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Organized Common Sense: Some Lessons from Judge Jack Weinstein's Uncommonly Sensible Approach to Expert Evidence

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ORGANIZED COMMON SENSE: SOME LESSONS FROM JUDGE JACK WEINSTEIN'S UNCOMMONLY SENSIBLE APPROACH TO EXPERT EVIDENCE

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Science is . . . nothing but trained and organized common sense.
—Thomas Huxley[1]

INTRODUCTION

Judge Jack Weinstein would likely refuse any credit—or blame—for the landmark decision of *Daubert v. Merrell Dow Pharmaceuticals, Inc.*[2] Yet the sensibilities of that decision echo in much of Judge Weinstein's judicial opinions and legal scholarship. *Daubert* shares Judge Weinstein's commonsense, practical approach to the challenges of integrating scientific research into legal decision making. However, while Judge Weinstein's intellect and knowledge of scientific methods have permitted him to manage *Daubert*'s demands, it is less clear that the average trial court judge has been as successful. In this tribute to Judge Weinstein, we consider *Daubert*'s demand that lawyers and judges become more sophisticated consumers of science. Unfortunately, this demand has largely gone unmet. Lawyers and judges remain, on average, largely innumerate, with little understanding of the basic requirements of the scientific method. Moreover, fundamental challenges associated with reasoning derived from scientific research to legal decision making have been understudied, and the translation of research data for legal decision makers remains something of a muddle. Judge Weinstein's opinions and scholarship, however, pro-

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1. THOMAS H. HUXLEY, *On the Educational Value of the Natural History Sciences* (1854), *in* LAY SERMONS, ADDRESSES, AND REVIEWS 77 (1915). An alternative and fitting version of this quote is the following: "Science is organized common sense where many a beautiful theory was killed by an ugly fact." Thomas H. Huxley, *quoted in* THE ULTIMATE BOOK OF QUOTATIONS 343 (Joseph M. Demakis ed., 2012).

2. 509 U.S. 579 (1993).

vide many lessons for any sensible attempt to move forward out of this muddle.

Scientists and lawyers approach empirical questions very differently. First, and foremost, science and the methods of science are not part of the core set of skills lawyers obtain in law school. Although "law and . . ." classes have proliferated over time, virtually no law schools require classes in research methods and statistics.[3] And few students come to law school with this skillset. Law school remains a good option for the straight-A, math-phobic history or English major. Students who excel in math and science might also go to law school, but there are a host of lucrative alternative options awaiting them. The average law student shares Huckleberry Finn's lament about mathematics:

> I had been to school most all the time, and could spell and read and write just a little, and could say the multiplication table up to six times seven is thirty-five, and I don't reckon I could ever get any further than that if I was to live forever. I don't take no stock in mathematics, anyway.[4]

Second, and more fundamentally, there is a basic disconnect between how scientists approach the empirical world and the way courts do so. Whereas scientists typically collect data in order to make general statements about phenomena, these general phenomena are employed in the courtroom to make statements about individuals. This basic tension between the group-data orientation of science and the individual decision making required in the courtroom is usefully termed the G2i problem.[5] This problem involves the challenges associated with group-to-individual inference in scientific expert testimony. For example, in *Daubert*, research studies were offered to

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3. Michael Heise, *The Importance of Being Empirical*, 26 PEPP. L. REV. 807, 817 (1999).

4. MARK TWAIN, THE ADVENTURES OF HUCKLEBERRY FINN 15 (Perennial Classic ed. 1965) (1885).

5. David L. Faigman et al., *Group to Individual (G2i) Inference in Scientific Expert Testimony*, 81 U. CHI. L. REV. 417, 420 (2014). We described the concept of G2i in that article as follows:

> [The] gap between conventional scientific practice and ordinary trial practice involves the challenge of reasoning from group data to decisions about individuals (an analytical process that we designate "G2i"). . . . [A]ll expert evidence, whether based on controlled experimental research or years of experience, presents G2i issues. Experts testify to such matters as the conditions likely to lead to false confessions, the indicia of schizophrenia, factors that contribute to eyewitness misidentification, the cancer-causing properties of benzene, and thousands more. These are all general—population-based—statements about the empirical world. They are the "G" of G2i and represent the ordinary perspective of most research and most expertise. However, in the courtroom, the operative questions pertain to the particular case at hand, the "i" of G2i: Did the suspect falsely confess? Does the defendant have schizophrenia? Was the eyewitness's identification accurate? Did benzene cause the plaintiff's leukemia?

Id; *see also infra* notes 113–114 and accompanying text.

prove that Bendectin caused birth defects in some women who took it during pregnancy to relieve extreme morning sickness.[6] At trial, in contrast, courts must determine whether a particular case is an instance of the general phenomenon of interest. Thus, in *Daubert*, the operative question was whether Jason Daubert's birth defects were caused by his mother's ingestion of Bendectin. The challenges of reasoning from group scientific data to an individual person in cases like *Daubert* appears to resemble what physicians must do in their daily practice. In medicine, reasoning from G2i is ordinarily accomplished via a methodology known as "differential diagnosis." The conventional medical understanding of this method, however, does not fully map onto the law's needs. What is usually needed in court is not a diagnosis of illness, but rather a diagnosis of what *caused* that illness.

Physicians, like courts, must routinely make judgments about individual people based on general research. Indeed, the entire "evidence-based medicine" movement can be understood as an attempt to systematize and improve G2i.[7] Moreover, medical experts regularly testify in court regarding both general research findings and their application to individual cases. Thus, in daily medical practice, a doctor might recommend that a patient take an anticoagulant despite the heightened risk of hemorrhagic stroke associated with such drugs. In a subsequent civil suit against the drug's manufacturer, in which the patient is now the plaintiff, medical experts might be asked to describe the scientifically established association between anticoagulants and stroke, and then to opine on whether the plaintiff's stroke was caused by the defendant's anticoagulant. While the physician's advice to the patient was part of ordinary medical practice and hopefully evidence-based, the courtroom testimony about causation is not a common part of medical training. In effect, what is needed for the use of scientific data in the courtroom is a theory of "evidence-based scientific evidence."

The basic lesson of evidence-based medicine can be found in the essential sensibilities of the Supreme Court's decision in *Daubert*. The *Daubert* Court held that Rule 702 of the Federal Rules of Evidence requires judges to be scientific gatekeepers.[8] According to the Court, this function means that trial courts have to evaluate the validity of the methods and principles underlying scientific expertise.[9] In two

6. *Daubert*, 579 U.S. at 582–84.

7. For a good introduction to evidence-based medicine, see SHARON E. STRAUSS ET AL., EVIDENCE-BASED MEDICINE: HOW TO PRACTICE AND TEACH IT (4th ed. 2011).

8. *Daubert*, 579 U.S. at 597.

9. *Id.*

subsequent decisions, the Court ruled that this gatekeeping function is a principal responsibility of the trial court,[10] and extended the doctrine to all expert evidence, not just testimony labeled "scientific."[11] Since *Daubert* was decided, the debate has raged as to whether courts can manage the task.

Although *Daubert* employed the gatekeeping metaphor, courts had arguably operated as "gatekeepers" under the old rule established in *Frye v. United States*.[12] Under *Frye*, courts had to determine whether scientific evidence offered in court was generally accepted in its respective field.[13] Thus, the real revolution of *Daubert* involved the nature of the inquiry at the gate, not the existence of the gate. *Daubert* mandated judicial inspection of the premises of scientific opinion, whereas *Frye* required merely a survey of practitioners in the relevant field. Judges thus needed to develop some facility with scientific methods and, in time, begin to understand the logical structure of scientific inference. It turns out, however, that scientific inference is fundamentally at odds with the kinds of inference that are endemic to decision making in the courtroom. *Daubert* laid bare those differences.

The process of translating scientific knowledge for legal use requires some degree of scientific literacy and an understanding of the sum and substance of the law. We begin Part II by considering the issue of legal actors' scientific literacy, and consider *Daubert*'s implicit call for greater enlightenment among judges and lawyers. This Part considers at some length Judge Weinstein's views on the subject—which are not entirely in line with *Daubert*'s prescriptions—and his practice, which more nearly aligns with that decision. In Part III, we examine one application of scientific evidence—the matter of medical causation—and consider how confusion over terms and misapprehension of the underlying science has led to confusion. Judge Weinstein was an early leader in bringing a commonsense approach to the complex problem of making inferences across disciplines. Part IV proposes ways to bring greater clarity to the translational challenges presented in medical causation cases. This Part can only begin to map this complex issue, but gains much from the lessons of Judge Weinstein's jurisprudence in this area. Finally, in Part V, we offer concluding remarks.

10. General Elec. Co. v. Joiner, 522 U.S. 136, 142 (1997).

11. Kumho Tire Co. v. Carmichael, 526 U.S. 137, 138 (1999).

12. 293 F. 1013, 1014 (D.C. Cir. 1923).

13. *Id.*

II. The Need for Scientific Literacy

In *Jackson v. Pollion*,[14] Judge Richard Posner expressed considerable chagrin over the quality of scientific literacy displayed by the district judge, magistrate judge, and the lawyers involved in the case.[15] In particular, he criticized the magistrate and district judges for reaching the wrong conclusion about whether the plaintiff's failure to receive his hypertension medications for a brief period could have caused a serious medical condition.[16] Judge Posner commented that "[t]his lapse is worth noting because it is indicative of a widespread, and increasingly troublesome, discomfort among lawyers and judges confronted by a scientific or other technological issue. 'As a general matter, lawyers and science don't mix.'"[17] Judge Posner continued by noting that many of those with little proclivity toward math and science select law as a career: "Innumerable are the lawyers who explain that they picked law over a technical field because they have a 'math block'—'law students as a group, seem peculiarly averse to math and science.'"[18]

Yet, paradoxically, in *Daubert*, the Supreme Court adopted a test that, at least ostensibly, requires an understanding of science. Indeed, Chief Justice Rehnquist famously wrote separately in *Daubert* to express his concern that the majority opinion seemingly calls on judges to become "amateur scientists."[19] *Daubert*'s holding imposes on trial court judges the "daunting task" of evaluating the methods and principles underlying proffered expert opinion and determining whether they are more likely than not scientifically valid.[20] In fact, the four nonexclusive factors suggested by the Court to aid this determination are quintessentially scientifically based—adequate testing, peer review and publication, acceptable error rates, and agreement among other scientists in the field.[21] Although working scientists would employ a rather more robust set of evaluative factors, the four chosen by

14. 733 F.3d 786 (7th Cir. 2013).

15. *Id.* at 787.

16. *Id.*

17. *Id.* (quoting Peter Lee, *Patent Law and the Two Cultures*, 120 Yale L.J. 2, 4 (2010)).

18. *Id.* at 788 (quoting 1 David L. Faigman et al., Modern Scientific Evidence: Standards, Statistics, and Research Methods, at v (student ed. 2008)).

19. Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 601 (1993) (Rehnquist, C.J., concurring in part and dissenting in part); *see also* David L. Faigman, *Judges as "Amateur Scientists,"* 86 B.U. L. Rev. 1207, 1209 (2006) ("In the twenty-first century—and the sooner the better—judges have no choice but to become amateur scientists.").

20. Daubert v. Merrell Dow Pharm., Inc., 43 F.3d 1311, 1315 (9th Cir. 1995) ("Federal judges . . . face a far more complex and daunting task in a post-*Daubert* world than before.").

21. *See generally* 1 David L. Faigman et al., Modern Scientific Evidence: The Law and Science of Expert Testimony § 1 (2014).

the Court would be considered fairly standard considerations by most scientists.

A. The Meaning of Daubert

The basic outline of the requirements of the *Daubert* trilogy and Rule 702 are well-known and not controversial as listed. In the *Zyprexa* litigation,[22] Judge Weinstein helpfully summarized the basic criteria as follows:

> [A] gatekeeping function is conferred upon the district court by the Rules of Evidence. *Daubert*, and the guidelines set forth in Rule 104(a) . . ., suggest a preliminary determination that the testimony of experts expected to testify is or is not helpful to the trier of fact, reliable from an evidentiary standpoint, and relevant to the issues in the case. The method for determining the reliability of such testimony is within the discretion of the district court. It should make a suitable inquiry before reaching its determinations.[23]

The last line of this quote—that courts should make "a suitable inquiry"—of course permits considerable latitude. Some courts apply a strong form of *Daubert* and require a demonstrated scientific foundation for scientific and technical evidence.[24] Other courts employ a decidedly less rigorous application of the *Daubert* test.[25]

Indeed, following the quoted paragraph above, Judge Weinstein, taking his cue from the Second Circuit's fairly lax standards for admissibility of expert opinions, wrote as follows: "Since 'Rule 702 embodies a liberal standard of admissibility for expert opinions,' the assumption the court starts with is that a well-qualified expert's testimony is admissible."[26] Yet, the final sentence of the same paragraph states that "[t]he party who presents an expert bears the burden of

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22. *In re* Zyprexa Prods. Liab. Litig., 489 F. Supp. 2d 230 (E.D.N.Y. 2007).

23. *Id.* at 282 (citations omitted).

24. *See, e.g.*, Miller v. Pfizer, Inc., 196 F. Supp. 2d 1062, 1072–75 (D. Kan. 2002) (finding that the expert's hypothesis—that the drug Zoloft induces suicidal ideation—was testable, but had not been adequately tested); Andrew Jurs & Scott DeVito, *The Stricter Standard: An Empirical Assessment of* Daubert*'s Effect on Civil Defendants*, 62 CATH. U. L. REV. 675, 686 (2013).

25. *See, e.g.*, Milward v. Acuity Specialty Prods. Grp., Inc., 639 F.3d 11, 26 (1st Cir. 2011) (reversing the trial court's exclusion of the plaintiff's toxicology expert and ruling that the lower court had applied *Daubert* too rigorously).

26. *In re Zyprexa*, 489 F. Supp. 2d at 282 (citation omitted) (quoting Nimely v. City of New York, 414 F.3d 381, 395–96 (2d Cir. 2005)). In *Falise v. American Tobacco Co.*, Judge Weinstein refused to overanalyze proffered expert testimony, commenting as follows:

> Too nitpicking an approach to find reasons to exclude expert testimony from distinguished scientists will tend to drive the best of them out of the courtroom. The greatest danger to the courts is not the incompetent who will testify for pay, but our failure to encourage sound scientists to assist the law.

107 F. Supp. 2d 200, 205 (E.D.N.Y. 2000).

proving each element necessary to the admissibility of that expert's testimony and report."[27]

This paragraph thus juxtaposes what appear to be two contrary principles. The first, a mainstay of Second Circuit case law, is the assertion that Rule 702 embodies a liberal standard of admissibility. This belief that *Daubert* and Rule 702 were meant to produce a more liberal standard of admissibility is not shared by all circuits or, for that matter, the Supreme Court. In fact, there is little in the *Daubert* trilogy to suggest that the Court itself believed that it was adopting a liberal rule of admissibility for expert testimony.[28] Despite throwaway lines in *Daubert* stating that the "basic standard of relevance" in the Federal Rules "is a liberal one,"[29] or the existence of allusions to the "austere standard" inherent in the traditional *Frye* approach,[30] the results in all three cases suggest otherwise. It can hardly be a coincidence that all three cases in the *Daubert* trilogy ultimately ended with the exclusion of the proffered expertise and summary disposition on the merits.[31] And in what might be considered the fourth case in the trilogy, *Weisgram v. Marley*,[32] the Court made plain its view that the gatekeeping responsibility was serious and substantive.[33]

In *Weisgram*, the trial court admitted the plaintiffs' expert testimony regarding the source of a fire that destroyed their home.[34] The jury ruled in favor of the plaintiffs.[35] On appeal, the Eighth Circuit held that the trial court had erred as a matter of law in admitting the plaintiffs' fire experts.[36] The appellate court then ruled that without this expert evidence, the plaintiffs had insufficient proof to support their case.[37] The appellate court directed a judgment in favor of the defendant.[38] The court thus refused to give the plaintiffs a "second bite at the apple" by remanding for further proceedings.[39] The *Weisgram* Court agreed that the plaintiffs should not be given a second

27. *In re Zyprexa*, 489 F. Supp. 2d at 282.

28. *See* David L. Faigman, *The* Daubert *Revolution and the Birth of Modernity: Managing Scientific Evidence in the Age of Science*, 46 U.C. DAVIS L. REV. 893 (2013) (reviewing the *Daubert* trilogy and a fourth case, *Weisgram v. Marley*, 528 U.S. 440 (2000), for clues as to the Supreme Court's own understanding of the import of *Daubert*).

29. Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 587 (1993).

30. *Id.* at 589.

31. *See* Faigman, *supra* note 28, at 925–26.

32. 528 U.S. 440 (2000).

33. *Id.* at 440–47.

34. *Id.* at 445.

35. *Id.*

36. *Id.*

37. *Id.*

38. *Weisgram*, 528 U.S. at 445.

39. *Id.* at 445–46.

chance to find admissible experts.[40] Justice Ginsburg, writing for the Court, stated:

> Since *Daubert* . . . parties relying on expert evidence have had notice of the *exacting standards of reliability such evidence must meet.* It is implausible to suggest, post-*Daubert*, that parties will initially present less than their *best expert evidence* in the expectation of a second chance should their first try fail. We therefore find unconvincing [the plaintiffs'] fears that allowing courts of appeals to direct the entry of judgment for defendants will punish plaintiffs who could have shored up their cases by other means had they known their expert testimony would be found inadmissible.[41]

In the hands of scientifically sophisticated judges such as Judge Weinstein, a test that provides significant latitude in application can be a powerful mechanism to do justice. It might allow, for instance, leniency in civil cases when either the law is unfair or the science is not of the highest order. It might additionally allow for severity in criminal cases when the forensic labs are sloppy or unaccredited, or when the experts claim more in their testimony than the science can prove.

However, in the hands of scientifically unsophisticated judges, a test that provides significant latitude in application can lead to injustice and the perpetuation of the status quo. As some commentators have observed, for example, *Daubert* seems to have been applied with more bite in civil cases against plaintiffs than it has in criminal cases against prosecutors.[42] Whether this apparent phenomenon is a consequence of judges' ideological bent favoring prosecutorial expert evidence or the relatively poorer *Daubert* challenges mounted by criminal defense counsel has yet to be determined with any certainty by research. It seems clear, however, that on balance, *Daubert*'s gatekeeping mandate has been carried out more rigorously in civil cases, to the disadvantage of plaintiffs, and less so in criminal cases, to the advantage of prosecutors.[43]

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40. *Id.* at 456.

41. *Id.* at 455–56 (emphasis added) (footnote omitted) (citations omitted).

42. This appears to be the general view among academic writers. *See generally* Elizabeth L. DeCoux, *The Admission of Unreliable Expert Testimony Offered by the Prosecution: What's Wrong with* Daubert *and How To Make It Right,* 2007 UTAH L. REV. 131; Jennifer L. Groscup et al., *The Effects of* Daubert *on the Admissibility of Expert Testimony in State and Federal Criminal Cases*, 8 PSYCHOL., PUB. POL'Y & L. 339 (2002); Wes R. Porter, *Repeating, yet Evading Review: Admitting Reliable Expert Testimony in Criminal Cases Still Depends on Who Is Asking*, 36 RUTGERS L. REC. 48 (2009); D. Michael Risinger, *Navigating Expert Reliability: Are Criminal Standards of Certainty Being Left on the Dock?*, 64 ALB. L. REV. 99 (2000); Donald E. Shelton, *Forensic Science Evidence and Judicial Bias in Criminal Cases*, JUDGES' J., Summer 2010, at 18.

43. Of course, another explanation for the differential impact of *Daubert* in the civil and criminal arenas is that plaintiffs are more prone to proffer bad science than prosecutors. While there is undoubtedly little shortage of bad science peddled by plaintiffs, much of the forensic identifi-

B. Understanding Science

That judges have to know something about science in order to do their jobs appears to be a first principle for Judge Weinstein. Although referring to nonjury trials, Judge Weinstein observed seven years before *Daubert* that judges should "become familiar with the scientific background by reading about the issues and discussing them with the experts."[44] Indeed, he emphasized that "[t]he court owes an obligation to the parties, to society, and to itself in obtaining the best possible answers to the scientific questions before it."[45]

Judge Weinstein is realistic, however, and well understands the limits of judges' knowledge of science and that they, and their juries, might sometimes need more than the parties do, or can, provide. Indeed, in a variety of different contexts, Judge Weinstein wrote approvingly of the value of "neutral" experts. In a 1998 law review article, for example, Judge Weinstein described how he had presided over a case involving a child's brain injuries allegedly caused by administration of the whole-cell pertussis vaccine.[46] The defense made use of highly competent and well-qualified experts, whereas the plaintiff called a scientist that was "borderline, under *Daubert*, in terms of expert credentials."[47] Judge Weinstein explained that the plaintiff's expert "had the proper degrees and had done some research, but he had published nothing on the subject and had entered the field at the request of [the] plaintiff's attorney."[48] The jury found for the plaintiff, but Judge Weinstein set aside the verdict as not supported by the evidence.[49] He lamented this shortage of proof: "[I]t was somewhat disquieting not to be able to reach out to the scientific community to obtain an expert who could testify as a 'neutral authority' in court."[50]

Judge Weinstein has not hesitated to take his own advice.[51] In an opinion that perhaps best illustrates Judge Weinstein's commitment to

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cation science introduced by prosecution experts, other than DNA, has suspect scientific bases. *See National Research Council's Publication "Strengthening Forensic Science in the United States: A Path Forward": Hearing Before the Subcomm. on Crime, Terrorism & Homeland Sec. of the Comm. on the Judiciary*, 111th Cong. 1–2 (2009).

44. Jack B. Weinstein, *Improving Expert Testimony*, 20 U. RICH. L. REV. 473, 494 (1986).

45. *Id.* at 495.

46. Jack B. Weinstein, *Science, and the Challenges of Expert Testimony in the Courtroom*, 77 OR. L. REV. 1005, 1009–10 (1998).

47. *Id.* at 1009.

48. *Id.*

49. *Id.* He explained the verdict for the plaintiff as a consequence of the "compelling" nature of the case, which involved a "profoundly disabled child." *Id.*

50. *Id*.

51. *See, e.g.*, United States v. D.M., 942 F. Supp. 2d 327, 335 (E.D.N.Y. 2013) ("The authority to appoint expert witnesses is underutilized in contemporary litigation.").

doing the most he could to get the science right, he appointed two experts to assist him explore the statistical reasoning that might inform a sentencing decision for drug running.[52] In the truly remarkable opinion of *United States v. Shonubi*,[53] Judge Weinstein set forth in extraordinary detail a reasoning process that is "rigidly accurate in observation, and merciless to fallacy in logic."[54] Nonetheless, the Second Circuit disagreed and reversed one of the great exegeses in contemporary law and statistical inference.[55]

Another particularly useful idea in the 1998 article, among many important ones, was Judge Weinstein's suggestion of bringing experts' testimony in the courtroom to the greater attention of those experts' respective professional communities.[56] Such a course would bring a sort of professional peer review to expert testimony.[57] He believed that "the publication of expert testimony, or synopses of such testimony, in professional journals" might bring a needed mainstream scientific perspective to the courtroom.[58] Judge Weinstein explained,

> We have often touted the advantages of our system of public trials, in which witnesses appear in open court. As a practical matter, however, there are rarely more than a few spectators in the courtroom. Most scientists do not have time to become legal buffs, hanging out at the local courthouse waiting for trials involving scientific evidence to unfold. Publication would be a means of bringing expert testimony to the attention of those who are in a position to evaluate it.[59]

This suggestion anticipates Justice Breyer's often-quoted statement in *Kumho Tire Co. v. Carmichael*,[60] decided one year later, in which he explained that a primary purpose of the *Daubert* gatekeeping re-

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52. *United States v. Shonubi*, 895 F. Supp. 460, 468 (E.D.N.Y. 1995), *vacated*, 103 F.3d 1085 (2d Cir. 1997).

53. 895 F. Supp. 460.

54. THOMAS H. HUXLEY, THE CRAYFISH: AN INTRODUCTION TO THE STUDY OF ZOOLOGY 2 (1880).

55. *Shonubi*, 103 F.3d at 1092–93.

> Judge Weinstein considered this case to be "an opportunity to observe, explain, and discuss forensic decision-making," an opportunity he seized with his customary thoroughness and erudition. Though his comprehensive opinion is a valuable addition to the legal literature on the subject of evidence in particular and judicial decision-making in general, we conclude that he relied on evidence beyond the category of "specific evidence" that our prior opinion ruled was required for determination of a "relevant conduct" drug quantity for purposes of imposing a criminal sentence.

Id. (citations omitted) (quoting *Shonubi*, 895 F. Supp. at 464).

56. Weinstein, *supra* note 46, at 1011–12.

57. *Id*.

58. *Id.* at 1011.

59. *Id.*

60. 526 U.S. 137 (1999).

quirement "is to make certain that an expert, whether basing testimony upon professional studies or personal experience, employs in the courtroom the same level of intellectual rigor that characterizes the practice of an expert in the relevant field."[61] Judge Weinstein's publication idea provides a concrete way to achieve Justice Breyer's injunction. Although such an effort would have been unrealistic in 1998 as a practical matter, contemporary technology makes such an insight feasible.[62]

In 1991, Judge Weinstein gave a speech at the Eighth Circuit Judicial Conference, later published under the title *Rule 702 of the Federal Rules of Evidence Is Sound; It Should Not Be Amended*.[63] In it, as is true of so much of his work, the reader feels the deeply layered folds of the Judge's thought processes. In his writing, Judge Weinstein walks along an intellectual path of discovery and the reader has the distinct pleasure of accompanying him on the journey as the judge points out important landmarks along the way. And he is rigorously evenhanded. For instance, he maintains, on the one hand, that "the vast bulk of cases in our courtrooms involve experts who testify sensibly and truthfully."[64] Yet, he observes, on the other hand, that "[w]e would not allow what modern consensus tells us is not credible."[65] Testimony that witches or ghosts exist, or that the world is flat, falls obviously into this category. But, Judge Weinstein states, some "would put in this same category harm from Bendectin [or] electromagnetic waves of nearby power lines."[66] He then asks the pivotal question: "What is the role of the judge? Is it active or passive?"[67]

It is here that we somewhat disagree with Judge Weinstein's stated views[68]—or, at least, his views circa 1991. His inclination is to limit

61. *Id.* at 152.

62. Partly on the basis of Judge Weinstein's suggestion here, one of the authors, David L. Faigman, has recently cofounded a company and website dedicated to the idea of bringing professional peer review to expert testimony. *See* JURILYTICS, http://www.jurilytics.com/, last visited Mar. 27, 2015.

63. Jack B. Weinstein, *Rule 702 of the Federal Rules of Evidence Is Sound; It Should Not Be Amended*, 138 F.R.D. 631 (1991) [hereinafter *Weinstein Speech*].

64. *Id.* at 638.

65. *Id.* at 632.

66. *Id.*

67. *Id.*

68. We hasten to add that one of Judge Weinstein's most admirable characteristics is that he does not expect that everyone will agree with him. Indeed, in noting that his views in his speech did not align with several illustrious members of the Advisory Committee on Civil Rules, Judge Weinstein observed that "[w]e are dealing here with judgments about how the United States adversarial system should operate in view of its history and such fundamental constitutional controls as the right to a jury trial. As to these matters, reasonable members of the legal profession will differ in good faith." *Id.* at 634.

judicial management of experts and rely instead "primarily upon lawyer-adversaries and sensible triers of fact to evaluate conflicts."[69] Our disagreement, as discussed in the next section, is more a matter of degree than kind. Indeed, it might be said to be a difference of emphasis, or of presumptive burdens of proof, than any disagreement we might have with his analysis of the issue of expert testimony.

C. The Need for Daubert

As the title of his speech at the Eighth Circuit Judicial Conference indicates, Judge Weinstein was considering the wisdom of a proposed amendment to Rule 702.[70] Of historical note, although that amendment was never adopted, the *Daubert* Court essentially adopted its key provisions as within the meaning of the then-existing Rule 702.[71] In particular, the proposed rule would have added a "reliability" requirement, which was seemingly absent from the existing Rule 702. In *Daubert*, of course, the Court found reliability to be a central feature of Rule 702, finding that the rule's "overarching subject is the scientific validity—and thus the evidentiary relevance and reliability—of the principles that underlie a proposed submission."[72]

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69. *Weinstein Speech*, *supra* note 63, at 631.

70. *Id.* In 1991, the proposed amendment to Rule 702 read as follows:

> If the court finds [1] (1) that reliable [2] scientific, technical, or other specialized information will substantially [3] assist the trier of fact to understand the evidence or to determine a fact in issue; and (2) that a witness is qualified [4] as an expert by knowledge, skill, experience, training, or education to provide such assistance, [5] it may permit [6] the witness to testify thereto in the form of an opinion or otherwise. Except with leave of court for good cause cause shown, the witness shall not testify on direct examination in any civil action to any opinion or inference or reason or basis therefore, that has not been seasonably disclosed as required under the proposed amendments to Rules 26(a)(2) and 26(e)(1) of the Federal Rules of Civil Procedure.

Id. at 636 (new text underlined).

71. Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 592–95 (1993). The further irony is that the *Daubert* Court expressly stated that "[w]e interpret the legislatively enacted Federal Rules of Evidence as we would any statute." *Id.* at 587. Yet, the Court essentially adopted the provisions of the proposed amendment and, moreover, Rule 702 was amended in 2000 to reflect the Court's decisions in *Daubert* and its progeny, *General Electric Co. v. Joiner*, 522 U.S. 136 (1997), and *Kumho Tire Co. v. Carmichael*, 526 U.S. 137 (1999). FED. R. EVID. 702 advisory committee's note. The current version of Rule 702 provides as follows:

> A witness who is qualified as an expert by knowledge, skill, experience, training, or education may testify in the form of an opinion or otherwise if:
>
> (a) the expert's scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue;
>
> (b) the testimony is based on sufficient facts or data;
>
> (c) the testimony is the product of reliable principles and methods; and
>
> (d) the expert has reliably applied the principles and methods to the facts of the case.

FED. R. EVID. 702.

72. *Daubert*, 509 U.S. at 594–95.

In 1991, Judge Weinstein doubted the wisdom of extending the trial court's responsibilities to evaluating reliability. He observed that "[t]he word 'reliable' emphasizes that the court must decide initially on reliability, greatly expanding the judicial role of today where the primary issue is whether a reasonable jury could find the testimony helpful and reliable."[73] Mostly, however, Judge Weinstein appeared to be concerned with the overformalization of the admissibility requirements, which he read the proposed amendment to do. He preferred a set of general nonbinding protocols that would produce "improvement in dealing with expert testimony without a change in Rule 702."[74] It is worth quoting this list at length, which is directed at changes courts could institute:

> A. Systemic Changes
>
> 1. Changes in rules dealing with pretrial conferences, easier discovery, etc.
>
> 2. Training of judges and others . . . .
>
> B. Changes in Judicial Practice Under Existing Rules.
>
> 1. Required exchange of data and expert reports well in advance of trial.
>
> 2. Meetings in advance of trial of opposing experts to agree on data bases and statistical analysis; advance meeting by the court with experts before trial to narrow disputed scientific issues and to limit the number of experts; limiting the testimony of experts to specific issues.
>
> 3. Notice of treatises and reports and assumptions on which the expert will testify.
>
> 4. Use of expert panels to mediate the differences among experts and to limit their areas of dispute.
>
> 5. Selection of jurors with backgrounds adequate to the task of evaluating complex evidence.
>
> 6. Detailed instructions by the judge during trial and at its end; use of intermediate summations; use of notes and notebooks by juries; sending copies of experts' reports to juries; encouraging use of general education witnesses for the judge before trial and for juries during trial without cross-examination or with colloquy among experts, counsel and the judge; use of Rule 706 experts and panels.
>
> 7. Sanctions for abuse by experts including exclusion from future trials of experts who improperly exploit their role, contempt and referral to a certifying agency or professional society; exclusion of experts or parts of their testimony.
>
> 8. Questions and clarifying comments by the judge during trial; tight reins by judges on experts who make speeches on cross-examination; joint testimony of opposing experts; voir dire by opponents

73. *Weinstein Speech*, *supra* note 63, at 636.
74. *Id.* at 639.

> and judge before trial or at least before testimony; limiting and defining issues; and so on.[75]

Two observations might be offered regarding these proposed recommendations. First, to the extent that some of them have been broadly implemented since 1991, these reforms are most likely attributable to *Daubert*'s enlistment of the "reliability" requirements as pivotal to the operation of Rule 702. Expanded discovery, pretrial hearings, judicial education, and increased focus on the substance of expert testimony are all largely attributable to the revolution in perspective wrought by *Daubert*. Second, to the extent that courts have failed to implement certain changes in practice, such as increased use of court-appointed scientific panels or greater judicial management of expert witnesses, they have failed to realize the promise of *Daubert*. What seems abundantly clear is that Judge Weinstein was far ahead of the curve on the reforms *Daubert* brought about and, indeed, is far ahead on the reforms yet to be adopted by the vast majority of federal courts.

Of course, any blanket statements about the scientific illiteracy of the legal profession are inevitably overly broad and many exceptions might be found, with Judge Weinstein being an exemplary instance. Nonetheless, the general state of affairs with regard to the law's understanding of the methods of science creates substantial obstacles to the coherent use of empirical knowledge gleaned from complex research studies. Ultimately, any effective translation of scientific knowledge for legal use requires a sophisticated understanding of both methods and principles underlying that knowledge and the uses to which it will be put in legal disputes. The challenges of translating science for legal use arise across the entire law and science frontier. In the next Part, we consider a particularly telling example of these challenges: the issue of reasoning from general research data in medicine to the issue of causation in an individual legal case.

III. The Etymology of Differential Etiology

The basic orientation of scientists is to study the empirical world in order to generalize about phenomena of interest. Hence, scientists might research the parts of the brain associated with lying, or identify factors that interfere with eyewitness identification, or examine the toxic effects of benzene. In contrast, the basic orientation of participants in the courtroom is to determine whether a particular case is an instance of some general phenomenon. Therefore, courts might have

75. *Id.* at 639–40.

to resolve whether the defendant's brain images indicate lying, or that an eyewitness' identification was inaccurate, or that the plaintiff's leukemia was caused by exposure to benzene. Inherent at the intersection of science and law lies the basic challenge that science begins—and often ends—with general probabilistic statements about phenomena, whereas courts need to make categorical judgments respecting whether a particular case is an instance of some phenomenon. This is the problem of reasoning from group data to individual cases, or G2i.[76]

A. Reasoning from Group Data to Individual Decisions (G2i)

The G2i problem is not specific to the courtroom. Indeed, it is an aspect of all applied science. Thus, clinical medicine, in particular when it is evidence-based, is a form of G2i. For example, if someone arrives at the emergency department of a hospital with chest pains, doctors will need to determine whether she is suffering from acute coronary ischemia or nonischemic chest pain.[77] This determination is essential for treatment. For example, the former benefits from hospitalization, but the latter does not.[78] In general, this process of identifying the patient's condition or illness is known as differential diagnosis.[79] The basic idea is to identify all of the possible alternatives, ruling out as many as possible, with the objective of identifying the one true condition or illness.[80]

Many other areas of applied science, of course, operate similarly, including such widely varying domains as meteorology, ecology, geophysics, psychology, and psychiatry. In each of these domains, research informs such general phenomena as hurricanes, extinctions,

76. Faigman et al., *supra* note 5, at 420.

77. THOMAS B. NEWMAN & MICHAEL A. KOHN, EVIDENCE-BASED DIAGNOSIS 3 (2009).

78. *Id.*

79. *Id*. "Ischemia" is a condition that involves "a decreased supply of oxygenated blood to a body part." MOSBY'S DICTIONARY OF MEDICINE, NURSING & HEALTH PROFESSIONS 965 (9th ed. 2013). A heart attack occurs when the flow oxygenated blood to the heart is blocked. A heart attack can be fatal and requires immediate hospitalization. *Heart Attack: Definition*, MAYO CLINIC (Nov. 15, 2014), http://www.mayoclinic.org/diseases-conditions/heart-attack/basics/definition/con-20019520. "Nonischemic chest pain" is a category which encompasses any chest pain that is not caused by the obstruction of oxygenated blood to the heart, and thus may not require hospitalization. *See* JOYCE E. DAINS ET AL., ADVANCED HEALTH ASSESSMENT AND CLINICAL DIAGNOSIS IN PRIMARY CARE 81 (4th ed. 2012) ("A significant proportion of patients whose presenting symptoms include acute chest pain have esophageal spasm or gastroesophageal reflux disease (GERD); however, harmless conditions can mimic more serious disease.").

80. *See generally* MOSBY'S DICTIONARY OF MEDICINE, NURSING & HEALTH PROFESSIONS, *supra* note 79, at 533 ("Differential diagnosis" is defined as "the distinguishing between two or more diseases with similar symptoms by systematically comparing their signs and symptoms.").

earthquakes, acts of domestic violence, and mental illnesses. And for all of these phenomena, determining individual instances might be highly relevant to a legal or policy decision, such as evacuating a coastal community ahead of a hurricane, protecting an endangered species from extinction, warning a region about a seismic event, protecting children from pedophiles, or civilly committing dangerous individuals. The G2i challenge is thus endemic to the enterprise of applied science and is present in any domain that relies on general data to make decisions in individual cases.

However, the G2i problem sometimes manifests quite differently when it is applied across disciplines. For instance, in many—but certainly not all—medical contexts, G2i is a matter of differential *diagnosis*, not *etiology*. The operative question for a doctor is often what is the plaintiff's condition (e.g., ischemic or nonischemic), not what caused it.[81] Many other applied disciplines also operate by identifying conditions or correlates without knowing etiology. Predictions regarding a defendant's likelihood of violence might depend on knowledge of the person's past offenses, her drug addiction, marital status, and other factors, without any model regarding the mechanics of how these variables relate to the increased risk of violence.[82] Similarly, psychiatrists might be able to diagnose and treat a person as schizophrenic without knowing the illness' cause or even its biological mechanism.

The G2i problem in the law turns out to be highly diverse and, in many contexts, a moving target. In regard to the diagnosis versus etiology issue, the law sometimes makes relevant one and sometimes the other. In civil litigation, etiology is usually the operative question in cases such as products liability, toxic torts, and medical malpractice.[83] In most of these sorts of cases, the substantive law requires proof of

81. NEWMAN & KOHN, *supra* note 77, at 2 ("[E]ntities with different etiologies or different pathologies may have the same treatment. If the goal is to make decisions about treatment, the etiology or pathology may be irrelevant.").

82. *See* Helena Chmura Kraemer et al., *Coming to Terms with the Terms of Risk,* 54 ARCHIVES GEN. PSYCHIATRY 337 (1997). To call a variable a risk factor does not imply that its relationship to the outcome is "causal."

83. *See, e.g.*, *In re* "Agent Orange" Prod. Liab. Litig., 597 F. Supp. 740, 782 (E.D.N.Y. 1984) ("The critical problem for the plaintiffs to establish is that the relatively small quantities of dioxin to which servicepersons were exposed in Vietnam caused their present disabilities."); *In re* Zyprexa Prods. Liab. Litig., Nos. 04-MD-1596, 06-CV-1729, 2007 WL 1580083, at *1 (E.D.N.Y. May 30, 2007) (severing a plaintiff's causation claim from otherwise consolidated cases for trial to avoid confusing the jury); Falise v. Am. Tobacco Co., 258 F. Supp. 2d 63, 65 (E.D.N.Y. 2000) ("The trial court is not called upon to analyze in great detail the proposed testimony of an expert as part of the *Daubert* hearing—although at times it may be useful to do so as in connection with problems of proving general causation in the first cases on the subject of harm caused by a pharmaceutical product.").

causation. Conversely, in some civil cases, especially those that are quasi-criminal, as well as in most criminal contexts, diagnosis rather than causation is the legally relevant issue. Legal relevance in these cases—which typically concern concepts such as mental illness or abnormality, likelihood of violence, or intellectual disability—does not depend on etiology. For example, a capital defendant who is found to be "intellectually disabled" is exempt from the death penalty, whatever the original cause of that condition.[84]

In summary, then, the concept of G2i is endemic in the enterprise of applied science and is inevitably present when science is applied in the courtroom. In many medical and psychiatric contexts, for example, the reasoning process of G2i serves treatment purposes, and knowledge of etiology may not be necessary or possible. Knowing, for instance, what caused the patient's lung cancer is not necessary for treatment. In other medical contexts, however, knowledge of causation might be essential to treatment and, moreover, within the profession's ability to determine. Allergists, for example, attempt to identify the etiology of allergic reactions in order to treat them (or to advise the patient to avoid what caused them), though it might still be possible to treat the allergic reactions without knowing their etiology. Similarly, the law sometimes calls for proof of etiology and sometimes it does not. Very often, proving etiology is not necessary, because merely being diagnosed with a condition might be legally relevant. Under many civil commitment statutes, the State must prove that the defendant is "mentally ill."[85] A diagnosis of schizophrenia in such a case is sufficient to meet this requirement, and there is no expectation that the cause of the schizophrenia must be determined or is otherwise

84. Hall v. Florida, 134 S. Ct. 1986, 1988 (2014). It is worth noting, however, that the diagnosis requires that the condition manifest prior to the age of eighteen. *Id.* So, at least under current Supreme Court precedent, someone who becomes intellectually disabled after the age of eighteen—by accident or disease—is not per se exempt, though she might have both an Eighth Amendment and an Equal Protection claim for such a result. *See id.* at 2003.

85. *See* Francis S. v. Stone, 221 F.3d 100, 101–02 (2d Cir. 2000) ("New York statutes, like those of other states, distinguish between the procedures to be followed for the involuntary civil commitment of persons suffering from mental illness and the procedures that apply to persons charged with a crime and determined, by a plea or a verdict, to be 'not responsible by reason of mental disease or defect.'"). *See generally* Foucha v. Louisiana, 504 U.S. 71, 78 (1992) ("[K]eeping [the defendant] against his will in a mental institution is improper absent a determination in civil commitment proceedings of current mental illness and dangerousness."). *But see* Kansas v. Hendricks, 521 U.S. 346, 359 (1997) ("Contrary to [the defendant's] assertion, the term 'mental illness' is devoid of any talismanic significance. Not only do 'psychiatrists disagree widely and frequently on what constitutes mental illness,' but the Court itself has used a variety of expressions to describe the mental condition of those properly subject to civil confinement.") (quoting Ake v. Oklahoma, 470 U.S. 68, 81 (1985)).

relevant.[86] In other legal contexts, however, causation is the operative issue under the substantive law. Hence, in a lawsuit claiming that the defendant's drug caused the plaintiff's diabetes, causation is at the heart of the matter.[87] As this summary suggests, then, G2i is a concept endemic to applied science and might involve reasoning from group data to diagnosis or from group data to etiology. In the law, sometimes only an inference of diagnosis is necessary, while sometimes an inference of causation is required. The substantive law usually sets forth the necessary level of proof. The problem occurs when the language used, and the concepts involved, are muddled as scientific evidence crosses these domain boundaries. As the next section documents, this is exactly what has occurred in the areas of medical diagnosis and medical causation. Thus, it should be imperative that when G2i issues cross domain boundaries, everyone—i.e., judges, lawyers, and scientists—should be clear on their meaning and relevance.

B. Some Historical Perspective

A search of the WestlawNext database indicates that the first time a court used the term "differential etiology" in a published opinion was in the 1995 case *McCullock v. H.B. Fuller Co*.[88] This term, however, appears to be an invention of the *McCullock* court, or perhaps of the expert who appeared at trial.[89] Differential etiology was apparently a revision of the commonly used term "differential diagnosis," the accepted methodology for identifying a patient's disease or injury by comparing her symptoms with the symptoms of similar diseases or injuries. According to *Stedman's Medical Dictionary*, differential diagnosis is defined as the "the determination of which of two or more diseases with similar symptoms is the one from which the patient is

86. *Cf.* Yu-Wen Lu v. Unum Grp., No. 09–cv–03080 RMW, 2012 WL 44636, at *4 (N.D. Cal. Jan. 9, 2012) ("The Plan defines 'mental illness' as 'a psychiatric or psychological condition regardless of cause such as schizophrenia, depression, manic depressive or bipolar illness, anxiety, personality disorders and/or adjustment disorders or other conditions.'").

87. *See, e.g.*, Guinn v. AstraZeneca Pharm. LP, 602 F.3d 1245, 1254 (11th Cir. 2010) ("The district court did not abuse its discretion by finding that [the expert's] differential diagnosis was unreliable under *Daubert* because she failed to adequately consider possible alternative causes of [the plaintiff's] weight gain and diabetes.").

88. 61 F.3d 1038, 1043 (2d Cir. 1995).

89. The first mention of "differential etiology" in the opinion implies that the expert described his methodology in these terms: "[The defendant] disputes that the method [Dr. David] Fagelson used to come to his medical conclusion, 'differential etiology,' qualifies as scientific under *Daubert*." *Id.* at 1043. Moreover, our searches of medical and scientific databases, including popular websites such as Wikipedia, failed to identify any regular use of the term "differential etiology" as a term of art.

suffering by a systematic comparison and contrasting of the clinical findings."[90]

Prior to 1995, courts regularly employed the medical term "differential diagnosis" in their evaluations of proffered medical testimony. Indeed, differential diagnosis was used as early as 1940 in its medical sense to identify the plaintiff's disease.[91] However, in the 1980s, the idea that differential diagnosis might be used to explain not just the identification of the illness but also its cause began to creep into court decisions. In a 1982 case out of the Eastern District of New York, for example, Judge George C. Pratt noted that the plaintiff's expert had relied on a differential diagnosis to "rule[ ] out other possible causes" in support of his conclusion that the likelihood that the plaintiff's "optic neuritis was caused by the swine flu vaccine exceeds 90%."[92] The court ultimately excluded this testimony, finding that it was based on little more than temporal proximity between the vaccine and the onset of symptoms.[93] Through the 1980s, courts continued to employ the term "differential diagnosis," primarily to designate its medical sense, but increasingly to also include the identification of the cause of some illness. This trend continued into the 1990s, and then exploded following the Court's decision in *Daubert* in 1993. This section traces some of this history, or the etymology of, the term "differential etiology."

C. Inventing "Differential Etiology"

Although *McCullock* appears to be the first published case to use the term differential etiology to distinguish it from the medical meaning of differential diagnosis, the court paid it little attention. The court made no effort to define the term and, indeed, was likely entirely unaware of the term's significance. The court stated that the expert "based his opinion on a range of factors," including "differential etiology," but did nothing more than list them *seriatim*.[94]

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90. STEDMAN'S MEDICAL DICTIONARY 531 (28th ed. 2006).

91. Phoenix Mut. Life Ins. Co. of Hartford, Conn. v. Harmegnies, 110 F.2d 20, 26 (8th Cir. 1940).

92. Grill v. United States, 552 F. Supp. 505, 507 (E.D.N.Y. 1982).

93. *Id.* at 510.

94. McCullock v. H.B. Fuller Co., 61 F.3d 1038, 1044 (2d Cir. 1995). According to the *McCullock* court:

> [The expert] based his opinion on a range of factors, including his care and treatment of McCullock; her medical history. . . ; pathological studies; review of Fuller's MSDS; his training and experience; use of a scientific analysis known as differential etiology (which requires listing possible causes, then eliminating all causes but one); and reference to various scientific and medical treatises.

Id.

Following *McCullock*, the term "differential etiology" began to appear more regularly in court decisions, often with perfunctory citations to *McCullock* itself.[95] However, courts tended to use differential etiology and differential diagnosis interchangeably. For example, the Fourth Circuit, in *Westberry v. Gislaved Gummi AB*,[96] stated that "[d]ifferential diagnosis, or differential etiology, is a standard scientific technique of identifying the cause of a medical problem by eliminating the likely causes until the most probable one is isolated."[97] The court then went on to define differential *diagnosis* as a process of identifying "the possible *causes* for the patient's symptoms and then eliminating each of these potential causes until reaching one that cannot be ruled out."[98] Yet, the *Westberry* court cited a Third Circuit case for support, which had defined the accepted medical meaning of differential *diagnosis*, which involves determining "which of two or more diseases with similar symptoms is the one from which the patient is suffering."[99] In the same citation string, the *Westberry* court also cited *McCullock*'s approval of differential *etiology*. The *Westberry* court, however, did not cite any medical or scientific literature for the reliability and validity of differential etiology, presumably because none exists.[100] Instead, *Westberry* cited the Third Circuit case, which had relied on *Stedman's Medical Dictionary* to support the medical sense of differential diagnosis.[101] By confusing etiology with diagnosis, the court accepted the validity of the former because it equated it with the latter.[102]

This confusion of terms between the medically accepted method of differential diagnosis and the legally relevant issue of differential eti-

95. *See, e.g.*, Zuchowicz v. United States, 140 F.3d 381, 385 (2d Cir. 1998) ("[Dr. Mathay's] conclusion was based on the temporal relationship between the overdose and the start of the disease and the differential etiology method of excluding other possible causes."); Berk v. St. Vincent's Hosp. & Med. Ctr., 380 F. Supp. 2d 334, 354 (S.D.N.Y. 2005) ("[The medical expert] applied a methodology termed 'differential etiology' . . . to rule out causes of the plaintiff's illnesses other than one traceable to the defendants in that case." (citations omitted)).

96. 178 F.3d 257 (1999).

97. *Id.* at 262.

98. *Id.* (emphasis added).

99. Kannankeril v. Terminix Int'l Inc., 128 F.3d 802, 807 (3d Cir. 1997) (quoting STEDMAN'S MEDICAL DICTIONARY 428 (25th ed. 1990)).

100. Other courts have also failed to cite any medical or scientific literature for the reliability and validity of differential etiology. *See, e.g.*, Golod v. La Roche, 964 F. Supp. 841, 858 (S.D.N.Y. 1997); Haggerty v. Upjohn Co., 950 F. Supp. 1160, 1165–67 (S.D. Fla. 1996).

101. *Westberry*, 178 F.3d at 262 (citing to *Kannankeril*, 128 F.3d at 807).

102. *Id.* at 263 ("Thus, we hold that a reliable differential diagnosis provides a valid foundation for an expert opinion [on causation].").

ology plagues a multitude of judicial opinions.[103] Increasingly, however, courts are emphasizing the point that medical diagnosis and etiology are different concepts. For example, in *Hendrix v. Evenflo Co.*,[104] the court noted that "[a]lthough the parties and other cases often refer to this method as 'differential diagnosis,' throughout the opinion we will use the more precise term 'differential etiology.'"[105] Many other cases have similarly begun to make clear the distinction between medical diagnosis and etiology.[106]

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103. Hardyman v. Norfolk & W. Ry. Co., 243 F.3d 255, 260 (6th Cir. 2001) ("The Fourth Circuit recently addressed the differential diagnosis methodology in making a *Daubert* determination, stating: 'Differential diagnosis, or differential etiology, is a standard scientific technique of identifying the cause of a medical problem by eliminating the likely causes until the most probable one is isolated.'" (quoting *Westberry*, 178 F.3d at 262)); *see also* Cano v. Everest Minerals Corp., 362 F. Supp. 2d 814, 841 (W.D. Tex. 2005) ("Many cases involving issues of external causation have involved witnesses who testify to having arrived at an opinion on cause through a process of ruling out or eliminating other causes, a process frequently referred to by the courts and witnesses as 'differential diagnosis' or 'differential etiology' . . . . Not infrequently, this form of testimony is implicitly or explicitly offered to satisfy the applicable burden of proof on causation." (quoting FED. JUDICIAL CTR., REFERENCE MANUAL ON SCIENTIFIC EVIDENCE 470 n.112 (2d ed. 2000)); Smith v. Wyeth-Ayerst Labs. Co., 278 F. Supp. 2d 684, 692 (W.D.N.C. 2003) ("Differential diagnosis, or differential etiology, is a standard scientific technique of identifying the cause of a medical problem by eliminating the likely causes until the most probable one is isolated." (quoting *Westberry*, 178 F.3d at 262)); *Golod*, 964 F. Supp. at 858 (S.D.N.Y. 1997) ("Like the expert physician in *McCullock*, Drs. Barasch, Friedman and Oksman used a scientific analysis known as differential etiology or differential diagnosis to rule out other possible causes of Golod's injuries, leaving Tegison as the most likely etiologic agent. This methodology is accepted in this Circuit and other jurisdictions." (citations omitted)); Lytle v. Ford Motor Co., 696 N.E.2d 465, 476 (Ind. Ct. App. 1998) ("The intellectual and logical process of deductive reasoning that Peterson employed—which is formally known as differential diagnosis or differential etiology—is frequently used by experts in many fields to determine whether a product that could generally cause a type of injury was the cause in fact of a particular injury and is well recognized as a legitimate and scientifically valid methodology."); Boren v. Burlington N. & Santa Fe Ry. Co., 637 N.W.2d 910, 920 (Neb. Ct. App. 2002) ("Boren's medical experts based their opinions on what is known as differential diagnosis. Differential diagnosis, or differential etiology, is a standard scientific technique of identifying the cause of a medical problem by eliminating the likely causes until the most probable one is isolated." (citations omitted)).

For more examples of this confusion of terms, see Schultz v. Akzo Nobel Paints, LLC, 721 F.3d 426, 433 (7th Cir. 2013); Tingey v. Radionics, 193 F. App'x 747, 766–67 (10th Cir. 2006); Quirin v. Lorillard Tobacco Co., No. 13 C 2633, 2014 WL 716162, at *5 (N.D. Ill. Feb. 25, 2014); Zellars v. NexTech Ne., LLC, 895 F. Supp. 2d 734, 741–42 (E.D. Va. 2012); Wagoner v. Exxon Mobil Corp., 813 F. Supp. 2d 771 (E.D. La. 2011); Pritchard v. Dow Agro Scis., 705 F. Supp. 2d 471, 479 (W.D. Penn. 2010); *In re* Fosamax Prods. Liab. Litig., 645 F. Supp. 2d 164, 178–79 (S.D.N.Y. 2009); King v. Burlington N. Santa Fe Ry. Co., 746 N.W.2d 383, 391 (Neb. Ct. App. 2008); San Francisco v. Wendy's Int'l, Inc., 656 S.E.2d 485, 497 (W. Va. 2007).

104. Hendrix *ex rel.* G.P. v. Evenflo Co., 609 F.3d 1183 (11th Cir. 2010).

105. *Id.* at 1194 n.5.

106. *See, e.g.*, S. States Coop., Inc. v. Melick Aquafeeds, Inc., 701 F. Supp. 2d 1348, 1358 n.5 (M.D. Ga. 2010) ("The Court believes that the process that Dr. Davis used is defined as 'differential etiology.' Differential diagnosis leads to the diagnosis of a patient's condition, not necessarily the cause of the condition. In contrast, differential etiology is 'a term used on occasion by expert witnesses or courts to describe the investigation and reasoning that leads to the determi-

Although courts might be starting to understand the difference between the two terms, they have not seriously considered how the underlying methods and principles actually differ.[107] Thus, while the *Hendrix* court distinguished the two terms, it concluded summarily that "the differential etiology method can provide a valid basis for medical causation opinions."[108] *Hendrix* cited *McClain v. Metabolife International, Inc.*[109] for that proposition. However, *McClain* never analyzed the methodology of differential etiology; it merely distinguished it from the medical understanding of differential diagnosis.[110] Indeed, the *McClain* court ruled against the plaintiff on the ground that the general association between the claimed toxin and the plaintiff's illness had not been demonstrated.[111] The first step of any differ-

nation of external causation." (citations omitted)); King v. Burlington N. Santa Fe Ry. Co., 762 N.W.2d 24, 49–50 (Neb. 2009) ("We pause here to note that courts, including this court, have not always been careful to distinguish between differential diagnosis and differential etiology. But differential diagnosis refers to a physician's 'determination of which one of two or more diseases or conditions a patient is suffering from, by systematically comparing and contrasting their clinical findings.' In contrast, etiology refers to determining the causes of a disease or disorder." (footnotes omitted)); Jones v. CSX Transp., Inc., 54 Va. Cir. 341, 341 (2001) ("They claim to have used the concept of 'differential diagnosis' (more appropriately denoted 'differential etiology' as diagnosis refers to a determination of the disease or condition and etiology to its cause).").

107. In a trend worth noting, but which exceeds the scope of the present enterprise, courts have increasingly considered, and sometimes required, the use of a differential etiology in nonmedical contexts. In *Safrani v. Werner Co.*, an engineering expert witness used differential etiology to determine whether a design or manufacturing defect in the rivet of a six-foot aluminum ladder caused the plaintiff's fall and injuries. No. 95 Civ. 1267(LBS), 1997 WL 729110, at *1 (S.D.N.Y. Nov. 24, 1997). The court evaluated the sufficiency of the expert's methodology, and found that the expert had appropriately based his opinion on factors such as: (1) a review of the ladder and accident site; (2) his interview of the plaintiff; and (3) his research in the common failures of rivet joints. *Id.* In *Armeanu v. Bridgestone/Firestone North American Tire, LLC*, the court found that a tire analyst expert did not properly employ differential etiology in his causation analysis of the plaintiff's tire failure, because he did not eliminate a statistically significant number of potential causes. No. CIV 05-619 JB/DJS, 2006 WL 4060665, at *18 (D.N.M. Sept. 26, 2006). In *Southern States Coop., Inc. v. Melick Aquafeeds, Inc.*, the court found that a fish nutrition expert's testimony was admissible, even though the opponent contended that the expert did not properly employ differential etiology in his causation analysis. 476 F. App'x. 185, 188 (11th Cir. 2012). The court described "differential etiology" as "a process of elimination in which (1) an expert compiles all possible causes of an injury, . . . and (2) he rules out each of the potential causes 'until reaching one that cannot be ruled out or determining which of those that cannot be excluded is the most likely.'" *Id.* (citations omitted). The court found that the expert sufficiently evaluated each possible cause of the slowing of fish growth, and then ruled out each of the potential causes until he determined that the changes in feed was the most likely cause. *Id.*

108. *Hendrix*, 609 F.3d at 1195. It is worth noting that the *Hendrix* court went on to point out that what it believed to be a generally valid method had to be shown to have been applied reasonably to "the facts of this case." *Id.* Ultimately, however, the court affirmed the trial court's exclusion of the expert evidence on the basis that the plaintiff had failed to show general causation, thus obviating any need for a differential etiology. *Id.*

109. 401 F.3d 1233 (11th Cir. 2005).

110. *Id.* at 1252.

111. *Id.* at 1253.

ential etiology must be that the purported cause could have caused the claimed illness.[112] Only if the substance *could* cause the illness should the claimant be able to prove that it did so in a particular case.

IV. Toward an Epistemology of "Differential Etiology"

As is generally understood today, medical causation operates at the two levels of generality that constitute the G2i of all applied science. In such cases, the "G" of G2i is typically referred to as "general causation." In court, however, the question also arises as to whether a particular case is an instance of some general phenomenon.[113] This is the "i" of G2i. In medical causation cases, courts refer to this as "specific causation." Hence, general and specific causation are subcategories of G2i. In many scientific evidence contexts, of course, the legal issue is not causation; it might only be association (as with predictions of violence) or descriptive (as with psychiatric diagnoses, such as schizophrenia or bipolar disorder).[114] G2i, then, describes the general problem of reasoning from group data to an individual case, and medical causation (general and specific) is one aspect of it.

A. Describing Differential Etiology

In the context of medical causation, the concepts of general and specific causation constitute the two component parts of the necessary

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112. *See infra* notes 115–119 and accompanying text; *see also, e.g.*, Clausen v. M/V New Carissa, 339 F.3d 1049, 1057–58 (9th Cir. 2003); Black v. Food Lion, Inc., 171 F.3d 308, 314 (5th Cir. 1999).

113. In some cases, especially involving constitutional litigation, the only relevant issue will be the G of G2i. For example, in First Amendment cases involving legislative restrictions on violent video games, the issue concerned whether, as a general matter, the legislature's claim that such games led to increased violence in children was supported by research. There was no corresponding issue regarding any individual cases. The case was resolved at the general level of the research. *See* Brown v. Entm't Merchs. Ass'n, 131 S. Ct. 2729, 2739 (2011) (dismissing studies purporting to indicate a connection between exposure to violent video games and harmful effects on children because they merely "show at best some correlation between exposure to violent entertainment and minuscule real-world effects, such as children's feeling more aggressive or making louder noises in the few minutes after playing a violent game than after playing a nonviolent game").

114. Interestingly, a WestlawNext search of all federal cases for courts' use of these terms prior to *Daubert* identified only seventeen cases in which these terms were used substantively, and three of these were Judge Weinstein's opinions. The search term used was "general /5 causation & specific /5 causation," with a date limitation of prior to June 28, 1993. The three Judge Weinstein opinions were *In re "Agent Orange" Product Liability Litigation*, 611 F. Supp. 1396, 1408 (E.D.N.Y. 1985); *In re "Agent Orange" Product Liability Litigation*, 597 F. Supp. 740, 782–83 (E.D.N.Y. 1984); and *In re "Agent Orange" Product Liability Litigation*, 100 F.R.D. 718, 724 (E.D.N.Y. 1983).

proof.[115] General causation is demonstrated by sufficient empirical evidence to prove that the substance in question *can* cause the illness in question. Specific causation is demonstrated by sufficient empirical evidence to prove that the substance in question *did* cause the illness in question. Differential etiology is a methodology that courts have identified as a way to prove specific causation. Unfortunately, differential etiology is a legal term of art, not a scientific method.[116] Not surprisingly, then, it is well described but poorly defined.[117]

Courts and commentators have repeatedly described the basic concept behind differential etiology. As an initial matter, as noted above, the putative cause of the illness must be "ruled in" by sufficient proof; differential etiology is the process of ruling out other possible causes. In the Federal Judicial Center's *Reference Manual on Scientific Evidence*, Michael Green and colleagues described the term as follows:

> In a differential etiology, an expert first determines other known causes of the disease in question and then attempts to ascertain whether those competing causes can be "ruled out" as a cause of plaintiff's disease . . . . By ruling out (or ruling in) the possibility of other causes, the probability that a given agent was the cause of an individual's disease can be refined.[118]

As Green and colleagues observe, "the logic" of this methodology "is sound": "[e]liminating other known and competing causes increases the probability that a given individual's disease was caused by exposure to the agent."[119] However, therein lies the problem. Differential etiology is ostensibly a scientific methodology, but one not developed by, or even recognized by, physicians or scientists. As described, it is entirely logical, but has no scientific methods or principles underlying it. It is a legal invention and, as such, has analytical heft, but it is entirely bereft of empirical grounding. Courts and commentators have so far merely described the logic of differential etiology; they have yet to define what that methodology is.

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115. *See* Smith v. Gen. Motors Corp., 376 F. Supp. 2d 664, 667 (W.D. Va. 2005) (quoting JACK B. WEINSTEIN ET AL., WEINSTEIN'S FEDERAL EVIDENCE § 702.06 (2d ed. 2014) ("The issue of causation can be viewed in two parts, general causation and specific causation.")).

116. FED. JUDICIAL CTR., REFERENCE MANUAL ON SCIENTIFIC EVIDENCE 691 (3d ed. 2011) [hereinafter SCIENTIFIC EVIDENCE] ("[D]ifferential etiology is a legal invention not used by physicians.").

117. *See generally* Joseph Sanders & Julie Machal-Fulks, *The Admissibility of Differential Diagnosis Testimony To Prove Causation in Toxic Tort Cases: The Interplay of Adjective and Substantive Law*, LAW & CONTEMP. PROBS., Autumn 2001, at 107.

118. SCIENTIFIC EVIDENCE, *supra* note 116, at 617–18.

119. *Id.* at 617.

B. Toward a Definition of Differential Etiology

Differential etiology is a reasoning process that involves a multitude of factors, few of which are easily quantified. It is well recognized that an expert must first "rule in" the purported cause of the illness or condition.[120] However, in practice, the purported general cause might be strongly associated with the condition or weakly associated with the condition. Hence, an expert offering an opinion regarding a specific case must first consider the strength of the evidence for the general proposition being applied in the case. If the claim is that substance X caused the plaintiff's condition Y, the initial inquiry must concern the strength of the relationship between X and Y as a general proposition. For example, both second-hand smoke and first-hand smoke are associated with lung cancer, but the strength of the relationship generally is much stronger for the latter than it is for the former. The inquiry regarding the strength of the relationship will depend on many factors, including, among other things, the statistical strength of any claims and the quality of the methods used in the research. Additionally, the general model must consider the strength of the evidence for alternative possible causes of Y and the strength of their respective relationships (and possibly interactions with other factors). Again, the quality of the research and the different methodologies employed will make comparisons difficult. Complicating matters further regarding identification of potential causes of condition Y are the myriad of possible causes that have not been studied, or have not been studied adequately. Hence, determining the contours of the general model is a dicey affair in itself, because it requires combining disparate research results and discounting those results by an unknown factor associated with additional variables not yet studied. And this is just the first part of the necessary analysis if the expert wants to give an opinion about an individual case.

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120. In *Cavallo v. Star Enterprise*, the trial judge observed as follows:

> The process of differential diagnosis is undoubtedly important to the question of "specific causation." If other possible causes of an injury cannot be ruled out, or at least the probability of their contribution to causation minimized, then the "more likely than not" threshold for proving causation may not be met. But, it is also important to recognize that a fundamental assumption underlying this method is that the final, suspected "cause" remaining after this process of elimination must actually be *capable* of causing the injury. That is, the expert must "rule in" the suspected cause as well as "rule out" other possible causes. And, of course, expert opinion on this issue of "general causation" must be derived from a scientifically valid methodology.

892 F. Supp. 756, 771 (E.D. Va. 1995), *aff'd in part, rev'd in part*, 100 F.3d 1150, 1159 (4th Cir. 1996).

The second part of the analysis—the specific application of general propositions that are themselves supported by adequate research—requires two abilities, neither of which is clearly within most scientists' skill sets. The first, and perhaps less problematic, is that of forensic investigator. Almost no matter what the empirical relationship, whether medical or psychological, exposure or dosage levels will be relevant to the diagnosis. The first principle of toxicology is that "the dose makes the poison," because any substance in sufficient quantities could injure or kill someone. Similarly, in a wide variety of psychological contexts, the exposure or dose will be the poison. For instance, the degree of trauma affects diagnostic categorization between PTSD and adjustment disorder, the level of anxiety affects eyewitness identifications, the amount of sleep deprivation affects false confession rates, and so on. The expert testifying to specific causation must determine exposure and dosage levels for the suspected cause (i.e., the source suspected by the client), as well as for all other known or possible causes. This task is difficult enough alone, but is made enormously complicated by the significant potential for recall bias, given that the litigation will be profoundly affected by what is recalled.

The second skill set that is needed has not yet been invented or even described with precision. Somehow, the diagnostician must combine the surfeit of information concerning the multitude of factors that make up the general model, then combine it with the case history information known or suspected about the individual, and offer an opinion with some level of confidence that substance or experience X was the likely cause of condition Y. In practice, this opinion is usually stated as follows: "Within a reasonable degree of medical/psychological certainty, it is my opinion that X caused [a particular case of] Y." This expression has no empirical meaning and is simply a mantra repeated by experts for purposes of legal decision makers who similarly have no idea what it means.[121] But even less extreme versions of this statement—such as, "It is more likely true than not that this case is an instance of some general phenomenon"—are objectionable. Just how, for instance, would an eyewitness researcher determine that a witness was more likely than not inaccurate when the witness made a cross-racial identification of the defendant after seeing the unarmed perpetrator for five minutes under a streetlight from an unobstructed view twenty feet away from the crime? There are no data that would support psychologists' ability to make such statements, however modest

121. *See generally* Jeff L. Lewin, *The Genesis and Evolution of Legal Uncertainty About "Reasonable Medical Certainty,"* 57 MD. L. REV. 380 (1998); Robert D. Miller, *Reasonable Medical Certainty: A Rose by Any Other Name*, 34 J. PSYCHIATRY & L. 273, 278 (2006).

or innocuous they may appear. Experts' case-specific conclusions appear to be based largely on an admixture of an unknown combination of knowledge of the subject, experience over the years, commitment to the client or cause, intuition, and blind faith.

V. Conclusion

In this Article, we have considered many inconsistencies and ironies that lie along the border of law and science. In 1993, the Supreme Court adopted a scientific perspective in interpreting Federal Rule of Evidence 702, requiring judges to examine the methods and principles underlying proffered expert opinions. This mandate calls for judges, and the lawyers who practice before them, to be scientifically literate. Yet, even twenty years after *Daubert* brought the scientific revolution to the courtroom, lawyers and judges continue to struggle with the complexities of the methods and mathematics of science. This has made translating scientific findings into legal decisions a challenging affair.

Translating science for courtroom use is made inherently difficult because of a basic tension that exists between how scientists collect data about the world and how courts use those data. Scientists study phenomena with the goal of generalizing their results. In the courtroom, these phenomena have relevance to the extent that they inform about a particular case. Thus, scientists primarily study groups in order to identify generalizable phenomena, whereas courts are primarily interested in determining whether an individual case is an instance of some general phenomenon. This is the problem of G2i reasoning.

In the context of medical causation, G2i translation challenges have been particularly acute. In the practice of medicine, G2i is accomplished through the well-accepted methodology of differential diagnosis. Using this method, physicians use general data to identify what illness a person suffers from by ruling out as many alternatives as possible. In the courtroom, however, diagnosis of an illness is not ordinarily the operative question, but rather the identification of its etiology.

Initially, in the 1980s, courts used the term differential diagnosis to mean both identification of illness and its etiology. However, this is not the medical or scientific meaning of the term. Beginning in 1995, a new term arose—differential etiology—to describe the necessary methodology for identifying cause. However, differential etiology is a term invented by courts and was not used, or defined, by scientists. Indeed, though the logic of ruling out alternative causes is sound, courts and commentators have yet to define just how this method works. More problematic, scientists and statisticians have yet to do so

either. We offer a few tentative ideas on what such a method might look like, but much more needs to be done.

It is perhaps ironic that *Daubert* called upon courts to increase their scientific literacy, a call that has still gone largely unheeded. Yet, in the context of medical causation, courts have invented a methodology—differential etiology—that purports to resolve the G2i problem. Unfortunately, this method has only so far been described; it has not been defined with any precision. For now, it remains a highly ambiguous idea, sound in principle, but profoundly underdefined. Ultimately, however, courts are unlikely to have the wherewithal to do better in this regard than they have done so far. Courts will need the help of the scientific community if they are ever to do more than simply muddle through the G2i problem.