1992

Proof in Law and Science

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Recommended Citation
David H. Kaye, *Proof in Law and Science*, 32 *Jurimetrics J.* 313 (1992).

SYMPOSIUM

THE CONTRASTING CULTURES OF LAW AND SCIENCE

The 1992 annual meeting of the American Association for the Advancement of Science included a session on "The Contrasting Cultures of Law and Science." Organized by Lee Loevinger and Deborah Runkle on behalf of the AAAS-ABA National Conference of Lawyers and Scientists, and held in Chicago on February 8, 1992, this session featured presentations by J.D. Fleming, Sheila Jasanoff, David Kaye, Lee Loevinger, and William (Tom) Thomas.

In this special symposium, we present revised and edited versions of three of these presentations. In publishing these materials, we hope to highlight and perhaps clarify some of the differences between legal and scientific reasoning, between the standards of proof employed in law and science, and between science as it is practiced by scientists and understood by courts.

PROOF IN LAW AND SCIENCE*

D.H. Kaye**

I have been asked to discuss proof in law and science.[1] I shall suggest that in both disciplines, there are two sorts of proofs: proof of facts and proof of theories. Because the objectives behind these proofs differ in legal and scientific work, the specific procedures for proving facts and theories also differ.

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[1]This article was originally prepared for a symposium on "The Contrasting Cultures of Law and Science" at the February 1992 annual meeting of the American Association for the Advancement of Science.

In both disciplines, however, proof of theories takes the form of argument—a series of premises followed by a conclusion. The rules that determine whether the conclusion "follows" from the premises constitute a "logic." In what ways, I ask, does the logic governing legal proof differ from that governing scientific proof?

Before attacking this question, I should emphasize two limitations to my inquiry. For one thing, I shall only scratch the surface of the topic. The nature of reasoning is complicated, and I shall not even try to list all the qualifications that a more complete analysis would require. Moreover, I am not certain whether all that I shall say is correct. Although stated rather baldly, my analysis is actually tentative and is intended to inspire reflection or discussion rather than to settle long-standing philosophical debates.

For another thing, I shall not discuss the process of discovering facts and theories. Even in science, this process of discovery may not be "logical."[2] A discovery may come from perseverance, insight, luck, or inspiration. But the psychological origins of a scientific conclusion have little bearing on its truth or validity.[3] In law, too, justification is distinct from discovery. The early "legal realists" focused on the little understood process of discovery when they stressed the judicial "hunch"[4] and the fact that settled legal rules do not always dictate unique outcomes in new cases.[5] The recognition that judges write opinions after they have made up their minds—for reasons of which even they may not be conscious—is important. But it does not detract from the reasoning—the "proof"—set out in these opinions[6] any more than Gauss's frequent revisions of his proofs before publication[7] reduces the greatness of his myriad contributions to mathematics.[8]

In any event, my concern here is not with discovery, but with proof. The

[2]*But see* Blachewicz, *Discovery and Ampliative Inference*, 56 PHIL. SCI. 438 (1989); Kelly, *The Logic of Discovery*, 54 PHIL. SCI. 435 (1987).

[3]Kekulé's theory for the cyclic and resonating structure of benzene is a celebrated example. The idea came, he reported, from a series of dreams. *August Kekulé and the Birth of the Structural Theory of Organic Chemistry in 1858*, 35 J. CHEMICAL EDUC. 21 (1958). Similarly, the humoral transmission of nerve impulses via chemical substances occurred to Loewi in his dreams. Ulrich Weiss & Ronald A. Brown, *An Overlooked Parallel to Kekulé's Dream*, 64 J. CHEMICAL EDUC. 770 (1987). These discoveries, however, were not accepted until justified by subsequent experimental evidence. For further discussion of these and other examples of scientific discovery, see, e.g., R.M. ROBERTS, SERENDIPITY: ACCIDENTAL DISCOVERIES IN SCIENCE (1989); Mullis, *The Unusual Origin of the Polymerase Chain Reaction*, SCI. AM., April 1990, at 56.

[4]Hutcheson, *The Judgment Intuitive: The Function of the "Hunch" in Judicial Decision*, 14 CORNELL L.Q. 274 (1929).

[5]The extreme version of "realism" depicts the judge's published reasoning as a facade concealing the true nature of the law. J. FRANK, LAW AND THE MODERN MIND 7–21 (1935).

[6]R.A. WASSERSTROM, THE JUDICIAL DECISION: TOWARD A THEORY OF LEGAL JUSTIFICATION 12–38 (1961).

[7]In this respect, Gauss was said to be "like the fox who effaces his tracks in the sand with his tail." H. MESCHKOWSKI, WAYS OF THOUGHT OF GREAT MATHEMATICIANS 62–63 (1964).

[8]This example is taken from Steven P. Goldberg, *On Legal and Mathematical Reasoning*, 22 JURIMETRICS J. 83 (1981). Goldberg argues that the parallels between mathematical proof and legal justification are closer than they are generally thought to be.

logic that I describe pertains only to the more formal argument that comes after such discovery. I begin with the proof of fairly basic facts and then consider the proof of more complex theories.

I. LOGIC IN FACT-FINDING

Science and law both are mired in evidence. Scientists and lawyers alike seek facts, and they understand these facts in terms of some theory or theories.[9] Experimental scientists devote their professional lives to gathering data that may confirm or refute theoretical predictions. Even the purest theorists pay homage to facts when they deplore the demise of a beautiful theory killed "by an ugly fact,"[10] or when they denigrate a theory as "[m]ost ingenious, and adequately protected by its great complexity against being proved wrong."[11]

In law, evidence is said to be of two types: direct and circumstantial. Direct evidence is evidence that, if true, establishes with certainty the proposition for which it is advanced. For instance, the report of an eyewitness that the defendant fled from a bar at the time it was robbed is direct evidence of the defendant's flight. If the witness's account is true, then it is true that the defendant fled the scene. But this direct evidence of flight is only circumstantial evidence of the defendant's guilt. After all, flight is consistent with many other hypotheses besides guilt. For instance, the defendant may have been a bystander who fled because she did not want her parents to know she was at a bar. Nevertheless, without powerful evidence to support some such competing hypothesis, the fact of flight enhances the probability that the defendant committed the robbery.

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[9]For a perceptive account of the influence of theory on the attitudes toward specific facts, see Lightman & Gingerich, *When Do Anomalies Begin?*, 255 SCIENCE 690 (1992). Of course, the dichotomy between "facts" and "theories" is not perfectly sharp and clear-cut, but we use it all the time. Scientists use theory to decide what data to seek, and they use data to formulate and test their theories. For instance, the Big Bang theory of the universe explained the finding of a substantial and apparently irreducible level of noise in a radio telescope in New Jersey. This discovery, in turn, prompted astronomers to verify that the frequency spectrum of the background radiation was indeed a black-body curve, further confirming the hypothesis of a Big Bang. The observations—that is, the measurements of the intensity of the radiation at specific frequencies—are facts. Indeed, these observation-statements are at the ground level of facts in science. The Big Bang hypothesis is a theory, although it is now so firmly entrenched that it would not be strange to hear it presented as "fact." In bold, a factual statement is a report of a sensory observation or a fairly direct inference from that observation-statement, while a theory is less immediately perceptible, much more general and ties otherwise disparate facts together.

[10]"[T]he slaying of a beautiful hypothesis by an ugly fact," in Thomas Huxley's words, is "the great tragedy of Science." THOMAS HENRY HUXLEY, *Biogenesis and Abiogensis* viii (1870), *in* DISCOURSES BIOLOGICAL AND GEOLOGICAL (1903).

[11]"The most interesting theoretical work produced recently is the Heisenberg-Born-Jordan theory of quantum states," Einstein wrote in a letter. "It's a real witches' calculus, with infinite determinants (matrices) taking the place of Cartesian coordinates. Most ingenious, and adequately protected by its great complexity against being proved wrong." Klein, *Einstein and the Development of Quantum Physics*, *in* EINSTEIN: A CENTENARY VOLUME 133, 148–49 (A.P. French ed., 1979).

The process of drawing inferences from evidence is inductive, although a certain amount of deduction also may be involved. A deductive argument is *valid* if and only if it is logically *impossible* that its conclusion is false while its premises are true. In contrast, an inductive argument is *strong* if and only if it is *improbable* that its conclusion is false given that its premises are true.[12] The measure of the strength of an inductive argument is known as an inductive probability. That is, an inductive probability measures how probable the conclusion is given that the premises are true. Thus, the strength of the argument for the defendant's guilt based on the fact of flight—what lawyers call the probative value of the circumstantial evidence—can be expressed as an inductive probability,[13] and can be denoted Pr(H|F), for the probability (Pr) of the hypothesis of guilt (H) given the fact of flight (F).

Like proof of facts in a court of law, factual proof in scientific settings is a mixture of deductive and inductive reasoning. Here, "direct evidence" consists of statements of observations from which one deduces or induces other facts. A radio telescope pointed at the Crab Nebula registers the intensity and polarization of radiation at various frequencies. These data, if correct, are direct evidence that the Crab Nebula is a radio source (or, more precisely, that something in the direction of the Crab is emitting radio waves). Using mathematics and the appropriate equations of electromagnetism as premises, we deduce that free electrons in a strong magnetic field will produce radiation with the observed characteristics. This deductive reasoning fits into an inductive argument that the Crab Nebula is the remnant of a supernova emitting radio energy by synchrotron radiation.[14] A lawyer would say the radio observations are circumstantial evidence supporting the hypothesis of a supernova. A logician might denote the degree of this support by Pr(H|D), the inductive probability of the hypothesis about the nature of the nebula (H) given the data from the radio telescope (D).

If inductive and deductive reasoning underlie the proof of facts in law as well as science, as I suggest, then a further question arises: Do the same logical rules operate in both domains? Philosophical attempts to explicate the rules of inductive logic have proved controversial,[15] but I believe that the applicable

[12]It is often said that deductive reasoning goes from the general to the specific, while inductive reasoning proceeds from the specific to the general. *See* ARISTOTLE, ANALYTICA PRIORA. For examples of inductive and deductive arguments that conflict with this common view, see B. SKYRMS, CHOICE AND CHANCE: AN INTRODUCTION TO INDUCTIVE LOGIC 13 (3d ed. 1986) ("[s]uch a view is nonsense").

[13]*See* I STUDIES IN INDUCTUVE LOGIC AND PROBABILITY (Carnap & Jeffrey eds., 1971).

[14]There may be other deductively valid arguments which posit quite different phenomena culminating in the emission of the observed radiation. Whether the synchrotron radiation theory should be provisionally accepted depends on its inductive probability. *But see* I. LEVI, GAMBLING WITH TRUTH: AN ESSAY ON INDUCTION AND THE AIMS OF SCIENCE (1967).

[15]*See, e.g.*, APPLICATIONS OF INDUCTIVE LOGIC (L.J. Cohen & M. Hesse eds., 1980); L.J. COHEN, THE PROBABLE AND THE PROVABLE (1977).

inductive logic [16] follows the rules of probability theory. This logic identifies the inductive probability that a conclusion, like the hypothesis H, to an argument actually follows from its premises, such as the data D, as a familiar conditional probability, like Pr(H|D).[17] This is defined as the joint probability of the hypothesis and the data divided by the probability of the data, Pr(H and D)/Pr(D).[18] In short, when it comes to proving facts, the logic of law and that of science are one and the same. At an abstract level, the rules of inference can be given the same formal representation.

On the other hand, the *procedures* for establishing facts look very different in science than they do in law. Scientific findings are announced at professional meetings and in scholarly publications. The scientist does not unveil data by testifying under oath. The declarant is not subject to cross-examination. There are no evidentiary presumptions that shift the burden of proof from one side to another, no tribunal ready and bound to announce its conclusions as to the assertions of fact, and no burdens of persuasion, like proof beyond a reasonable doubt, that tell the tribunal how to resolve factual uncertainty.

The reasons for these differences in format are not hard to find.[19] Adjudication is a response to a controversy thought desirable to settle then and there, for once and for all. In general, the method for resolving the dispute must prove satisfactory to the parties, and the results must have public credibility. The events in question are over and done with. They cannot be replicated. Further observations of what actually transpired are impossible. Most witnesses appear for a single trial, and they will not be brought to task except perhaps for the more egregious lies. Few are interested in truth as a value. Under these circumstances, a hearing or a trial-type proceeding is a reasonable vehicle for seeking a resolution of historical facts. As the response to the Warren Commission's inquiry into the assassination of President Kennedy reveals, even these attempts to put questions surrounding recent history to rest do not always succeed, but they are reasonably calculated to do so.

Scientists, on the other hand, do not conduct trials and hearings to answer questions about the natural order because tentative rather than definitive answers are acceptable and because the subject matter consists of reproducible

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[16] D.C. STOVE, THE RATIONALITY OF INDUCTION 113 (1986) criticizes the phrases "inductive probability" and "inductive logic." He recommends "logical probability" and "non-deductive logic." The probabilities that I refer to are indeed logical probabilities. They also can be called personal or subjective. *See* D.H. Kaye, *What Is Bayesianism?*, *in* PROBABILITY AND INFERENCE IN THE LAW OF EVIDENCE (P. Tillers & E. Green eds., 1988).

[17] *See, e.g.*, J.M. KEYNES, A TREATISE ON PROBABILITY (1921).

[18] One can motivate this identification, which presupposes "epistemic" probabilities that specific propositions (like H and D) are true, by observing that any set of such probabilities defined over all possible propositions that does not conform to the axioms of mathematical probability is contradictory in the sense that it assigns different probabilities to the same propositions when the propositions are expressed in superficially different, but logically equivalent, forms. *See* SKYRMS, *supra* note 12.

[19] *See, e.g.*, Hart & McNaughton, *Evidence and Inference in Law*, 87 DAEDALUS 40, 44–48 (1958).

phenomena rather than what happened on a specific occasion and who was responsible. The best test of the accuracy of data is not the ability of the scientist to testify credibly, but the reproducibility of the data. Most experiments and observations are subject to replication, and professional reputations rise and fall according to the results. Like the fallible trial-type procedures, these incentives for inducing accuracy and honesty do not always succeed.[20] But they probably work better to produce correct accounts than the pressures engendered in trial-type proceedings. Also, their presence helps explain the absence of the procedures for introducing and evaluating evidence that characterize legal systems.[21]

In sum, evidence is central to law and to science. The differences in the procedures for establishing facts in the two realms are starkly different, but the differences are explicable and, in a sense, superficial. The proof of facts, in law as in science, ultimately is a matter of inductive logic, and, I believe, the same logic governs both enterprises.

II. LOGIC IN LAW-FINDING

A. The Model of Deduction

Having discussed factual reasoning, I turn to the question of legal reasoning—arguments about what the law requires in a particular factual setting. Much legal reasoning looks deductive in that it is expressed in the following form:

if (P_1 and P_2 and . . . and P_n) then C	(legal rule)
P_1 and P_2 and . . . and P_n	(facts)
C	(conclusion).

For example, the legal rule may be that if a person knowingly takes the life of another human being, then that person is guilty of murder; the factual finding may be that the defendant is a person who knowingly took the life of another

[20]Engler et al., *Misrepresentation and Responsibility in Medical Research*, 317 New Eng. J. Med. 1383 (1987); Woolf, *Deception in Scientific Research*, 29 Jurimetrics J. 67 (1988).

[21]As one moves away from the natural sciences in which experimentation is the dominant mode of investigation, the distinguishing features identified here assume less importance. For example, geology, paleontology, and evolutionary theory concern unrepeatable events. *E.g.*, Allan C. Wilson & Rebecca L. Cahn, *The Recent African Genesis of Humans*, Sci. Am., Apr. 1992, at 66; Alan G. Thorne & Milford H. Wolpoff, *The Multiregional Evolution of Humans*, Sci. Am., Apr. 1992, at 76; J. Brendan Murphy, *Mountain Belts and the Supercontinent Cycle*, Sci. Am., Apr. 1992, at 84. Psychology and cultural anthropology may utilize the "testimony" of witnesses. Yet, the procedures of proof still differ as between these sciences and law. Although I believe the differences with respect to even these disciplines remain explicable in terms of the way the procedures function to produce accurate theories, I do not pretend to have established this claim here.

human being; and the conclusion would be that the defendant is guilty of murder.[22]

Yet, the "formalist" view that legal conclusions are deductively valid consequences of unambiguous and settled premises is plainly untenable. Almost a century ago, Oliver Wendell Holmes complained that:

> [T]he logical method and form flatter the longing for certainty and for repose which is in every human mind. But certainty generally is illusion, and repose is not the destiny of man. Behind the logical form lies a judgment as to the relative worth and importance of competing legislative grounds, often an inarticulate and unconscious judgment, it is true, and yet very root and nerve of the whole proceeding. You can give any conclusion a logical form. . . . But why do you [do] it?[23]

In the same vein, nearly half a century ago, Edward Levi insisted that:

> It is important that the mechanism of legal reasoning should not be concealed by its pretense. The pretense is that the law is a system of known rules applied by a judge; the pretense has long been under attack. In an important sense, legal rules are never clear, and if a rule had to be clear before it could be imposed, society would be impossible.[24]

The dominant modern perception, then, is that although "the conclusions of legal reasoning commonly are expressed in the deductive form," and although "[l]ogical validity within this form is often regarded as necessary in legal reasoning," the deductive form "in itself is of trivial importance."[25]

B. The Role of Analogy

The more challenging problem for lawyers and judges is not how to put an opinion or argument into a deductively valid form, but rather how to determine what the legal rule in such an argument will be or what it means in concrete cases. Consider the following rule: "No state shall . . . deny any person . . . the equal protection of the laws."[26] Imagine that shortly after this grandiose but vague rule is adopted, a litigant argues that a state law that requires racial segregation in passenger trains deprives him of the equal protection of the law, but the court decided that having one car for whites and another no less well appointed car for blacks, does not infringe the requirement of

[22]For other examples and a fuller development of the claim that judicial conclusions can be, and often are, presented as logical deductions, see N. MacCormick, Legal Reasoning and Legal Theory 19-52 (1978).

[23]Oliver Wendell Holmes, *The Path of the Law*, 10 Harv. L. Rev. 457, 466 (1897).

[24]E.H. Levi, An Introduction to Legal Reasoning 1 (1948).

[25]S.J. Burton, An Introduction to Law and Legal Reasoning 43 (1985). Treating classical syllogisms as the paradigm of legal deductive reasoning, Burton adds that "[t]he key problems are (1) adopting a correct major premise; (2) formulating a correct minor premise in the language of the major premise; and (3) using the relationship of the premises to yield a sound conclusion." The first of these problems is the most interesting and typically the crucial step in the analysis.

[26]U.S. Const. amend. XIV.

"equal protection."[27] The rule seems to be that the state may not bar a racial minority from access to superior amenities, but it may use race to determine access to comparable facilities (Rule I).

Some years later, another litigant challenges another state law that requires racial segregation, this time in public elementary schools. Certainly, there are similarities between these two cases, but there are also differences. Riding in a train is one thing; attending a public elementary school is another. The court concludes that a separate, but tangibly equal state school system offends the equal protection rule.[28] Perhaps the rule is that "separate but equal" state segregation in an institution of fundamental importance to the individual is impermissible, but is allowed in other contexts (Rule II). Or, maybe the rule is that the state cannot determine access to any state-owned facility on the basis of race (Rule III).

A third case arises. A litigant argues that a law requiring racial segregation in a courtroom is unconstitutional. The previous two decisions are precedents that help explicate the meaning of equal protection, but, for the purpose of applying the requirement, is sitting in a courtroom more like riding a passenger train or more like attending a public school? The lawyers offer answers to this question based on the characteristics that they contend are important, or, to put it another way, the rules that they see as best explaining the previous cases. The court decides that the state cannot maintain racial segregation in the courtroom.[29] Of the rules we have enumerated, only Rule III accommodates all the cases, but other rules could be stated that are consistent with the three outcomes.

The point of this example is not to describe the development of the equal protection clause of the U.S. Constitution, but to illustrate some of the limitations of the formal, deductive model of legal reasoning.[30] For one, the decided cases—the data, so to speak—are imperfect. The particular facts important to the decisions are not always immediately apparent. And, it always can be argued that some of the previous cases were wrongly decided, so that the soundest and best-fitting rule is one that ignores these outliers.[31] For another, the rule that is supposed to explain the precedent, to make coherent the previous decisions that deserve to be followed, keeps changing. Again, Levi described the process well:

> The basic pattern of legal reasoning is reasoning by example. It is reasoning from case to case. . . . [T]he rules change from case to case

[27] *Cf.* Plessy v. Ferguson, 163 U.S. 537 (1896).

[28] *See* Brown v. Board of Educ., 347 U.S. 483 (1954).

[29] *See* Johnson v. Virginia, 373 U.S. 61 (1963) (segregated courtroom); *cf.* New Orleans City Park Improvement Ass'n v. Detiege, 358 U.S. 54 (1958) (public park).

[30] Each generation, it seems, is fated to rediscover these limitations. *E.g.*, Allen et al., *The Double Jeopardy Clause: Constitutional Interpretation and the Limits of Formal Logic*, 26 VAL. U. L. REV. 281 (1991).

[31] *See* R. DWORKIN, TAKING RIGHTS SERIOUSLY (1977).

> and are re-made with each case. [T]he scope of a rule of law, and therefore its meaning, depends upon a determination of what facts will be considered similar to those present when the rule was first announced. The finding of similarity or difference is the key step in the legal process. . . .
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> In the long run, a circular motion can be seen. The first stage is the creation of the legal concept which is built up as cases are compared. The period is one in which the court fumbles for a phrase. . . . The second stage is the period when the concept is more or less fixed, although reasoning by example continues to classify items inside and outside of the concept. The third stage is the breakdown of the concept, as reasoning by example has moved so far ahead as to make clear that the suggestive influence of the word is no longer desired.[32]

Even so, to recognize that "reasoning by example"—analogical reasoning—lies at the "root and nerve" of the process is to take but the first step toward articulating a satisfactory logic for legal reasoning. To pinpoint the logic that determines when the factual similarities between two situations outweigh the differences is an ambition that remains to be satisfied.[33]

C. The Natural and the Constructive Models

Analogical reasoning has a place in science. Physicists, for instance, once conceived of atoms as miniature solar systems. Such analogies may provide insights and clues into the laws governing the system to which the analogy applies, but no one would insist that just because planets obey the dictates of an inverse square law, orbital electrons must do the same. Analogies in science may be valuable as heuristic devices, but they do not constitute proof of the theory motivated or made more intelligible by contemplating the previous example.[34] In law, however, we have seen how examples—prior decisions of legally authoritative bodies—become the basis for analogies that are used to justify the next decision and to articulate a rule that is said to yield this outcome.

The reason for this dichotomy lies in the nature of the phenomena that engage the professional attention of lawyers and scientists. In both contexts, one seeks a theory that best explains certain phenomena and that fits together well with other known facts and accepted theories. Logical consistency is therefore a minimal prerequisite of an acceptable theory. However, the phenomena to be explained in science are empirical and independent of the feelings and judgments of human beings, while in law the phenomena being considered

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[32] LEVI, *supra* note 24, at 1–2, 8–9.

[33] *See* Wertzenfeld, *Valid Reasoning by Analogy*, 51 PHIL. SCI. 137 (1984).

[34] Some scientific disciplines arguably use analogical reasoning as more than a heuristic tool. Thus, taxonomists debate which system of classifying organisms is best and which features of organisms are most relevant to the classifications. *E.g.*, Wendy J. Bailey, Jerry L. Slightom, & Morris Goodman, *Rejection of the "Flying Primate" Hypothesis by Phylogenetic Evidence from the ϵ-Globin Gene*, 256 SCIENCE 86 (1992).

are conscious choices that intentionally affect human beings. In science, one seeks a model of the natural order. Whether a particular model, like the planetary model of the atom, is satisfactory is entirely an empirical question. There is no *a priori* reason to demand that an atom be like a solar system. In law, one does not search for a natural model, but rather purposefully constructs a model that reconciles cases and other legal materials:

> Legal rulings are normative—they do not report, they *set* patterns of behaviour; they do not discover the consequences of given conditions, they ordain what consequences *are* to follow upon given conditions. They do not present a model *of* the world, they present a model *for* it.[35]

The constructive model responds to a demand of the social rather than the natural order—the principle which holds that justice requires similarly situated people to be treated similarly and differently situated people differently. If this principle of formal justice[36] is accepted, the tribunal justifying its decision in the next case must explain how that decision is similar to previous cases decided the same way and different from past cases decided the opposite way (or why some of the previous cases should be overruled). Hence, justifications using reasoning by example, so prominent in law, are much less persuasive in science.

Conclusion

Finding facts in law involves the same logic but quite different procedures than scientific fact-finding. Finding, or rather constructing, the law is also very different from scientific theorizing. But such differences do not indicate that one system of inquiry is deficient or the other superior. The fact-finding and law-constructing procedures that may seem odd or cumbersome to some scientists, are rational responses to constraints that are simply not present in scientific inquiry. The conclusion that legal and scientific reasoning and proof are different if only because law and science have different functions and goals may seem obvious, but this basic point is worth emphasizing in the effort to describe the contrasting cultures of law and science.

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[35]MacCormick, *supra* note 22, at 103–04; *see also* Dworkin, *supra* note 30, at 160–63 (distinguishing between the "natural" and "constructive" models of moral reasoning); Hart & McNaughton, *supra* note 19, at 41–42.

[36]Without some material criteria for ascertaining what is "similar" and "different," this demand for equality is strictly formal. *E.g.*, Joel Feinberg, Social Philosophy (1973).