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Evidence Matters: Science, Proof, and Truth in the Law. Susan Haack. Cambridge: Cambridge University Press, 2014, 446 pages, $34.99 paperback.

Reviewed by Erica Beecher–Monas, Wayne State University

Expert testimony has troubled judges for centuries. Since judges rarely have backgrounds in science, having to tell genuine knowledge from hokum is frequently a challenge, especially in this era of increasing courtroom use of expert testimony. In this book of "interdisciplinary essays," Susan Haack, renowned epistemologist, attempts to teach judges something about how to evaluate scientific testimony by focusing on the intersection of law, philosophy, and science, invoking concepts of inquiry and truth as they are used in all three disciplines.

The reason it is up to judges to decide whether expert testimony is genuine knowledge that would be helpful to the jury is the Supreme Court's *Daubert* decision,[1] which placed the gatekeeping task of evaluating scientific validity on federal judges. The Court's subsequent decisions elucidated the gatekeeping requirement;[2] and the amendment to Federal Rule of Evidence 702 codifies these decisions.[3]

Based on the judge's duty to assess relevance in determining admissibility, the *Daubert* Court told federal judges to engage in a "preliminary assessment of whether the reasoning or methodology underlying the testimony is scientifically valid and whether that reasoning or methodology properly can be applied to the facts in issue."[4] The rationale for permitting experts — who have no personal knowledge of the events at issue — to testify, the Court noted, "is premised on an assumption that the expert's opinion will have a reliable basis in the knowledge and experience of his discipline."[5] The Court then gave judges some "general observations" (the *Daubert* factors) to guide their assessment:

Correspondence concerning this article should be addressed to Professor Erica Beecher–Monas, Wayne State University School of Law, 471 West Palmer Avenue, Detroit, Michigan 48202. Email: e.beecher@wayne.edu. [Editor's note: this review is in Blue Book style.]

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

[2]*E.g.*,General Electric Co. v. Joiner, 522 U.S. 136 (1997); Kumho Tire v. Carmichael, 526 U.S. 137 (1999).

[3]Federal Rule of Evidence 702, as amended, provides that:

> A witness that is qualified as an expert by knowledge, skill, experience, or other specialized knowledge 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 determine a fact in issue; b) the evidence is based on sufficient facts or data; c) the testimony is the product of reliable principles and methods; d) the expert has reliably applied the principles and methods to the facts of the case.

[4]*Daubert* at 592–593.

[5]*Id.* at 592.

testability,[6] subjection to peer review and publication,[7] known or potential error rate and the existence and maintenance of standards,[8] and general acceptance.[9]

Daubert linked the idea of reliability to helpfulness: something cannot be helpful to the jury if it is not reliable — meaning trustworthy. Rule 702 as amended tries to give guidance to the trustworthiness inquiry. It provides that a qualified witness may testify if it would be helpful to the trier of fact (usually the jury), and "the testimony is based on sufficient facts or data . . . is a product of reliable principles and methods . . . reliably applied . . . ." That requirement leaves open a raft of contentious issues. What amount of data is sufficient? How do you know if a principle is reliable? Is a reliable method just one that gives the same results if repeated? Does reliably applied mean only that the protocols were followed? And how would one know? None of these questions is addressed, either by the amended rule or by *Daubert*, so most judges continue to use the *Daubert* factors as a checklist[10] in determining evidentiary reliability. Moreover, the formalistic way many judges apply these factors and their tendency to "transmute scientific subtleties into formalistic jargon" is a cause for concern, especially when dealing with causation concepts.

The *Daubert* case, in placing the onus of gatekeeping expert testimony on federal judges, attempted to link admissibility of expert testimony to relevance. Unless empirical testing can show what it purports to show, it cannot be relevant to any issue in a case. According to *Daubert,* once the expert has demonstrated the basis of her testimony by explaining how her testing, methodology, error rate, exposure to critique and reasoning process lead to her conclusion, she ought to be permitted to testify. Other experts may well disagree, and as long as their disagreement is based on a rational basis, the jury should hear that too. In other words, while the judge must determine relevance, it is not up to the judge to determine who is right. That is the jury's province. Of course, as Learned Hand noted many years ago, that amounts to making the jury decide matters about which doctors disagree. But at least they get to hear the basis of the disagreement.

Haack is highly critical of the *Daubert* decision and has telling critiques of each of the *Daubert* factors. She demonstrates how none of these factors actually explains how to determine whether expert testimony is reliable. So, throughout this book, Haack attempts to show judges how they can actually do their required gatekeeping in an epistemically justifiable manner. While she agrees that judges should be gatekeepers with regard to expert testimony, and must do more than merely rely on the consensus of the scientific community in making those decisions,[11] she does not think the *Daubert* decision provides enough guidance about what makes expert testimony reliable.

As Haack nicely illustrates, each of the *Daubert* factors is epistemically problematic, and judges routinely make a mess of applying them. Haack contends that judicial confusion about how to apply these factors is due to the *Daubert* Court's failure to distinguish between

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[6] *Id.* at 593.

[7] *Id.*

[8] *Id.* at 594.

[9] *Id.*

[10] Despite the *Daubert* Court's warning that its factors were not "a definitive checklist." *See Daubert*, *supra* note 1 at 593.

[11] The general consensus standard, also known as the Frye standard, required scientific testimony to "be sufficiently established to have gained general acceptance in the particular field in which it belongs." Frye v. United States, 293 F. 1013 (D.C. Cir. 1923).

the scientific and the reliable.[12] She especially derides the Court's excursion into the philosophy of science. In particular, she is scornful of the Court's simultaneous citations to both Popper and Hempel, since they were on opposite sides of the philosophical argument about what distinguishes science from other forms of conjecture and belief (primarily metaphysics). Hempel was a logical positivist, while Popper argued against the positivists. Haack contends that the Court's simultaneous citation to Hempel and Popper meant that the Supreme Court thought that combining the two led to reliable science.

Whether or not the Supreme Court confused scientific and reliable, as Haack contends,[13] it is not because the Court cited to Hempel and Popper in the same sentence. In legal opinions, authority is used to demonstrate that the Court is not springing novel ideas on the citizenry. Judges need to demonstrate that their decisions have precedent (if not in case law, then in some other branch of knowledge). I suspect that neither the Court nor any of its clerks knew much about the philosophy of science, nor did they need to if all they had to show was that prominent authorities previously said what the Court wanted to say.

In this particular critique of the Court, Haack appears to misunderstand how and why legal writers use authority. Lawyers and judges cite to authority in a very superficial manner. They don't necessarily read everything the cited authorities ever wrote (or even the whole book that is cited).[14] While it would make for better reasoning if judges understood the body of work from which the citations are drawn, the time pressure on judges and lawyers makes it unfeasible. If the authority actually said what the Court wants to say, that's all that's required.

In *Daubert,* the sentence for which Hempel, Popper (and Green) are cited is: "Ordinarily, a key question to be answered in determining whether a theory or technique is scientific knowledge that will assist the trier of fact will be whether it can be (and has been) tested."[15] Although they disagreed about almost everything else, would either of the cited authors disagree with that sentence? I don't think so and Haack doesn't tell us. She does say that Hempel's philosophy is too simplistic for the complex evidence before the *Daubert* Court, and Popper thought that even the best tested theory could be proven wrong. Fair enough.

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[12]Reliability, the *Daubert* Court acknowledged, means different things to scientists and to ordinary people. For scientists, reliability means that if you repeat the same experiment you will get the same results. As Haack points out, those same results could be wrong; replicability does not guarantee correctness. To non-scientists, especially lawyers, reliable means trustworthy. *Daubert* acknowledged the different meanings, and then went on to conflate validity, which it defined as "good grounds," with evidentiary reliability, *id.* at 590, which the courts have been doing ever since. As Haack explains, the real question is not whether something is or is not scientific, but how well it explains an event, taking into account all the evidence, including the evidence against the particular explanation.

[13]Haack contends that every kind of empirical inquiry — not just the scientific — involves making an informed guess to explain an event, determining the consequences if the guess were true, and checking to see whether it stands up to the evidence.

[14]As an aside, Haack is similarly guilty: she cites Holmes throughout, without acknowledging that he believed that the "first requirement of a sound body of law is that it should correspond with the actual feelings and demands of the community, whether right or wrong" and probably without knowing just how deeply pessimistic he was. *See* Grant Gilmore, The Ages of American Law 44-45 (2nd ed. 2014) ["The real Holmes was savage, harsh, and cruel, a bitter and lifelong pessimist who saw in the course of human life nothing but a continuing struggle in which the rich and powerful impose their will on the poor and weak"]. Just as Holmes had some good insights into the workings of the common law, a lot of what he said was inconsistent, if not contradictory, and morally repugnant — think of Buck v. Bell, where he justified sterilizing a mentally retarded woman on a theory of eugenics. Should we disregard Haack's work based on her Holmes citations? I don't think so. She needed to make a point, and as long as Holmes actually said what she cites him for, that ought to suffice.

[15]*Daubert*, *supra* note 1 at 593.

According to *Daubert,* the "key question" in making admissibility determinations is testability. The Court cites Hempel for the proposition that "the statements constituting a scientific explanation must be capable of empirical test."[16] Popper's quotation is that "the criterion of the scientific status of a theory is its falsifiability, or refutability, or testability."[17] Both citations emphasize the importance of testability, and that is what the Court was arguing. Perhaps the authorities disagreed with each other about almost everything else, but on this one point they agreed. And that is the point the court wished to emphasize. Nor does Haack herself disagree with the concept of testability — she acknowledges that courts need to know if the basis of expert testimony is empirically testable, whether it has actually been tested, and how well the test is performed. In fact, she argues that is what reliability means.

Rather, Haack's disagreement with *Daubert* is over the whole enterprise of demarcation — separating science from other forms of human inquiry.[18] Instead of obsessing about whether evidence is scientific or not, Haack suggests judges get a grip on the complexities of evidence, understand that how well warranted a claim is depends on how well the evidence supports it (meaning how tightly evidence and claim fit together to form an explanatory account), how secure the background assumptions are, independent of belief, and how comprehensive the claim is. Essentially, she agrees with the Supreme Court's *Kumho Tire* decision, which instructed judges to ditch the idea that *Daubert*'s gatekeeping requirements applied only to "hard" science, and not to such disciplines as engineering and psychology.[19] Instead, the *Kumho Tire* Court emphasized, all expert testimony must be subject to rigorous empirical review.[20]

Haack claims that although courts recognize that testability is an important facet of reliability, they are apt to confuse its meaning (citing a case where expert DNA testimony was admitted despite lab error because the DNA had been tested, even if improperly). Who should have done the testing is also subject to court confusion, especially in forensic techniques where courts rely on "testing" by other courts (noting fingerprint cases where other courts are cited as authority for admissibility). Moreover, testability is problematic, apart from the brouhaha over citing Popper and Hempel, because not all scientists, as Haack points out, are reliable inquirers.

To be a reliable inquirer, scientists must seek out all the evidence, not just that which supports their theories. Good scientists, according to Haack, "make informed guesses at the answers to their questions, work out the consequences of these informed guesses, seek out evidence to check how well those consequences hold up, and use their judgment about how to proceed from there." But so do all other reliable inquirers. There is no uniquely rational mode of procedure or inference.[21]

Peer review and publication are even more indeterminate. Journals publish positive results; rarely do negative results see the light of day. Innovative work is often rejected. And judges

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[16] *Id.* at 593.

[17] *Id.*

[18] In fairness to the Supreme Court, it did not explicitly engage in a demarcation enterprise; rather, as *Kumho Tire* later pointed out, *Daubert* focused on scientific evidence rather than all expert testimony because that was the evidence at issue.

[19] *Kumho Tire supra* note 2.

[20] *Id.*

[21] Haack claims that science is not different from common sense, only more careful. Popper, who debunked the idea of a monolithic scientific method and thought that the only fundamental aspect of science was its openness to critique and revision, would agree with this. *See* Karl R. Popper, The Logic of Scientific Discovery 276–281 (5th ed. 1992).

miss the nuances of scientific publication; some courts admit testimony based on unreviewed or unpublished studies, while other courts exclude testimony in the absence of one or both. Moreover, scientific consensus can be bought, and tainted by litigation interests of manufacturers who frequently sponsor research. Haack notes that science's core values of honesty about what the evidence is and what it shows is increasingly under strain for financial reasons. Judges treat peer review as epistemic warrant, but scientists would not agree. A better indication of reliability than peer review and publication, Haack explains, is whether the study "has been out there long enough, has been read by enough others knowledgeable enough in the field, links up in an explanatory way with enough other bits of scientific theorizing, and has proven robust enough when new experiments or theoretical work assume its reliability." Maybe she's right, but how is a judge to know? Even Haack acknowledges that this formulation would be difficult to apply.

Consider the cases of shaken baby syndrome in which a caretaker is accused of murder based on expert forensic pediatric testimony that a triad of symptoms is diagnostic of murder.[22] Recent research has demonstrated that the triad is found in many unmurdered babies (some living, some dead of other causes). The old research about the triad had been "out there long enough" and was read by knowledgeable others; the experts had theories that explained how the triad caused death and why it only occurred by shaking (or falling from a very high building). Hundreds of people went to jail on the basis of this testimony. But the experts were wrong. New research debunked it. So how, prior to the new research, could a judge know that there were serious flaws in the doctors' hypotheses? Should they have known enough to question any diagnostic testimony that lacks a base rate of triad occurrence in normal populations (a question the experts could not have answered since the research did not exist)? Nothing in law school prepares a judge to understand the significance of such an inquiry. Furthermore, incomplete information is in large part a matter of funding. Unfunded research will not be done, and there is little incentive for forensic pediatricians to debunk their own theories, nor is there incentive for manufacturers to conduct safety research once a product is on the market.

In terms of error rate and methodology, Haack focuses on two recurring problems with admissibility decisions: which scientific methodologies to consider and statistical inference. In terms of choosing methodologies, many judges, following the Supreme Court in *Joiner*,[23] take a highly atomistic approach to causation evidence. For example, many judges will exclude causation testimony that, lacking epidemiology studies, relies on animal and other studies. This is a real hurdle in many toxic tort cases where epidemiology studies may not have been done. Most manufacturers sponsor only enough research to bring their products to market, and much, if not most, current research relies on industry funding. Judges are not unused to dealing with incomplete evidence — they know that a brick does not build a wall. But when it comes to assessing scientific testimony, many simply ignore this concept.

Sometimes, however, disparate bricks will not build a wall. It's always possible that unrelated pieces of evidence may just form a meaningless pile. Judges struggle to distinguish between meaningless rubble and wall-building bricks. Haack suggests that a better approach is to look at all the available evidence and use judgment to assess what the combined evidence shows and how the bits of evidence fit together, although she acknowledges that this "is a subtle and complex matter."

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[22] *See* Erica Beecher–Monas, *Lost in Translation: Statistical Inference in Court,* 46 Ariz. St. L. J. 1057, 1080–1083 (2014) [discussing admissibility of shaken baby syndrome].

[23] *Joiner supra* note 2.

Scientists understand causation as a mesh of interwoven elements that, if combined, will warrant a conclusion to a higher degree than any of its components alone. At a minimum, causation evidence should include a range of disciplines and evidence of biological mechanism. Determinants of evidential quality depend on how comprehensive the evidence is, how well the bits interlock, how well they explain and support the theory of causation. Interlocking bits of evidence may jointly warrant a conclusion better than any single bit. The degree to which evidence supports a claim depends on the contribution it makes to the explanatory integration of evidence plus conclusion.

Statistical inference is also a struggle for judges.[24] Many judges fail to recognize that statistical significance explains something about the data rather than a reliability factor. Many judges, if not most, insist that in order to be admissible expert epidemiology testimony must rely on a relative risk of two (rr=2), meaning a doubling of the risk. This mistaken understanding arose from a 1982 case that confused relative risk with the standard of proof, opining that only if the relative risk exceeds two can the evidence be more probable than not (the standard of proof for admissibility determinations). This, as Haack explains, is mixing apples and oranges. More probable than not is a statement of belief (Haack says warranted belief). Relative risk is a statistical assessment, measuring the relative frequency of occurrence. Confusing the two concepts completely misapprehends the concept of relative risk. Any positive relative risk means that the exposed population has suffered some effects greater than the unexposed population. A relative risk of two is neither necessary nor sufficient for causation. Thus, the third *Daubert* factor of methodology and error rate is frequently misunderstood in courts.

The fourth factor of general consensus is similarly fraught. While government sponsorship of research was once the norm, funding has been drastically reduced over the last several decades, and manufacturers (big pharma and chemical companies) have stepped in to fill the gap. While both the sponsors and the sponsored contend that the source of funding does not affect the objectivity of their research, human bias has a way of intruding. The sponsors want favorable results. The sponsored know what results their patrons seek. Even if unconscious, contrary evidence tends to be minimized. But it's worse than that, because many sponsors demand that unfavorable results not be published. As a result, company-sponsored research is more likely to be favorable to the sponsor. A more thorough inquiry, seeking all the evidence, favorable and unfavorable, would make for sounder science, although bias may sneak in to some extent (one reason that, in the rare event that an experiment is replicated by someone else, the results often fail to match the original study's — a phenomenon scientists often refer to as regression to the mean).

These problematic misunderstandings of the *Daubert* factors illustrate judges' discomfit and unfamiliarity with basic concepts in science. Admissibility decisions could be improved through education in these basic concepts, but Haack is highly critical of the worth of judicial conferences that attempt to teach judges much about science in a few days. By shedding light on many of the mistaken assumptions that prevent judges from making good admissibility decisions, Haack's book does educate its readers about how to think about expert evidence.

So just how can we tell whether expert testimony is reliable enough to be admitted into evidence? Haack says it's a matter of warrant, which she claims is tantamount to reliability. Haack, defining warrant as rational credibility, explains that the warrant for a conclusion depends on how supportive the evidence is, how secure, and how much of the relevant evidence is included — and what is missing. But she says that the Supreme Court's *Daubert*

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[24]*See, e.g.,* Beecher–Monas, *supra* note 19 passim (discussing judicial misunderstandings about statistics).

factors don't help, and that Popper is less than helpful.[25] Even Haack admits that specifying indicia of reliability is hard. The most that can be said is that rational credibility is what's at stake.[26]

Haack is not alone in critiquing the *Daubert* decision. *Daubert* was met by a great outcry from judges — many of whom claimed to be inadequate to the task of distinguishing sound science from claptrap — as well as legal scholars pro and con (thousands of articles have been published on the decision). Previously, judges, relying on *Frye,* a 1923 case which used a general consensus standard to exclude polygraph testimony, had only to determine whether the expert's theory had achieved general acceptance in the field. This made life fairly simple for judges, but the downside was a guild mentality about expertise. As long as a coterie of experts would validate the field, that was enough. *Daubert*, on the other hand, requires judges to examine the process: how the expert had come to his or her theory and whether that made any sense. This is a huge step forward. Judges do not have to decide whether the testimony is correct, just whether the expert's opinion was based on sound methodology and reasoning. Since most lawyers, including judges, went to law school to avoid science and math, judges felt that this validity inquiry is a tall order.

Epistemology can help these befuddled judges, according to Haack. She thinks that law is already "up to its neck in it," explicitly disagreeing with Richard Rorty, who would ditch the entire epistemological enterprise. Instead, Haack turns to works of John Stuart Mill for understanding the structure of evidence; L. Jonathan Cohen (the probable and the provable); Bentham (with his critique of exclusionary rules); Wigmore (diagrams of structure); Learned Hand (discussing the anomaly of expert witnesses), and Leonard Jaffee (on the role of statistical evidence) to support her thesis that epistemology is important in law. Hack contends that the core epistemological concern of the legal enterprise is to understand the structure of evidence and what makes evidence stronger or weaker. In other words, warrant. Perhaps so, but the legal enterprise of deciding about evidentiary strength has two parts: judge and jury. In the context of expert testimony, the judge's role is to determine relevance (which is an all-or-nothing proposition) and helpfulness to the jury (which *Daubert* defined as a "reliable basis in the knowledge and experience" of the expert's discipline). The jury's role is to assess the strength or weakness — the rational credibility — of the evidence.

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[25]Why Haack thinks that Popper had nothing to say about reliability is unclear. For instance, while Popper contended that "we may seek for truth, for objective truth, though more often than not we miss it by a wide margin," he also explained that what kept conclusions from being arbitrary was that "[t]hose among our theories which turn out to be highly resistant to criticism, and which appear to us at a certain moment of time to be better approximations to truth than other known theories, may be described . . . as 'the science' of that time." Karl R. Popper, Conjectures and Refutations: The Growth of Scientific Knowledge 14 (1963). Because theories cannot be positively justified, it is "the fact that we can argue about their claim to solve problems better than their competitors . . . which constitutes the rationality of science." *Id.* at vii. Reliability is found in whether the theory presents enough data and interpretation so that we can argue about how well it solves the issue before the court. Is this reliability something courts can grapple with? Haack appears to think so, since she contends that the explanatory value of a theory (defined as how well the data support the claim, how secure the data are, and how comprehensive the theory is) is what makes it reliable.

[26]Haack claims that this is emphatically a question of "whether the evidence presented warrants the propositions at issue to the required degree [more probable than not for civil cases and beyond a reasonable doubt for criminal cases]" (brackets in original). Well, actually, no. The judge's job in both criminal and civil cases is to determine by a preponderance whether a qualified expert's testimony is reliable enough to be admissible. The jury gets to decide which expert's testimony is rationally credible.

Haack thinks that judges could make better admissibility decisions if they had a better understanding of warrant, which she defines as the "degree of explanatory integration of the evidence with that conclusion." She rightly points out that degrees of warrant cannot be equated to degrees of probability, You can't put precise numbers on degrees of proof — you cannot weigh or precisely measure the credibility of a proposition or your belief in its probability. When we say more probable than not, we cannot mean that we are 50.1 percent certain (despite generations of law students having been told that's the meaning). Belief is not a thing that can be weighed or measured. The degree to which evidence supports a claim depends on the contribution it makes to the explanatory integration of evidence plus conclusion.

Haack recognizes that the reason "courts don't do science very well" (citing Hume), is because of real tensions between the goals and values of each. While scientific inquiry's core value is honesty about what the evidence is and the explanatory value of the evidence, legal determinations require not only factual correctness, but must be "consistent with reaching a resolution within a reasonable time, constitutional constraints, and policy considerations." She defines inquiry as the attempt to discover the truth by seeking out all evidence, weighing its strength, and concluding only when justified.

Although both science and law purport to be searches for truth, legal inquiry does not make the cut, because the adversary system more closely resembles what Haack defines as pseudo-inquiry: the attempt to make the best possible case for a foregone conclusion, seeking out all favorable evidence and playing down all unfavorable evidence. Of course, both sides in an adversary system are doing this, so the theory is that each side will seek out the most favorable evidence for its position. Although C.S. Peirce says that "bias and counter-bias" is not a logical way to extract the truth, and while Haack agrees that there is good reason to think that our adversary system is flawed, she nonetheless argues that the adversary system "can be a reasonable way to determine verdicts," as long as the parties have equal resources — a highly unwarranted assumption, especially in criminal cases. In any event, Haack is a pragmatist, and acknowledges that we are not likely to abandon the adversary system any time soon.

But Haack also points out that in addition to differing styles of inquiry, there are numerous "irreconcilable differences" in the values of science and law. For one thing, the pressure of commercial interests is most severe in disputed causation testimony. Since most research is now commercially funded, that puts a strain on honesty. In addition, most evidence in cases that come to trial is incomplete — the research simply has not been done, usually for lack of funding. Moreover, science answers questions about groups, while law is about individual cases. Further, the adversarial system seeks out experts who are more willing than most in their field to give an opinion on less than overwhelming evidence. As a result, the adversarial system often creates artificial doubt or certainty.

Haack focuses her book primarily on civil rather than criminal matters. Although *Daubert* technically applies to both civil and criminal cases, and criminal judges give *Daubert* lip service, they rarely apply *Daubert* with any rigor. This is partly an issue of unequal resources. As it stands, while poor defendants in our criminal justice system have a right to an attorney at trial, they don't have the right to pick their appointed attorney, and the quality of representation varies greatly. In addition, while poor criminal defendants may have the right to an expert, their lawyer has to request the expert, backing up the request with an explanation of why an expert is necessary (which requires at least some understanding of the potential expertise at issue, an understanding many lawyers lack), and the funds provided tend to be parsimonious at best. Moreover, in criminal cases, *stare decisis* often results in continued

admissibility of a particular kind of expertise — bite-mark evidence, for example[27] — even if the original testimony was admitted without much analysis. In civil suits, plaintiffs have a somewhat better time of it, particularly in class actions. There too, however, inequality of resources can thwart the search for truth.

And while we're speaking of the search for truth, just what is that? All three disciplines, law, science, and epistemology, engage in this search for truth. Haack recognizes that the legal search for truth is different from science, in that it is time and place bound (and requires policy judgments). Judges must decide on admissibility — they can't just wait until better evidence turns up. Juries must reach verdicts (or declare themselves unable to, in which case the process will begin over). In addition, the legal system has an interest in finality to prevent constantly relitigating old disputes. In an analysis of what it means to conduct an inquiry in this search, Haack cites F.P. Ramsey to argue that truth means, regardless of subject matter "p and p." What this means I have no idea, and no coherent explanation that does not involve p's and equations is forthcoming. Epistemologists may understand her arguments, but I do not, and neither, I suspect, will most lawyers. I do think, however, that we agree that truth corresponds to the real world.

Haack seems to think that "the truth" is ultimately knowable. She appears to be what Popper described as an optimistic epistemologist, in that she appears to think that truth, once revealed, is always recognizable, and that, if not yet revealed, is discoverable.[28] She goes after Popper through much of the book for asserting that we can never ultimately know the truth; the best we can do is to approach it, critiquing until evidence appears that changes what we know about the truth. Popper famously used the statement "all swans are white" which can only be true until a black swan is spotted. Then we have to adjust. It's not that reality has changed, but our understanding of it certainly has. Scientific pronouncements are full of black swans: public warnings of the health hazards or benefits of certain foods are replaced at regular intervals: don't drink wine, followed by drink a glass of red wine a day; caffeine is bad for you, followed by drink at least five cups of coffee a week for longevity. None of that means that there is no truth, only that our understanding of it is incomplete. Popper says that while it's rational to act on the basis of a well-corroborated theory, there is no reason to believe it is true.

This notion makes judges — and apparently Haack — very nervous, because they are looking to experts for definitive answers. The judge must make admissibility decisions based on the information presented by the lawyers and their experts, and judges are uncomfortable with the idea that what we understand today (caffeine is not good for you) may change tomorrow (five cups of coffee a week increases longevity). Judges seek authority for their decisions that will not prove unfounded the next day.[29] The uncertainty of science is thus troubling to the legal system.

The nature of scientific inquiry is much more contingent than Haack acknowledges. Haack analogizes scientific knowledge to a crossword puzzle, which suggests that there is a knowable correct answer — once correctly completed, the puzzle is done. But science isn't like that, it's always expanding, refining, discarding, reinterpreting. Sometimes the whole puzzle changes. [Take for example the upheaval quantum physics caused to Newtonian precepts.][30]

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[27] *See* Erica Beecher–Monas, *Reality Bites: The Illusion of Science in Bite-Mark Evidence,* 30 Cardozo L. Rev. 1369 (2009)[discussing the admissibility of bite-mark evidence].

[28] Popper, *supra* note 22 at 6-7.

[29] *See, e.g.*, the controversy over shaken baby testimony, discussed above.

[30] *See* Thomas Kuhn, The Structure of Scientific Revolutions (2d ed.1970) [arguing that science progresses not in a linearly accretion of knowledge, as Popper suggests, but as abrupt, discontinuous, and revolutionary paradigm shifts].

We are always learning something new about the world, often something that changes our perception entirely.[31] That doesn't mean reality is up for grabs; it just means we see though a glass, darkly.

Haack appears to think that truth is within our grasp, and takes umbrage at Popper's statement that you can only approach, but never know the truth. From Haack's perspective, once we know something we know it. This certainly is good news for judges, who would like to think that there are clear answers. But science has a way of shifting focus. Shaken baby syndrome is a good example of this phenomenon. What to do about all those convicted parents? In addition, Kuhn gives a number of examples of paradigm shifts, in which the same tests run the same way become understood in an entirely new light.

But these philosophical debates about the nature of truth aside, Haack's book gives us an excellent critique of courts' admissibility decisions, particularly in civil tort cases. She does not discuss criminal cases much, other than to castigate the forensic sciences as wholly without empirical foundation, an observation also made by the National Research Council's Report.[32] Judges in criminal cases (even those giving lip service to *Daubert* and Rule 702) don't even attempt to figure out the reliability of the evidence before them. Instead, they almost uniformly cite to other courts' admissibility decisions.

Haack's solutions to the problem of judicial inadequacy, however — regulation and education — are highly implausible. Her substitution of regulation for the tort system is unlikely to achieve just results for victims. We have regulatory agencies already: the Food and Drug Administration regulates the marketing of pharmaceuticals, and the Environmental Protection Agency regulates some chemicals (although most common household compounds have never been tested). As we know from bitter experience (the explosion and flouting of health and safety regulations in Massey mines, the Flint, Michigan water fiasco, where all branches of federal, state, and local government ignored the lead problem until a whistleblower brought it to national attention; FDA approval of numerous harmful drugs like Vioxx, among many others), regulators tend to be underfunded or to get captured by the regulated. Education? That might help. The problematic admissibility decisions Haack discusses illustrate judges' unfamiliarity with basic concepts in science.

One would think that unfamiliarity could be improved through education, but Haack is highly critical of judicial conferences that attempt to teach judges about science in a few days. Perhaps if we better educate our children about science, when they grow up they will understand the concepts better. That does not appear to be happening any time soon. Legal education? Even the few law schools that offer courses in statistics or scientific evidence find that the courses are overwhelmingly under-attended. Some efforts at education have been helpful, such as the Federal Judicial Center's Manual on Scientific evidence, which is increasingly cited in judicial admissibility decisions. The NRC/NAS Report[33] on the other hand, has been widely ignored. Certainly, *Evidence Matters* is a worthy attempt at education, and judges (and lawyers) would be well advised to take it seriously.

In sum, this work provides a valuable guide to what should go into rational decision making about the admissibility of scientific evidence. It clearly and concisely explains the faulty assumptions judges make about the factors they have been told are important to their task. Its chapters on legal positivism (attacking Bayesian evidence), peer review and publication, and understanding causation as a weight of the evidence inquiry are especially strong. The book's focus on the concept of warrant is particularly important and something every judge

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[31] *See, e.g., id.*

[32] National Research Council, National Academy of Sciences, Strengthening Forensic Science in the United States: A Path Forward (2009).

[33] *Id.*

and legal actor should understand. The limitations of Haack's work are those familiar to anyone attempting interdisciplinary work (and which Haack herself acknowledges): slippage in terms (such as equating relevance with reliability) and concepts (the burden of persuasion for admissibility decisions which — contra Haack — does not change in civil or criminal matters). But these are relatively minor matters, and should not detract from what the book has to say. The more important limitation is the book's failure to grapple with the uncertainties of science and Haack's consequent attack on the Supreme Court's citation to Popper, despite her assertion that the philosophy of science is irrelevant to legal decision making. If it's irrelevant, why object so strongly to one of its major voices? In any event, debates over the nature of truth have been with us for eons and are unlikely to be solved any time soon. This book is well worth reading for Haack's insights into the process of warranted decision making.