-86 (discussing use of limiting instructions where evidence admitted for limited purpose).
193. Perhaps one of the most forthright statements on the ability of the jury to follow cautionary or curative instructions is that of the Seventh Circuit: The presumption in our system, artificial as it may sometimes be, is that curative instructions cure, that admonitions to the jury are taken seriously. . . . We are not quite so naive as to believe that telling jurors not to think about something will cause them to forget it, but we trust jurors to behave responsibly and to put aside as considerations bearing on their judgment matters that the judge tells them to put aside. United States v. Mazzone, 782 F.2d 757, 764 (7th Cir.), cert. denied, 479 U.S. 838 (1986).
which the instruction is directed, thereby focusing the jury's attention on the pertinent issues. This portion of the instruction also reminds the jury that the expert testified concerning her qualifications. Although the issue of whether the proffered witness is qualified to testify as an expert is for the judge to decide in the first instance, the qualifications of the expert are relevant to the credibility of the testimony.

The instruction would continue:

The witness[es] [state names] qualified as [an] expert witness[es] due to [his, her, their] knowledge, skill, experience, training, or education. Although this expertise provides the witness[es] with specialized knowledge, it may also have the effect of giving the witness[es] a vested interest in publishing certain papers, or in seeing a certain outcome, or in maintaining [his, her, their] status, and it does not by itself render the witness[es] any more reliable than any other witness.

The first sentence of this portion of the instruction recites the language of Federal Rules of Evidence Rule 702 concerning the bases for qualification as an expert. The first clause of the second sentence of the instruction also utilizes language from Rule 702 but adds several cautionary phrases. These cautionary phrases bring the sociology of science to the jury's attention. First, the instruction notes that the witness may have a "vested interest in publishing certain papers." This incorporates aspects of the concept of inscriptions and informs the jury that a scientific expert's testimony may be influenced by her desire to produce inscriptions. Second, the instruction notes that the witness may have an interest in "seeing a certain outcome." This portion of the instruction informs the jury that a desire to preserve a scientific paradigm may affect an expert's testimony. Third, the instruction notes that the expert may have a vested interest in maintaining her status within the scientific community. This caution partly incorporates the concept of boundary work (viz., to have status in a community one first must be within the community) and hierarchy. The final clause of the second sentence is a direct admonition to avoid attributing excessive probative value to expert testimony based solely upon the credentials of the expert. This portion of the instruction is a direct caution against the assumption that scientific evidence is dispositive of the legal issue merely because it is scientific.

The next portion of the instruction is:

195. Id.
196. For a discussion of the concept of inscriptions, see supra subsection III.C.3.
197. See supra section III.B.
198. For a discussion of the concept of boundary work, see supra subsection III.C.1.
199. For a discussion of the concept of hierarchy, see supra subsection III.C.2.
When expert testimony is helpful, an expert is permitted to state [his, her] opinion for the information of the court and the jury. The opinion stated by [the, each] expert who testified before you was based on certain assumptions and facts. You may reject the expert's opinion if you find the facts to be different from those which formed the basis for the opinion. You may also reject the opinion if, after careful consideration of all the evidence in the case, expert and other, you disagree with the opinion or any of the assumptions upon which it was based.

The first sentence of this portion of the instruction merely refers to the helpfulness test under Federal Rules of Evidence Rule 703. The second and third sentences incorporate the concept of contingency.200 The jury is informed that the probative value of the evidence depends upon the acceptance of certain facts or assumptions that may be questioned. This information effectively allows the jury to consider the contingent nature of scientific evidence. The phenomenon of reification is not specifically mentioned because it would require extensive explanation, but the concept of reification is implicit in the concept of contingency. Reification is essentially nothing more than the removal of contingencies. These sentences also incorporate the notion of paradigms, which are, loosely speaking, sets of shared assumptions. The fourth sentence is a restatement of the traditional role of the jury as the finder of fact.201

The instruction concludes:

Moreover, you may choose to discount the expert testimony if you find that it was directed to a special situation that is dissimilar to the issue of causation before you. In other words, you are not required to accept an expert's opinion to the exclusion of the facts and circumstances disclosed by other testimony. An expert opinion is subject to the same rules regarding reliability as the testimony of any other witness. You should not give any extra weight to any testimony from an expert who is labelled a scientist merely because [he, she] is so labelled, and you are expected to rely upon common experience and good sense. All this evidence was given to assist you in reaching a proper conclusion; it must be considered by you but is entitled only to the weight as you find it to warrant, and no single piece of evidence is controlling upon your judgment.202

This portion of the instruction accomplishes two goals. The first sentence of this portion of the instruction calls the jury's attention directly to the translation of concepts. Although no direct mention is made of the issue of translating terms, the broad language of the instruction ("special situation that is dissimilar to the issue of causation before you") should be broad enough to cover this issue. Specific references to the difficulties of homophonic translation are likely to meet

200. For a discussion of the concept of contingency, see supra subsection III.C.4.
202. This jury instruction is loosely based upon New York Pattern Jury Instruction 1:90 which deals with the issue of expert witnesses. Although substantial portions of the New York instruction have been quoted, quotation marks have been omitted in order to preserve clarity.
with little more than the glazed eyes of the jurors. Thus, rather than risk diluting the impact of the numerous cautions already contained in the instruction, reference to the translation of terms is simply merged with reference to the translation of concepts.

This last portion of the instruction also reiterates the proper role of the jury. Because the primary danger is overreliance upon scientific experts, the jury is told in several different ways independently to weigh all the evidence as it sees fit. Instructing the jury in this manner will encourage the jury properly to weigh scientific evidence and should counterbalance the current tendency to mistranslate scientific evidence. The jury is an institution that is designed to bring a little common sense into the courtroom. That institution should be permitted to perform its intended function.

V. CONCLUSION

The law has traditionally applied a but for test of cause-in-fact. The employment of this test has resulted in the application of two causal paradigms, both of which seek real causes in the external world. Juries apply a folk paradigm that sees causation as mutually exclusive externalized causal chains that exist “out there” in the world. Judges conceive of causality more technically, seeing it as a potentially infinite series of externalized causal webs that is limited by the policy-based doctrine of proximate cause. Notwithstanding these differences, both the causal chains and causal webs are pre-existing external realities of nature.

The causal claims of science stand on completely different footing. They are not true of nature, but are dependent on a host of shared conventions and assumptions common to the community that produced the claim. The realist accounts of verificationism and falsificationism have largely been rejected, and the anti-realist account of the scientific enterprise provides an account of the generation of “facts” which is utterly foreign to the law and to the lay person. Scientific “facts,” such as a claim of causation, are manufactured by a small, highly homogenous scientific community that is committed to a certain paradigm and that seeks to perpetuate the paradigm through the mechanisms of hierarchy and boundary work. These mechanisms are also used in the reification of contingent statements that ultimately misleads the lay community as to their true nature.

The anti-realist account of the scientific community provides several challenges for the law. When the contingent and highly specialized products of a scientific community are offered to settle legal disputes, they must be translated into the legal notion of causation. The need for translation of scientific concepts and language creates potentially unresolvable philosophical difficulties. However, the general acceptance of science provides a sufficient basis for the admission
of scientific evidence. The most significant problem with using scientific evidence is the overreliance that results from mistranslation, and this problem should be cured by the use of cautionary jury instructions to inform the jury of the sociological nature of scientific evidence so that the jury may independently translate and evaluate the evidence.